EMISSIONS TEST REPORT

for

OXIDES OF NITROGEN (NO_X), CARBON MONOXIDE (CO), AND VOLATILE ORGANIC COMPOUNDS (VOC)

Willow Run Compressor Station – EUENGINE1

DTE GAS

WILLOW RUN COMPRESSOR STATION
Ypsilanti, Michigan

October 21, 2021

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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 was performed on October 21, 2021, to satisfy requirements of the Michigan Department of Environment, Great Lakes and Energy (EGLE) Permit to Install (PTI) No. 246-07A and 40CFR Part 60 Subpart JJJJ. Emissions tests were performed on the Engine 1100 (EUENGINE1) for oxides of nitrogen (NO_x), carbon monoxide (CO), and volatile organic compounds (VOC).

The results of the emissions testing are highlighted below:

Emissions Testing Summary -- Engine 1100
Willow Run Compressor Station
Ypsilanti, MI
October 21, 2021

	Oxides of Nitrogen (gram/BHP_d)	Oxides of Nitrogen (DE)	Carbon Monoxide (gram/BHP_d)	Volatile Organic Compounds (gram/BHP_d)
EUENGINE1	0.47	99.0	0.02	0.03
Permit Limit	0.9	93	2.5	1.0

ND – non detect

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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 was performed on October 21, 2021, to satisfy requirements of the Michigan Department of Environment, Great Lakes and Energy (EGLE) Permit to Install (PTI) No. 246-07A and 40CFR Part 60 Subpart JJJJ. Emissions tests were performed on the Engine 1100 (EUENGINE1) for oxides of nitrogen (NO_x), carbon monoxide (CO), and volatile organic compounds (VOC).

Testing was performed pursuant to Title 40, *Code of Federal Regulations*, Part 60, Appendix A (40 CFR §60 App. A), Methods 3A, 4, 7E, 10, 19, 25A, and ASTM D6348.

The fieldwork was performed in accordance with EPA Reference Methods, ASTM Methods and EM&S's Intent to Test[1], which was approved by EGLE[2]. The following EM&S personnel participated in the testing program: Mr. Mark Grigereit, Principal Engineer, and Mr. Thomas Snyder, Sr. Environmental Specialist, and Mr. Fred Meinecke, Environmental Specialist. Mr. Grigereit was the project leader.

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 in PTI 44-16B (flexible group FGENGINES and FGENGMACT4Z) and EUENGINE1 in PTI 246-07A (flexible group FGENGMACT4Z). The compressor turbine is identified as EUTURBINE1 in PTI 44-16B. 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 into and out of the gas storage field as well as to and from the pipeline transmission system.

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 atmospheric conditions, as it affects the density of air, limit the speed and torque at which the engine can effectively operate.

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[1] DTE Test Plan, Submitted January 22, 2021. (Attached-Appendix A)

[2] EGLE, Acceptance Letter, March 26, 2021. (Attached-Appendix A)

The turbine is equipped with low-NO_x burners and exhausts directly to the atmosphere through a dedicated vertical exhaust stack.

Each unit operates on an as needed basis providing pipeline pressure. Each engine was tested at 100% (+/- 10%) rated capacity to meet PTI and National Emissions Standards for Hazardous Air Pollutants (NESHAP) testing requirements. The turbine was tested at a minimum of 75% rated capacity, or the highest load point if 75% is not achievable, in accordance with New Source Performance Standards (NSPS) requirements.

A schematic representation of EUENGINE1 (Engine 1100) 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	O_2	Paramagnetic Analyzer
USEPA Method 4	Moisture Content	Weight Gain in Chilled Impingers
USEPA Method 7E	Nitrogen Oxides	Chemiluminescent Analyzer
USEPA Method 10	Carbon Monoxide	NDIR Analyzer
USEPA Method 19	Mass Emissions Calculations	Heat Input
USEPA Method 25A	Total Hydrocarbons	FID
ASTM D6348	Methane and Ethane	FTIR

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3.1 MOISTURE (USEPA METHOD 4)

3.1.1 Sampling Method

Determination of the moisture content of the exhaust gas was performed using USEPA Method 4, "Determination of Moisture Content in Stack Gases". The moisture was collected in glass impingers, and the percentage of water was then derived from calculations outlined in USEPA Method 4. Thirty-minute moisture tests were conducted in conjunction with each gaseous emissions test.

