EMISSIONS TEST REPORT

for

CARBON MONOXIDE (CO) CONTROL EFFICIENCY & EMISSION RATES, OXIDES OF NITROGEN (NO_X) AND NON-METHANE ORGANIC COMPOUNDS (NMOC) EMISSION RATES

UNIT 1

DTE Gas Willow Compressor Station

Ypsilanti, Michigan

July 1, 2015

Prepared By
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EXECUTIVE SUMMARY

DTE Energy's Environmental Management and Resources (EM&R), Field Services Group, performed emissions testing at the DTE Gas Willow Compressor Station, located in Ypsilanti, Michigan. The fieldwork, performed on July 1, 2015 was conducted to satisfy requirements of the Michigan Permit to Install No. 246-07. Emission tests were performed on Unit 1 for carbon monoxide (CO), oxides of nitrogen (NO_x) and non-methane organic compounds (NMOC) emission rates and CO control efficiency.

A summary of results of the emissions testing are highlighted below:

CO, NO_x and NMOC Emissions Test Results
Willow Compressor Station – Unit 1
Ypsilanti, Michigan
July 1, 2015

Unit 1	Load (%)	Carbon Monoxide (gram/B-Hp)	Carbon Monoxide (CE)	Oxides of Nitrogen (gram/B-Hp)	NMOC (gram/B-Hp)
Test 1	101	0.03	98.5	0.46	0.18
Test 2	102	0.01	99.2	0.46	0.45
Test 3	100	0.02	99.0	0.48	0.25
Average		**0.02**	**98.9**	**0.47**	**0.30**

Permit Limits:
NOx = 0.9 grams/B-Hp
NMOC = 1.0 grams/B-Hp
CO = 2.5 grams/B-Hp
CO = 93% CE

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1.0 INTRODUCTION

DTE Energy's Environmental Management and Resources (EM&R), Field Services Group, performed emissions testing at the DTE Gas Willow Compressor Station, located in Ypsilanti, Michigan. The fieldwork, performed on July 1, 2015, was conducted to satisfy requirements of the Michigan Air Permit to Install No. 246-07.

Testing was performed pursuant to Title 40, *Code of Federal Regulations*, Part 60, Appendix A (40 CFR §60 App. A), Methods 3A, 7E, 10, 18, and 25A.

The fieldwork was performed in accordance with EPA Reference Methods and EM&R's Intent to Test[1], Test Plan Submittal. The following EM&R Field Services personnel participated in the testing program: Mr. Mark Grigereit, Principal Engineer, Mr. Thomas Snyder, Senior Environmental Technician and Mr. Fred Meinecke, Senior Environmental Technician. Mr. Grigerit was the project leader. Mr. Thomas Maza with the Air Quality Division of the Michigan Department of Environmental Quality (MDEQ) witnessed the testing and approved the Test Plan[2].

2.0 SOURCE DESCRIPTION

The Willow Compressor Station located at 3020 East Michigan Avenue, Ypsilanti, Michigan, employs the use of a Caterpillar 3616 natural gas-fired 4,735 Horse Power reciprocating engine (Engine 1). The engine generates line pressure assisting the transmission of natural gas throughout the pipeline transmission system in SE Michigan.

The emissions from the engine are exhausted through a catalyst bed and to the atmosphere through an individual exhaust stack. The composition of the emissions from the engine depends both upon the speed of the engine and the torque delivered to the compressor. Ambient atmospheric conditions, as it affects the density of air, limit the speed and torque at which the engine can effectively operate.

During the emissions testing the engine was operated within 10% of its highest achievable load.

A schematic representation of the engine exhaust and sampling locations are presented in Figure 1.

