Emissions Test Report

for

Oxides of Nitrogen (NO_X), Carbon monoxide (CO) Destruction efficiency and Non-Methane Organic Compounds (NMOC)

EUENGINE1
40 CFR Part 60 Subpart JJJJ, and 40 CFR Part 63 Subpart ZZZZ

DTE-Gas Willow Compressor Station
Ypsilanti, Michigan

March 21, 2024

Prepared By
Environmental Management & Safety
Ecology, Monitoring, and Remediation Group
DTE Corporate Services, LLC
7940 Livernois Ave. G4-S
Detroit, MI 48210

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EXECUTIVE SUMMARY

DTE Energy's Environmental Management and Safety (EM&S), Ecology, Monitoring, and Remediation Group performed emissions testing at the DTE-Gas Willow Compressor Station, located in Ypsilanti, Michigan. The fieldwork performed March 21, 2024, was conducted to satisfy requirements of the Michigan Renewable Operating Permit MI-ROP-N7421-2022. 40 CFR Part 60 Subpart JJJJ, and 40 CFR Part 63 Subpart ZZZZ. Emission tests were performed on EUENGINE1 for oxides of nitrogen (NO_x), carbon monoxide (CO) and non-methane organic compounds (NMOC). Carbon monoxide (CO) destruction efficiency testing was performed on across each catalyst.

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

Emissions Test Results
Willow Run Compressor Station – EUENGINE1
Ypsilanti, Michigan
March 21, 2024

EUENGINE1	BHp (%)	Oxides of Nitrogen (gram/B-Hp)	Carbon Monoxide (gram/B-Hp)	Carbon Monoxide (DE)	NMOC (gram/B-Hp)
EUENGINE1	94.9%	0.39	0.03	98.3%	0.06
Permit Limit		0.9	2.5	>93%	1.0

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1.0 INTRODUCTION

DTE Energy's Environmental Management and Safety (EM&S), Ecology, Monitoring, and Remediation Group, performed emissions testing at the DTE-Gas Willow Compressor Station, located in Ypsilanti, Michigan. The fieldwork performed March 21, 2024, was conducted to satisfy requirements of the Michigan Renewable Operating Permit MI-ROP-N7421-2022, 40 CFR Part 60 Subpart JJJJ, and 40 CFR Part 63 Subpart ZZZZ. Emission tests were performed on EUENGINE1 for oxides of nitrogen (NO_x), carbon monoxide (CO) and non-methane organic compounds (NMOC). Carbon monoxide (CO) destruction efficiency testing was performed across the catalyst.

Testing was performed pursuant to Title 40, *Code of Federal Regulations*, Part 60, Appendix A (40 CFR §60 App. A), Methods 3A and 10 and ASTM Method D6348.

The fieldwork was performed in accordance with EPA Reference Methods and EMR's Intent to Test[1], Test Plan Submittal. The following EM&S Field Services personnel participated in the testing program: Mr. Thomas Snyder, Senior Environmental Specialist, Mr. Mark Grigereit, Principal Engineer, and Mr. Mark Westerberg, Senior Environmental Specialist. Mr. Snyder was the project leader. Mr. Andrew Riley with the Air Quality Division of the Michigan Department of Environment, Great Lakes, and Energy (EGLE) approved the Test Plan[2].

2.0 SOURCE DESCRIPTION

The Willow Run Compressor Station located at 3020 East Michigan Avenue, Ypsilanti, Michigan, employs the use of four (4) non-emergency natural gas-fired reciprocating internal combustion engines (RICE) and one (1) simple-cycle compressor turbine. The engines are identified as EURICE1-3 and EUENGINE1 ((flexible group FGENGINES and FGENGMACT4Z)). The compressor turbine is identified as EUTURBINE1. EURICE1 and EURICE2 are rated at 2,500 HP, EURICE3 is rated at 5,000 HP, EUENGINE1 is rated at 4,735 HP, and EUTURBINE1 is rated at 7,770 HP. The units generate line pressure assisting the transmission of natural gas throughout the pipeline transmission system in SE Michigan.