The EPA Method 4 sampling system consisted of the following:

(1) Stainless-steel sample probe (located in centroid of the exhaust stack)
(2) Unheated flexible line
(3) Set of four (4) Greenburg-Smith (GS) glass impingers:
    a. The first and second each containing 100 milliliters (mL) of water
    b. The third impinger dry
    c. The fourth impinger containing approximately 300 grams of silica gel desiccant
(4) Environmental Supply® control case equipped with a pump, dry gas meter, and calibrated orifice

Upon completion of each test, the impinger volumes were measured to determine moisture content of the gas stream using the calculations found in USEPA Method 4. After measuring and recording the liquid volumes, the solution was discarded.

Field data sheets for the Method 4 are in Appendix B.

3.1.2 Quality Control and Assurance

All sampling and analytical equipment was calibrated according to the guidelines referenced in EPA Method 5. Calibration data is provided in Appendix C.

3.2 CARBON DIOXIDE AND OXYGEN (USEPA METHOD 3A)

3.2.1 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 analyzers utilize paramagnetic sensors. 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 exhaust stack)
(2) Heated PTFE sampling line
(3) MAK® gas conditioner with particulate filter
(4) Flexible unheated PTFE sampling line
(5) Servomex 1400 O_2/CO_2 gas analyzer
(6) Appropriate USEPA Protocol 1 calibration gases
(7) Data Acquisition System

3.2.2 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 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 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.

3.2.4 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 are in Appendix B.

3.3 NITROGEN OXIDES AND CARBON MONOXIDE (USEPA METHODS 7E AND 10)

3.3.1 Sampling Method

Nitrogen oxide (NO_x) emissions were evaluated using USEPA Method 7E, "Determination of Oxides of Nitrogen Emissions from Stationary Sources". The NO_x analyzer utilizes a chemiluminescent detector. Carbon monoxide (CO) emissions were evaluated using USEPA Method 10, "Determination of Carbon Monoxide Emissions from Stationary Sources". The CO analyzer utilizes a non-dispersive infrared (NDIR) detector. Triplicate 60-minute tests were performed on the engine exhaust.

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

(1) Stainless-steel sample probe (traversed across the exhaust stack)
(2) Heated PTFE sampling line
(3) MAK® gas conditioner with particulate filter

(4) Flexible unheated PTFE sampling line
(5) TECO 42i Chemilumenecent NO/NO_x gas analyzer, and TECO 48i NDIR CO gas analyzer
(6) Appropriate USEPA Protocol 1 calibration gases
(7) Data Acquisition System.

3.3.2 Sampling Train Calibration

The NO_x / CO sampling train was calibrated according to procedures outlined in USEPA Method 7E and 10. Zero, span, and mid-range calibration gases were introduced directly into each analyzer to verify the instruments linearity. A zero and mid-range gas for each pollutant was then introduced through the entire sampling system to determine sampling system bias for each analyzer at the completion of each test.

3.3.3 Quality Control and Assurance

All sampling and analytical equipment was calibrated according to the guidelines referenced in Methods 7E and 10. 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.

DTE performed a NO_x converter efficiency test by directly challenging the NO_x analyzer with a nitrogen dioxide (NO_2) calibration gas of 50.6 ppm. The instrument measured 47.4 ppm, or 95.0% of 49.9, which satisfies the conversion efficiency requirement in USEPA Method 7E.

3.3.4 Data Reduction

Data collected during the emissions testing was recorded at 10-second intervals and averaged in 1-minute increments. The NO_x and CO emissions were recorded in parts per million, dry (ppmvd). The 1-minute readings collected are in Appendix B.

Emissions calculations, based on calculations located in USEPA Methods 7E, 10, and 19, are in Appendix E. The NO_x and CO emissions data collected during the testing was reduced to parts per million corrected to 15% oxygen on a dry basis (ppmvd @ 15% O_2) and grams per Brake Horsepower (gram/BHP-hr).