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[1] MDEQ, Test Plan, Submitted May 4, 2015. (Attached-Appendix A)

[2] MDEQ, Approval Letter, Received June 4, 2015. (Attached-Appendix A)

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3.0 SAMPLING AND ANALYTICAL PROCEDURES

DTE Energy obtained emissions measurements in accordance with procedures specified in the USEPA *Standards of Performance for New Stationary Sources*. The sampling and analytical methods used in the testing program are indicated in the table below

Sampling Method	Parameter	Analysis
USEPA Method 3A	Oxygen	Instrumental Analyzer Method
USEPA Method 7E	Oxides of Nitrogen	Chemilumenecent Instrumental Analyzer Method
USEPA Method 10	Carbon Monoxide	NDIR Instrumental Analyzer Method
USEPA Method 18	Gaseous Organic Compounds (Methane)	GC Analytical Method (Tedlar™ Bag Sample)
USEPA Method 25A	Total Hydrocarbon Compounds	FID Instrumental Analyzer Method

3.1 OXYGEN (USEPA METHOD 3A)

3.1.1 Sampling Method

Oxygen (O_2) emissions were evaluated using USEPA Method 3A, "Gas Analysis for Carbon Dioxide, Oxygen, Excess Air, and Dry Molecular Weight (Instrumental Analyzer Method)". The analyzer utilizes a paramagnetic sensor. Testing was performed simultaneously with the gaseous emissions testing.

The EPA Method 3A sampling system (Figure 2) consisted of the following:

(1) Single-point sampling probe (traversed across the duct according to procedures in Method 7E)

(2) Heated Teflon™ sampling line
(3) Gas conditioner with particulate filter
(4) Flexible unheated Teflon™ sampling line
(5) Servomax 1400 O_2/CO_2 gas analyzer
(6) Appropriate USEPA Protocol 1 calibration gases
(7) Data Acquisition System

3.1.2 Sampling Train Calibration

The O_2 analyzer was calibrated according to procedures outlined in USEPA Methods 3A and 7E. Zero, span, and mid range calibration gases were introduced directly into the analyzer to verify the instruments linearity. A zero and mid range span gas was then introduced through the entire sampling system to determine sampling system bias at the completion of each test.

3.1.3 Quality Control and Assurance

All sampling and analytical equipment was calibrated according to the guidelines referenced in Methods 3A and 7E. Calibration gases were EPA Protocol 1 gases and the concentrations were within the acceptable ranges (40-60% mid range and span) specified in Method 7E. Calibration gas certification sheets are located in Appendix C.

3.1.4 Data Reduction

Data collected during the emissions testing was recorded at 10-second intervals and averaged in 1-minute increments. The O_2 emissions were recorded in percent (%). The 1-minute readings collected during the testing can be found in Appendix B.

3.2 OXIDES OF NITROGEN AND CARBON MONOXIDE (USEPA METHODS 7E & 10)

3.2.1 Sampling Method

Oxides of nitrogen (NO_x) emissions were evaluated using USEPA Method 7E, "Determination of Oxides of Nitrogen Emissions from Stationary Sources". The NO_x analyzer utilizes a Chemiluminecent detector. Triplicate 60-minute tests were performed on the engine exhaust. Carbon monoxide (CO) emissions were evaluated using USEPA Method 10, "Determination of Carbon Monoxide Emissions from Stationary Sources". The CO analyzer utilizes an NDIR detector. Triplicate 60-minute tests were performed on the engine catalyst inlet and exhaust.

The EPA Method 7E & 10 sampling system (Figure 2) consisted of the following:

(1) Stainless-steel sample probe (traversed across the duct according to procedures in Method 7E)
(2) Heated Teflon™ sampling line
(3) Gas conditioner with particulate filter
(4) Flexible unheated Teflon™ sampling line
(5) TECO 42i Chemilumenecent NO/NO_x gas analyzer, TECO 48i NDIR CO gas analyzer
(6) Appropriate USEPA Protocol 1 calibration gases
(7) Data Acquisition System.

3.2.2 Sampling Train Calibration

The sampling train was calibrated according to procedures outlined in USEPA Method 7E. Zero, span, and mid range calibration gases were introduced directly into the analyzer to verify the instruments linearity. A zero and mid range span gas was then introduced through the entire sampling system to determine sampling system bias at the completion of each test.

3.2.3 Quality Control and Assurance

All sampling and analytical equipment was calibrated according to the guidelines referenced in Methods 7E. Calibration gases were EPA Protocol 1 gases and the concentrations were within the acceptable ranges (40-60% mid range and span) specified in Method 7E. Calibration gas certification sheets are located in Appendix C.