The emissions from each engine are exhausted through a catalyst bed and to the atmosphere through individual exhaust stacks. The composition of the emissions from the engine depends both upon the speed of the engine and the torque delivered to the compressor. Ambient

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[1] EGLE, Test Plan, Submitted January 16, 2024. (Attached-Appendix A)
[2] EGLE, Approval Letter, Received March 8, 2024. (Attached-Appendix A)

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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 EUENGINE1 was operated within 10% of its highest achievable load.

A schematic representation of the EUENGINE1 exhaust and sampling locations are presented in Figure 1.

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 10	Carbon Monoxide (CO)	NDIR
ASTM Method D6348	NO_x, CO, and VOC	FTIR

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.

Stratification testing was performed as a component of the first sample at each location. The exhausts were not stratified as the diluent gas (O_2) did not vary more than 0.14% at any point. Data was recorded at 10-second intervals.

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

(1) Single-point sampling probe (located in centroid of the exhaust stack)
(2) Heated Teflon™ sampling line
(3) MAK® gas conditioner with particulate filter
(4) Flexible unheated Teflon™ sampling line
(5) Servomax 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 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 CARBON MONOXIDE (USEPA METHOD 10)

3.2.1 Sampling Method

Carbon monoxide (CO) emissions at the inlet to the catalyst on EUENGINE1 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 each EUENGINE1 exhaust.

The EPA Method 10 sampling system (Figure 3) consisted of the following:

(1) Stainless-steel sample probe (located in centroid of the exhaust stack)
(2) Heated Teflon™ sampling line
(3) MAK® gas conditioner with particulate filter
(4) Flexible unheated Teflon™ sampling line
(5) TECO 48i NDIR CO gas analyzer

(6) Appropriate USEPA Protocol 1 calibration gases
(7) Data Acquisition System.

3.2.2 Sampling Train Calibration

The CO sampling train was calibrated per procedures outlined in USEPA Method 10. 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.

3.2.3 Quality Control and Assurance

All sampling and analytical equipment was calibrated per the guidelines referenced in Method 10. Calibration gases were EPA Protocol 1 gases, and the concentrations were within the acceptable ranges (40-60% mid-range and span). Calibration gas certification sheets are in Appendix C.

3.2.4 Data Reduction

Data collected during the emissions testing was recorded at 10-second intervals and averaged in 1-minute increments. The CO 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 Method 10, and 19 and can be found in Appendix E. The CO emissions data collected during the testing was calculated as grams per brake horsepower-hour (g/BHp-Hr).

3.3 MOISTURE (ASTM METHOD D6348)

3.3.1 Sampling Method

Moisture content in the exhaust was evaluated using ASTM Method D6348, "Measurement of Vapor Phase Organic Emissions by Extractive Fourier Transform Infrared (FTIR)".

3.4 OXIDES of NITROGEN, CARBON MONOXIDE, and VOC (ASTM METHOD D6348)

3.4.1 Sampling Method

Oxides of Nitrogen, Carbon Monoxide, and VOC emissions were evaluated using ASTM Method D6348, "Measurement of Vapor Phase Organic Emissions by Extractive Fourier Transform Infrared (FTIR)". Single point sampling was performed. Triplicate 60-minute test runs were performed.

The ASTM D6348 sampling system (Figure 2) consisted of the following:

(1) Single-point sampling probe
(2) Flexible heated PTFE sampling line
(3) Air Dimensions Heated Head Diaphragm Pump
(4) MKS MultiGas 2030 FTIR spectrometer
(5) Appropriate calibration gases
(6) Data Acquisition System

The FTIR was equipped with a temperature controlled, 5.11-meter multipass gas cell maintained at 191°C. Gas flows and sampling system pressures were monitored using a rotameter and pressure transducer. All data was collected at 0.5 cm^{-1} resolution.

3.4.2 Sampling Train Calibration

The FTIR was calibrated per procedures outlined in ASTM Method D6348. Direct measurements propane (C_3H_8), oxides of nitrogen (NO_x), carbon monoxide (CO), and ethylene (C_2H_4) gas standards were made at the test location to confirm concentrations.

A calibration transfer standard (CTS) was analyzed before and after testing at each location. The concentration determined for all CTS runs were within ±5% of the certified value of the standard. Ethylene was passed through the entire system to determine the sampling system response time and to ensure that the entire sampling system was leak-free.

Nitrogen was purged through the sampling system at each test location to confirm the system was free of contaminants.