3.4 MASS EMISSIONS (USEPA METHOD 19)

3.4.1 Sampling Method

Pollutant mass emissions were calculated using procedures used in USEPA Method 19. The CO analyzer utilizes non-dispersive infrared (NDIR) technology. Fuel flow (scf) was recorded during each test period and reduced to scf/hr. The facility provided fuel heat content (btu/scf) at the start of the test day.

Sample emissions calculations are presented in Appendix E.

3.5 TOTAL HYDROCARBON COMPOUNDS (USEPA METHOD 25A)

3.5.1 Sampling Method

Total hydrocarbon compound (THC) emissions were evaluated using USEPA Method 25A, "Determination of Total Gaseous Organic Concentration Using a Flame Ionization Analyzer". The THC analyzer utilizes a flame ionization detector (FID). The FID measures total hydrocarbon compounds (including Methane and Ethane). Triplicate 60-minute tests were performed on the engine exhaust.

The Method 25A sampling system (Figure 3) consisted of the following:

(1) Single-point sampling probe
(2) Heated PTFE sampling line
(3) JUM 109A® Total Hydrocarbon gas analyzer
(4) Appropriate USEPA Protocol 1 calibration gasses
(5) Data Acquisition System

3.5.2 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.

3.5.3 Quality Control and Assurance

The THC sampling equipment was calibrated with propane (C_3H_8) per 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 80-90% of span). Calibration gas certification sheets are in Appendix C.

3.5.4 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 are in Appendix B.

THC concentrations were converted from wet to dry, then adjusted to 15% oxygen. Methane and ethane concentrations (by FTIR, Section 3.7) were also converted from wet to dry at a propane standard, then adjusted to 15% oxygen. The dry, adjusted methane and ethane concentrations were subtracted from the dry, adjusted THC

concentration to calculate NMNEOC concentration for comparison to the NSPS emission limits.

3.6 METHANE AND ETHANE CONCENTRATION (ASTM METHOD D6348)

3.6.1 Sampling Method

Methane and ethane emissions were evaluated using a modified ASTM Method D6348, "Determination of Gaseous Compounds by Extractive Direct Interface Fourier Transform Infrared (FTIR) Spectroscopy". DTE personnel collected exhaust gas in a 10-liter Tedlar™ bag, which was then analyzed at an off-site laboratory via FTIR. 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 sampling system followed the procedures specified in Method 18 Section 8.2.1, Integrated Bag Sampling & Analysis.

The sampling system (Figure 5) consisted of the following:

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

3.6.2 Sampling Train Calibration

The FTIR was calibrated according to procedures outlined in ASTM Method D6348. Nitrogen, propane, methane, and ethylene gas standards were injected pre and post sample analysis to confirm concentrations.

3.6.3 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 methane and ethane were converted dry, at a propane standard, to subtract from the THC measured in the field. Units were reduced to NMNEOC ppmvd at 15% O_2 and grams per Brake Horsepower (gram/BHP-hr) for comparison to the NSPS emission standard.

Operational data is in Appendix F.

4.0 OPERATING PARAMETERS

The test program included the collection of engine torque (Hp), engine speed (RPM), inlet and exhaust catalyst temperature (°F) catalyst differential pressure (psi), fuel upper heating value (BTU), and fuel flow (100 scfh).

Operational data is in Appendix D.

5.0 DISCUSSION OF RESULTS

Table No. 1 presents the emission testing results from EUENGINE1 while operating at greater than 90% of full load conditions. Additional test data presented for each test includes the engine load in percentage (%), heat input (MMBtu/hr), and emissions (ppm). EUENGINE1 demonstrated compliance with NO_X, CO, and VOC emission limits as stated in Permit to Install No. 246-07A and the NSPS (40 CFR Part 60 Subpart JJJJ).