DTE performed a NO_x converter efficiency test by directly challenging the NO_x analyzer with a nitrogen dioxide (NO_2) calibration gas of 51.5 ppm. Results from the converter efficiency test demonstrated that the analyzer met the requirements of Method 7E (Eq-1). Equation-1 shows the converter efficiency test performed.

Eq. 1

$$Eff_{NO2} = \frac{C_{Dir}}{C_v} = \frac{47.4}{51.5} = 92.0\%$$

3.2.4 Data Reduction

Data collected during the emissions testing was recorded at 10-second intervals and averaged in 1-minute increments. The NO_x emissions were recorded in parts per million (ppm). The 1-minute readings collected can be found in Appendix B.

Emissions calculations are based on calculations located in USEPA Methods 7E and 19 and can be found in Appendix F. The NO_x emissions data collected during the testing was calculated as grams per brake-horsepower-hour (g/bhp-hr).

3.3 METHANE (USEPA METHOD 18)

3.3.1 Sampling Method

Methane (CH_4) emissions were evaluated using USEPA Method 18, "Measurement of Gaseous Organic Compound Emissions by Gas Chromatography (Tedlar™ Bag Sampling)". This method involves the collection of exhaust gas in a Tedlar™ bag, which is then analyzed at an off-site laboratory by gas chromatography (GC). Triplicate samples were collected simultaneously with the Total Hydrocarbon (Method 25A) sampling. The vacuum pump flowrate was set to allow for a constant rate, integrated sample, collected for the duration of each test run.

The EPA Method 18 sampling system followed the procedures specified in Section 8.2.1, Integrated Bag Sampling & Analysis.

The EPA Method 18 sampling system (Figure 3) consisted of the following:

(1) Stainless Steel Probe
(2) Teflon™ sampling line
(2) Sampling lung with 10-liter Tedlar™ bag
(3) Vacuum pump with regulator.

3.3.2 Sample Analysis

The Tedlar bag samples were labeled with the test number, test location and test date. The samples were shipped overnight via Federal Express to the laboratory at the completion of Unit 2 testing. Methane analysis was performed on the following day. Analysis, performed by Enthalpy Analytical Laboratory, Durham, NC followed the guidelines of EPA Method 18, including triplicate analysis and a spike recovery study. Analytical results of the Method 18 samples are located in Appendix D.

3.3.3 Data Reduction

Results from the methane sampling were used to determine the non-methane organic compound concentration from the source. Methane emissions were subtracted from total organic compound emissions (as determined by Method 25A).

The $CH_{4\ (as\ methane)}$ emission rate was reported in grams per Brake-Horsepower hour (gram/Bhp-hr) in order to subtract the CH_4 from the THC measured in the field (Eq-2).

Eq. 2

$$NMOC = THC_{(gram/Bhp-hr)} - CH_{4(gram/Bhp-hr)}$$

3.4 TOTAL HYDROCARBON COMPOUNDS (USEPA METHOD 25A)

3.4.1 Sampling Method

Total hydrocarbon compound (THC) emissions were evaluated using USEPA Method 25A, "Determination of Total Hydrocarbon Emissions from Stationary Sources (Instrumental Analyzer Method)". The THC analyzer utilizes a flame ionization detector (FID). The FID measures total hydrocarbon compounds (including Methane). Triplicate 60-minute tests were performed on the engine exhaust, simultaneously with the other gaseous emission testing.

The Method 25A sampling system (Figure 4) consisted of the following:

(1) Single-point sampling probe (placed in the center of the stack)
(2) Heated Teflon™ sampling line
(3) JUM 109A® Total Hydrocarbon gas analyzer
(4) Appropriate USEPA Protocol 1 calibration gasses
(5) Data Acquisition System

3.4.2 Sampling Train Calibration

In accordance with USEPA Method 25A, a 4-point (zero, low, mid, and high) calibration check was performed on the THC analyzer. The analyzer was calibrated with propane in the 0-1,000 ppm range. Calibration drift checks were performed at the completion of each run.