NO_x, CO, and C_3H_8 gas standards were passed through the sampling system at each test location to determine the response time and confirm recovery.

NO_x, CO, and C_3H_8 spiking was performed to verify the ability of the sampling system to quantitatively deliver a sample containing NO_x, CO, and C_3H_8 from the base of the probe to the FTIR. Analyte spiking assures the ability of the FTIR to quantify NO_x, CO, and C_3H_8 in the presence of effluent gas.

As part of the spiking procedure, samples from each EUENGINE1 were measured to determine NO_x, CO, and C_3H_8 concentrations to be used in the spike recovery calculations. The determined sulfur hexafluoride (SF_6) concentration in the spiked and unspiked samples was used to calculate the dilution factor of the spike and thus used to calculate the concentration of the spiked NO_x, CO, and C_3H_8. The following equation illustrates the percent recovery calculation.

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$$DF = \frac{SF_{6(spike)}}{SF_{6(direct)}}$$ (Sec. 9.2.3 (3) ASTM Method D6348)

$$CS = DF * Spike_{dir} + Unspike(1 - DF)$$ (Sec. 9.2.3 (4) ASTM Method D6348)

DF = Dilution factor of the spike gas
$SF_{6(direct)}$ = SF6 concentration measured directly in undiluted spike gas
$SF_{6(spike)}$ = Diluted SF_6 concentration measured in a spiked sample
$Spike_{dir}$ = Concentration of the analyte in the spike standard measured by the FTIR directly
CS = Expected concentration of the spiked samples
Unspike = Native concentration of analytes in unspiked samples

All analyte spikes were introduced using an instrument grade stainless steel rotometer. The spike target dilution ratio was 1:10 or less. All NO_x, CO, and C_3H_8 spike recoveries were within the ASTM Method D6348 allowance of ±30%.

3.4.3 Quality Control and Assurance

As part of the 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 software-generated results. The data is then validated if the two concentrations are within ± 5% agreement. If there is a difference greater than ± 5%, the spectra are reviewed for possible spectral interferences or any other possible causes that might lead to inaccurately quantified data. PRISM Analytical Technologies, Inc. validated FTIR data from all three of the sources. The data validation reports are in Appendix F.

3.4.4 Data Reduction

Each spectrum was derived from the coaddition of 64 scans, with a new data point generated approximately every minute. The NO_x, CO, and VOC emissions were recorded in parts per million (ppm) dry volume basis. The moisture content was recorded in percent (%).

FTIR Manufacture software calculated total non-methane- non-ethane VOC by summing the hydrocarbons measured, multiplied by each compounds' molar ratio to propane. VOCs measured consist of Propane, Butane, Ethylene, Acetylene, Propylene, Acetaldehyde, and Methanol.

Emissions readings on the inlet and outlet of the EUENGINE1 catalysts were reduced to parts by million by volume, dry, adjusted to 15% O_2 in accordance with 40 CFR Part 63 Subpart ZZZZ. The outlet concentration was divided by the inlet concentration to calculate percent destruction efficiency.

4.0 OPERATING PARAMETERS

For each test period, operators took screenshots of the process collection software. Once at the beginning and once at the end of a test period. Process data includes fuel flow (100scf/hr), catalyst pre and post temperature (°F), pressure drop across the catalyst ("H_2O), Brake-HP, and torque.

Operational data is in Appendix D.

5.0 DISCUSSION OF RESULTS

The Results of the NO_x, CO, and VOC testing for EUENGINE1 are presented in Tables 1-2. The NO_x, CO, and VOC emissions are presented in parts per million (ppm) and grams per brake horsepower-hour (g/Bhp-Hr). Process data presented includes the Unit load in percent (%), EUENGINE1 Torque in brake horsepower-hour (Brake-Hp), and Heat Input in Million British Thermal Unit per hour (MMBtu/hr) for each test.

The results of the testing indicate that EUENGINE1 meet the emissions limits established in Michigan Renewable Operating Permit MI-ROP-N7421-2022, 40 CFR Part 60 Subpart JJJJ, and 40 CFR Part 63 Subpart ZZZZ.

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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."