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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 1100 Exhaust Stack
October 21, 2021

Test	Test Date	Test Time	Unit Load (%)	Engine Speed (RPM)	Engine Torque (Brake-hp)	Fuel Flow (100 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	**21-Oct-21**	8:58-9:58	97	974	4,490	285.7	30.1	0.48	0.03	98.8
2		10:25-11:25	95	975	4,372	278.7	29.4	0.48	ND	99.0
3		11:37-12:37	94	976	4,358	277.5	29.3	0.46	ND	99.1
	Average:		*95*	*975*	*4,407*	*280.6*	*29.6*	*0.47*	*0.03*	*99.0*

(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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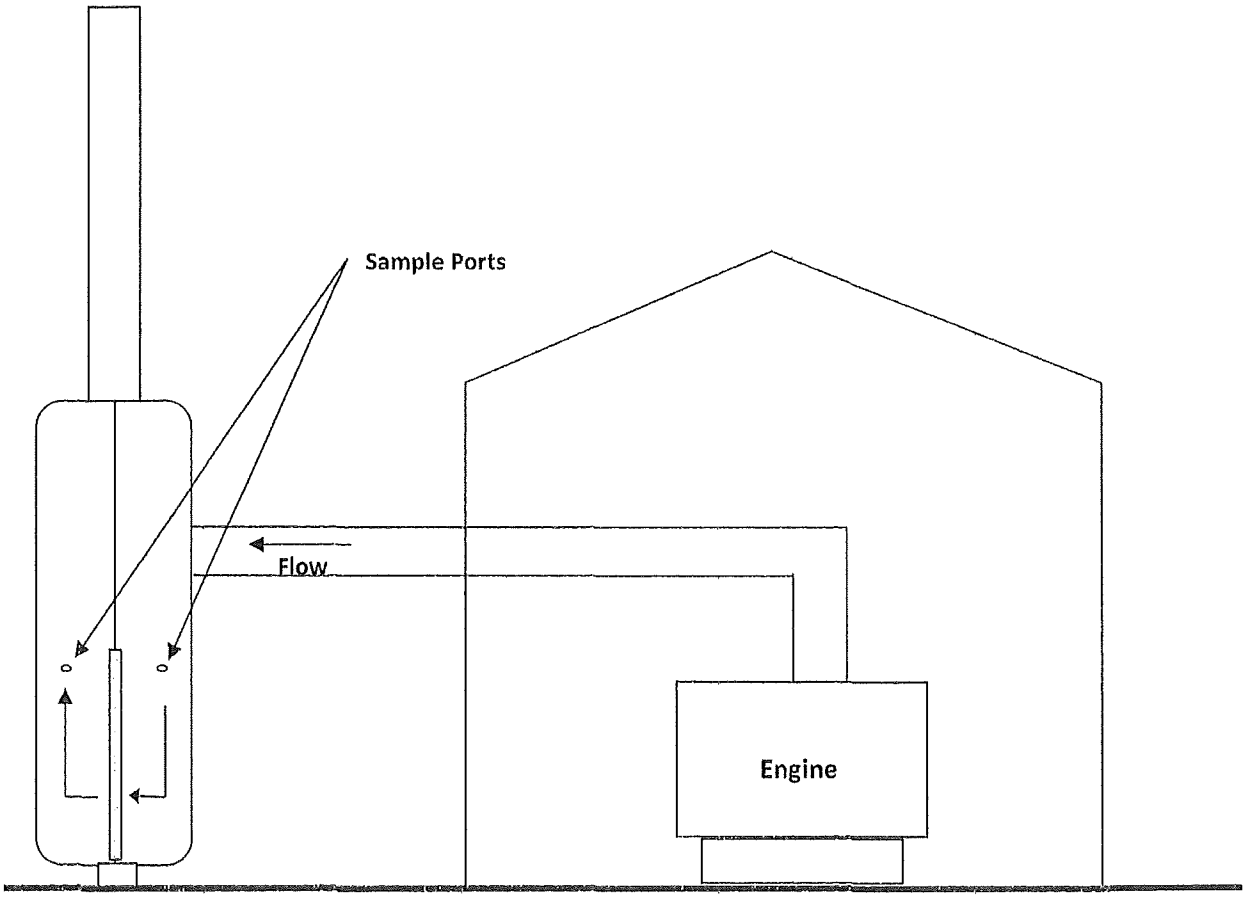
Figure 1 – Sampling Location
Willow Compressor Station
October 21, 2021