3.4.3 Quality Control and Assurance

The THC sampling equipment was calibrated with propane (C_3H_8) according to the guidelines referenced in Methods 25A. Calibration gases were EPA Protocol 1 gases and the concentrations were within the acceptable ranges (25-35% low range, 45-55% mid range and 80-100% of span). Calibration gas certification sheets are located in Appendix C.

3.4.4 Data Reduction

Data collected during the emissions testing was recorded at 10-second intervals and averaged in 1-minute increments. The THC emissions were recorded in parts per million (ppm) as propane (C_3H_8). The 1-minute readings collected can be found in Appendix B.

The NMOC emissions data collected during the testing was calculated and reported as g/Bhp-h. Emissions calculations are based on equations located in USEPA Methods 25A and 19 and can be found in Appendix F.

4.0 OPERATING PARAMETERS

The test program included the collection of generator load (kW), engine speed (RPM), inlet manifold air pressure (psi), fuel upper heating value (BTU), fuel flow (scfm) and generator operating hours (kW-hour).

Operational data is located in Appendix E.

5.0 DISCUSSION OF RESULTS

Table 1 presents the results of the NO_x and NMOC testing on Engine 1. The NO_x and NMOC emissions are presented in grams per brake horsepower hour (g/Bhp-hr). Measured concentrations of NO_x are 0.47 g/Bhp-hr (limit – 0.9 g/Bhp-hr) and NMOC are 0.30 g/Bhp-hr (limit – 1.0 g/Bhp-hr). Results of the CO emission testing are presented in g/Bhp-hr, prior to and after the catalyst, and the Control efficiency in percent (%). Measured concentrations of CO are 0.02 g/Bhp-hr (limit - 2.5 g/Bhp-hr) and 98.9% Control efficiency (limit – 93% DE). Also presented in the Results Table are the Unit load in percent (%), speed (rpm), brake horsepower, and heat input (MMBtu/hr).

The results of the testing indicate that Unit 1 is in compliance with Michigan Air Permit to Install No. 246-07.

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6.0 CERTIFICATION STATEMENT

"I certify that I believe the information provided in this document is true, accurate, and complete. Results of testing are based on the good faith application of sound professional judgment, using techniques, factors, or standards approved by the Local, State, or Federal Governing body, or generally accepted in the trade."

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RESULTS TABLE

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TABLE NO. 1
NO_x, CO and NMOC EMISSION TESTING RESULTS
Willow Compressor Station - Unit 1 Exhaust Stack
July 1, 2015

Test	Test Date	Test Time	Unit Load (%)	Engine Speed (RPM)	Engine Torque (Brake-hp)	Fuel Flow (SCFH)	Heat Input (MMBtu/hr)	NO_x Emission Rate [1] (gram/BHP-Hr, dry)	NMOC Emission Rate [2] (gram/BHP-Hr, dry)	CO Control Efficiency [3] (%)
1	1-Jul-15	8:45-9:45	101	993	4,749	31,614	33.67	0.46	0.18	98.5
2		10:07-11:07	102	994	4,801	31,550	33.60	0.46	0.45	99.2
3		11:26-12:26	100	993	4,702	31,324	33.36	0.48	0.25	99.0
	Average:		*101*	*993*	*4,751*	*31,496*	*33.54*	*0.47*	*0.29*	*98.9*