Mr. Mark Grigereit, QSTI

This report prepared by:

Mr. Mark Grigereit, QSTI
Principal Engineer, Ecology, Monitoring, and Remediation Group
Environmental Management and Safety
DTE Energy Corporate Services, LLC

This report reviewed by:

Mr. Thomas Snyder, QSTI
Senior Env. Specialist, Ecology, Monitoring, and Remediation Group
Environmental Management and Safety
DTE Energy Corporate Services, LLC

RESULTS TABLES

Gaseous Emissions Testing Results
EUENGINE1 (Unit 1100)
DTE Energy, Willow Compressor Station
Ypsilanti, Michigan

Parameter	Run 1	Run 2	Run 3	Average
Sampling Date	03/21/24	03/21/24	03/21/24	
Sampling Start Time	12:43	13:59	15:09	
Sampling End Time	13:43	14:59	16:09	
Gross Dry BTU	1078	1078	1078	
Load (%)	95.5%	94.4%	94.9%	
RPM	999	999	998	998
Brake-HP	4,524	4,471	4,492	4,496
Fuel Flow (100 scf/hr)	280.5	278.3	279.5	279.5
Heat Input Rate (MMBtu/Hr)	30.2	30.0	30.1	30.1
Average Inlet O_2 Content (%, dry)	11.9	11.9	11.9	11.9
Average Inlet O_2 Content (%, dry, corrected)[1]	11.9	11.9	11.9	11.9
Average Outlet O_2 Content (%, dry)	12.0	11.9	11.9	12.0
Average Outlet O_2 Content (%, dry, corrected)[1]	12.1	12.0	12.0	12.0
Average Inlet CO Concentration (ppmv, dry)	401.5	403.6	404.4	
Average Inlet CO Concentration (ppmv, dry, corrected)[1]	402.6	406.4	407.5	405.5
Average Inlet CO Concentration (ppmv, dry, corrected) @ 15% O2	263.9	266.3	267.1	
Average Inlet CO Concentration (lb/MMBtu)	0.59	0.60	0.60	0.60
Average Inlet CO Emission Rate (lb/hr, dry)	17.89	17.92	18.05	17.95
Inlet CO Emission Rate (gram/BHP-Hr, dry)	**1.79**	**1.82**	**1.82**	**1.81**
Average Outlet CO Concentration (ppmv, dry)	7.4	6.7	6.6	6.9
Average Outlet CO Concentration (ppmv, dry, corrected) @ 15% O2	5.0	4.4	4.4	4.6
AverageOutlet CO Concentration (lb/MMBtu)	0.01	0.01	0.01	0.01
Average Outlet CO Emission Rate (lb/hr, dry)	0.34	0.30	0.30	0.31
Outlet CO Emission Rate (gram/BHP-Hr, dry)	**0.03**	**0.03**	**0.03**	**0.03**
CO Control Effeciency (%)	**98.1%**	**98.3%**	**98.4%**	**98.3%**
Average Outlet NO_x Concentration (ppmv, dry)	50.0	52.3	53.5	51.9
Average Outlet NO_x Concentration (ppmv, dry) @ 15% O2	33.4	34.8	35.5	34.5
Average Outlet NO_x Concentration (lb/MMBtu)	0.12	0.13	0.13	0.13
Average Outlet NO_x Emission Rate (lb/hr, dry)	3.72	3.84	3.94	3.83
NO_x Emission Rate (gram/BHP-Hr, dry)	**0.37**	**0.39**	**0.40**	**0.39**

[1]corrected for analyzer drift as per USEPA Method 7E

O_2 : oxygen

CO : carbon monoxide

Gaseous Emissions Testing Results
EUENGINE1 (Unit 1100)
DTE Energy, Willow Compressor Station
Ypsilanti, Michigan

Parameter	Run 1	Run 2	Run 3	Average
Sampling Date	03/21/24	03/21/24	03/21/24	
Sampling Start Time	12:43	13:59	15:09	
Sampling Start Time	13:43	14:59	16:09	
Gross Dry BTU	1078	1078	1078	1078
Load (%)	95.5%	94.4%	94.9%	94.9%
RPM	999	999	998	998
Brake-HP	4,524	4,471	4,492	4,496
Fuel Flow (100 scf/hr)	280.5	278.3	279.5	279.5
Heat Input Rate (MMBtu/Hr)	30.2	30.0	30.1	30.1
Average Outlet O_2 Content (%, dry, corrected)[1]	12.1	12.0	12.0	12.0
THC Concentration (ppmv, as propane, dry corrected)[2]	8.53	8.50	8.7	8.6
THC Concentration (ppmv, as propane, dry corrected) @15% O2	5.70	5.65	5.76	5.70
THC Concentration (lb/MMBtu)	0.02	0.02	0.02	0.02
THC Emission Rate (lb/hr)	0.61	0.60	0.61	0.61
THC Emission Rate (gram/BHP-Hr)	**0.06**	**0.06**	**0.06**	**0.06**