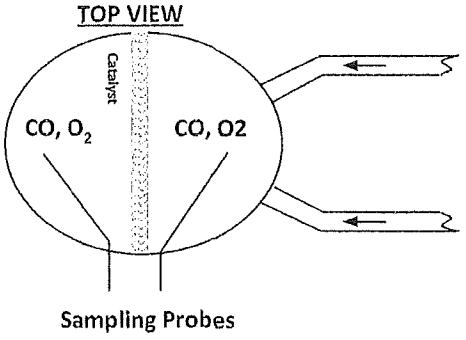


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Figure 2 – EPA Methods 3A/7E/10
Willow Compressor Station
October 21, 2021

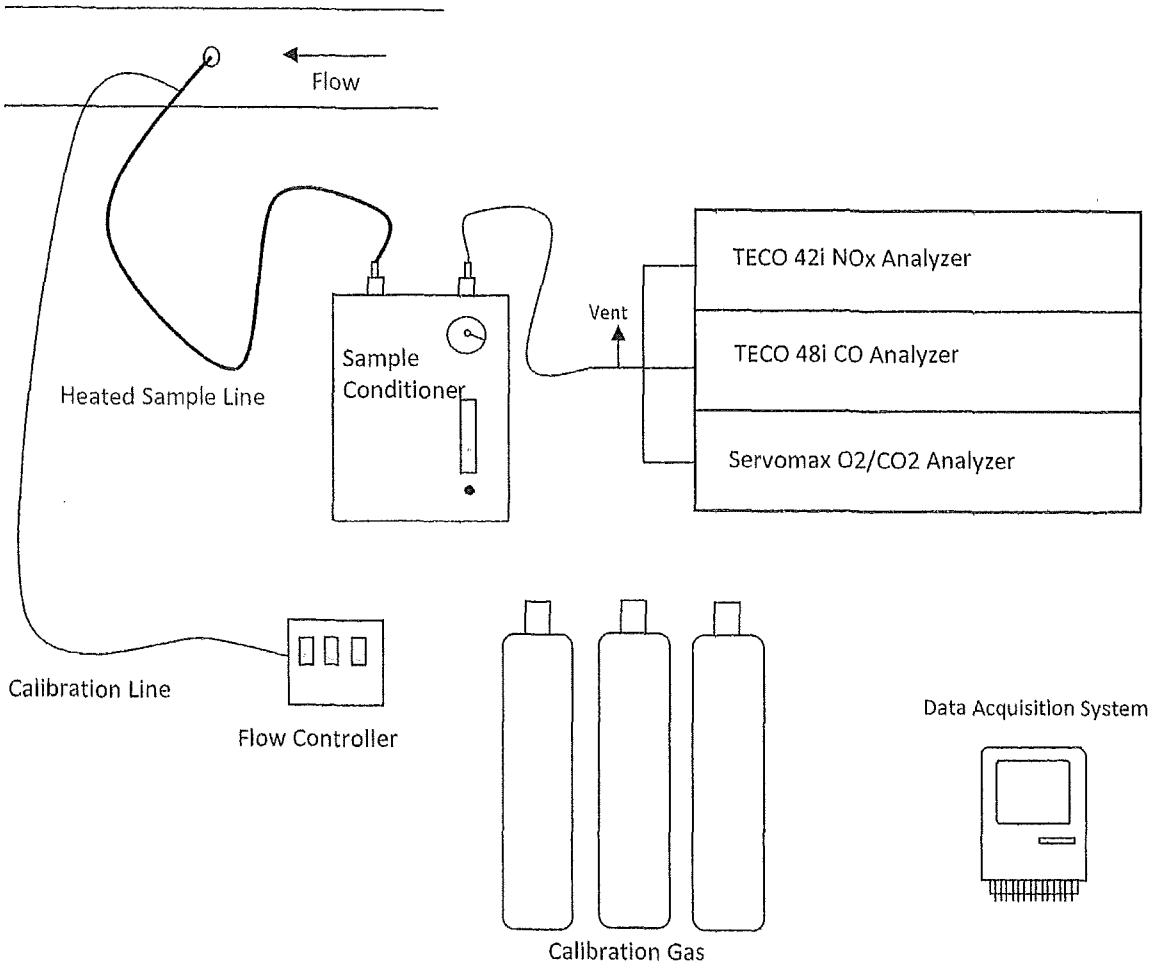