(1) NO_x Permit Limit = 0.9 gram/BHP-Hr

(2) NMOC Permit Limit = 1.0 gram/BHP-hr

(3) CO Permit Limit = 93% CE

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FIGURES

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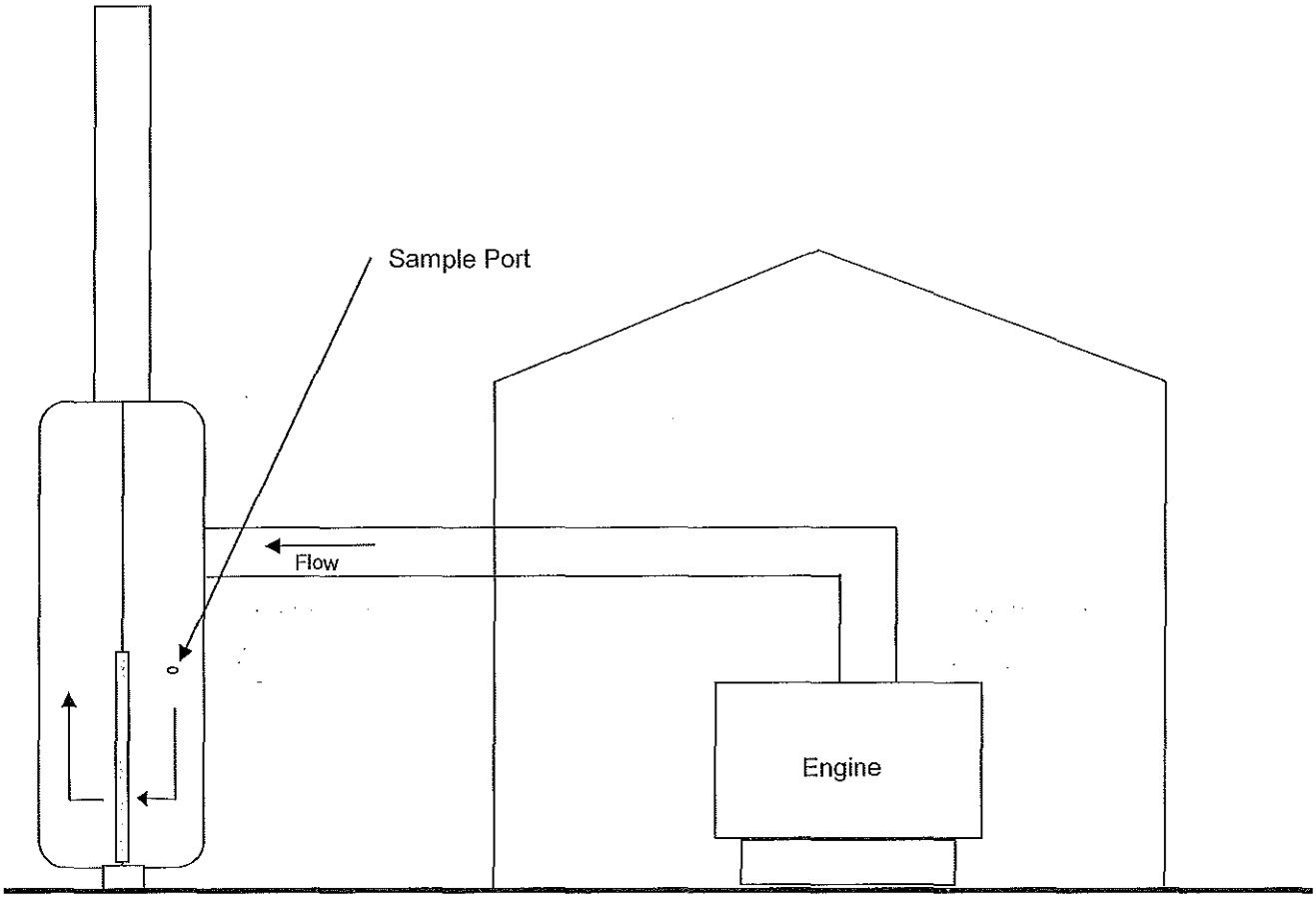
Figure 1 - Sampling Location
Willow Compressor Station
July 1, 2015



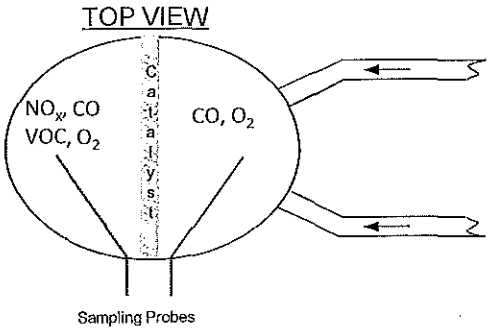


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Figure 3 - USEPA Method 18
Sampling Train
Willow Compressor Station
July 1, 2015