[1]corrected for analyzer drift as per USEPA Method 7E

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FIGURES

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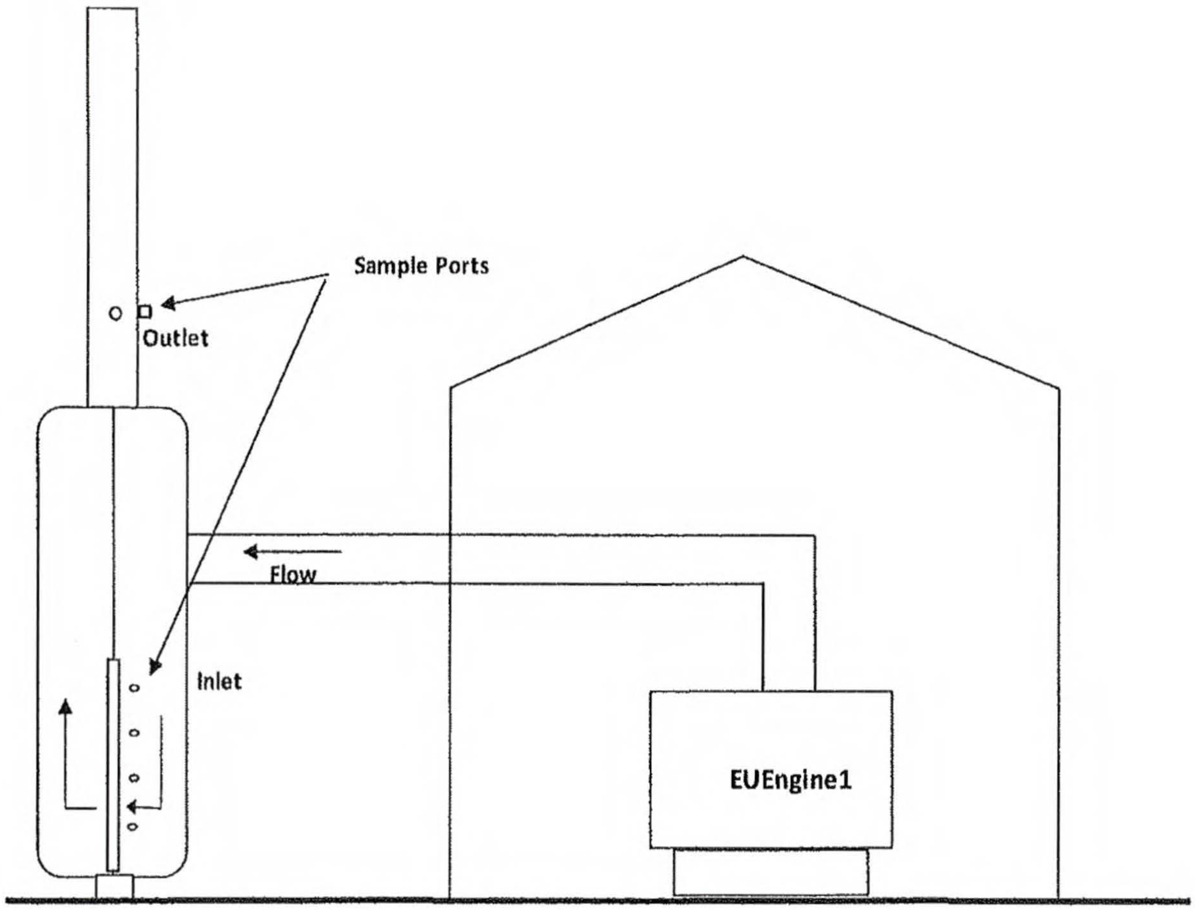
Figure 1 – Sampling Location
Willow Compressor Station
March 2024