Figure 3 – EPA Method 25A
Willow Compressor Station
October 21, 2021

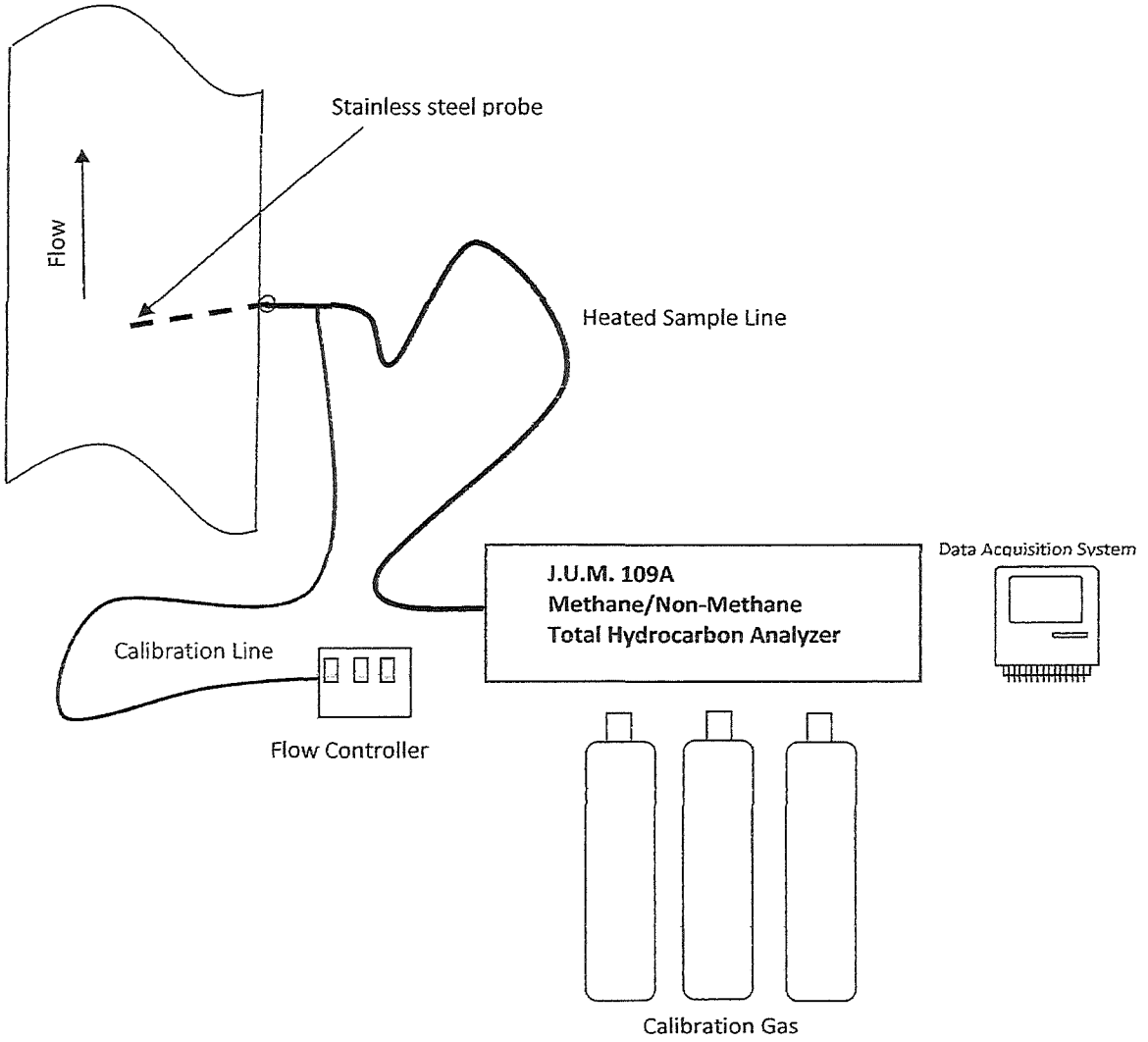

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Figure 4 – EPAethod 4
Willow Compressor Station
October 21, 2021