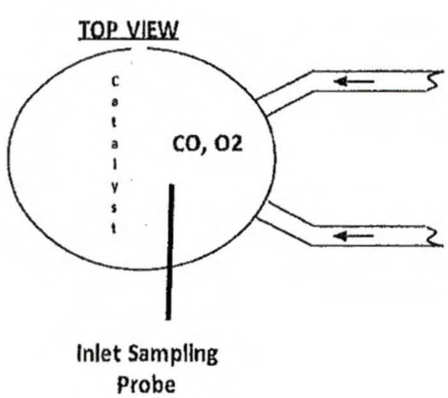


Figure 2 – EPA Methods 3A/10
Willow Compressor Station
March 2024

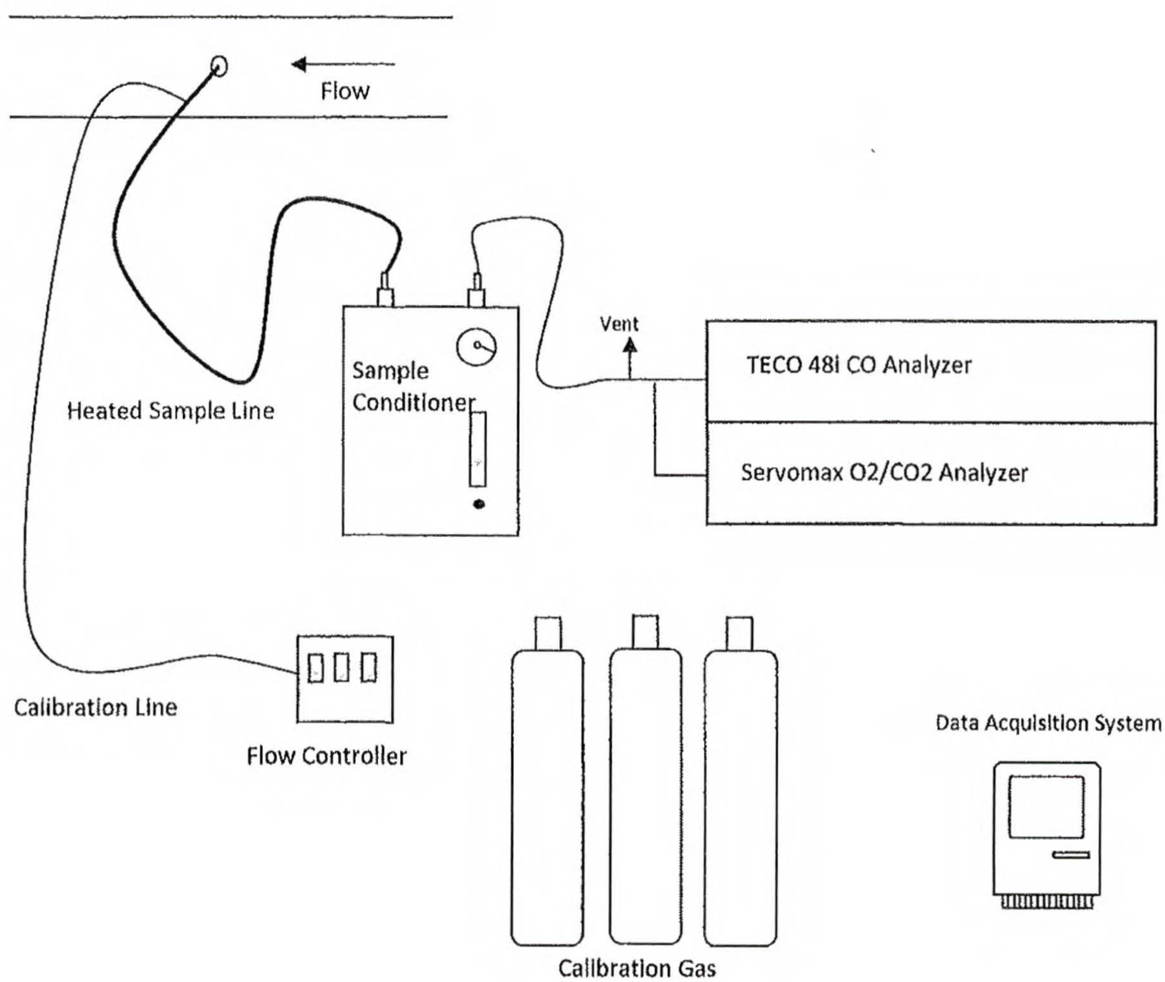
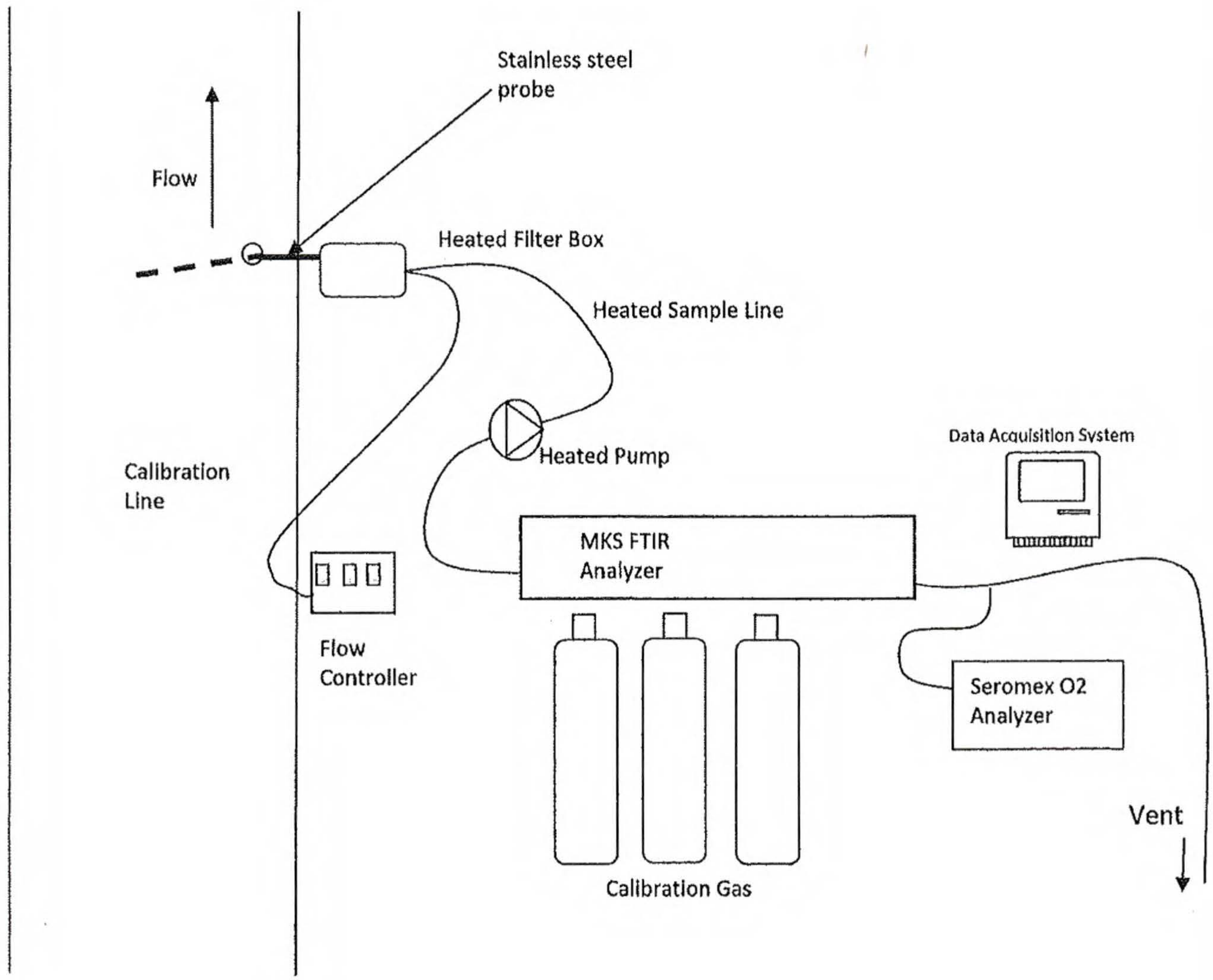


Figure 3 – ASTM D6348/ 3A
EUENGINE1
Willow Run Compressor Station
March 2024



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