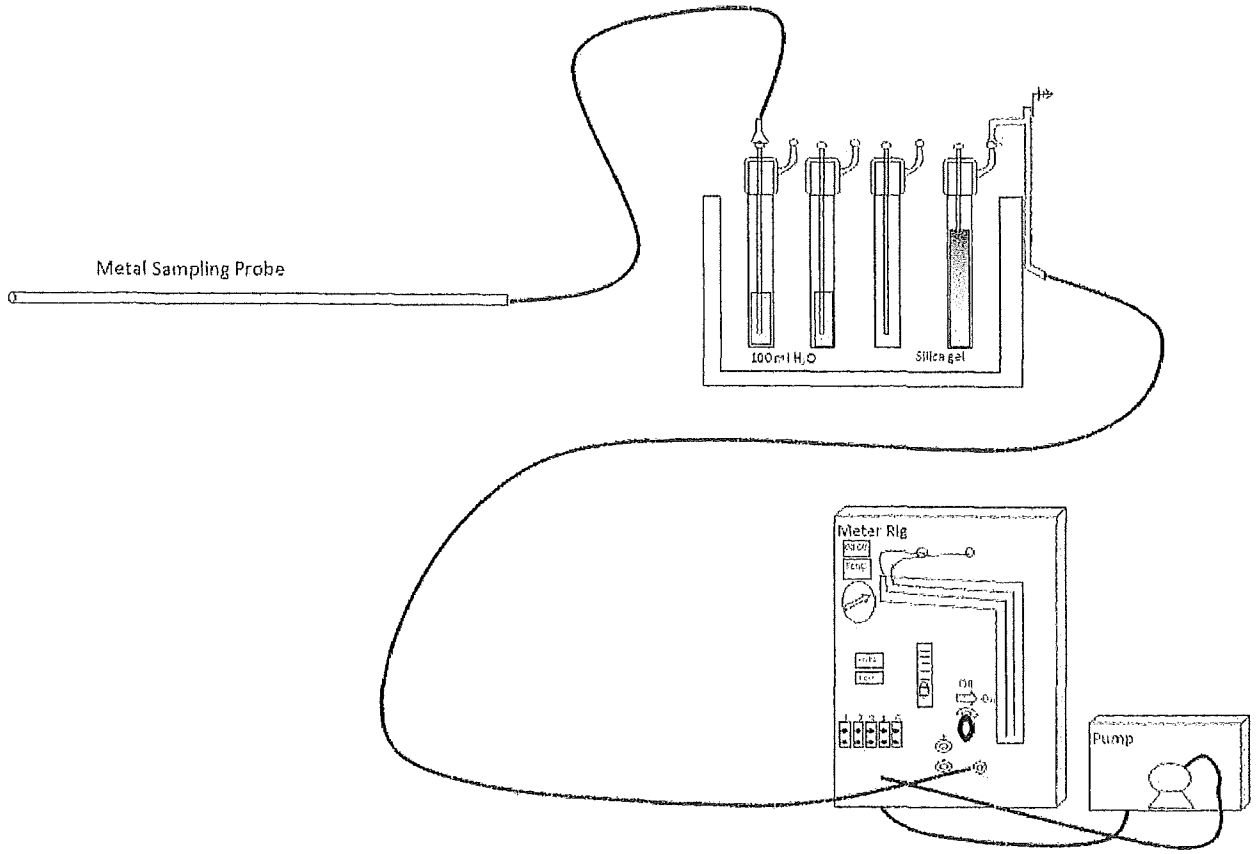

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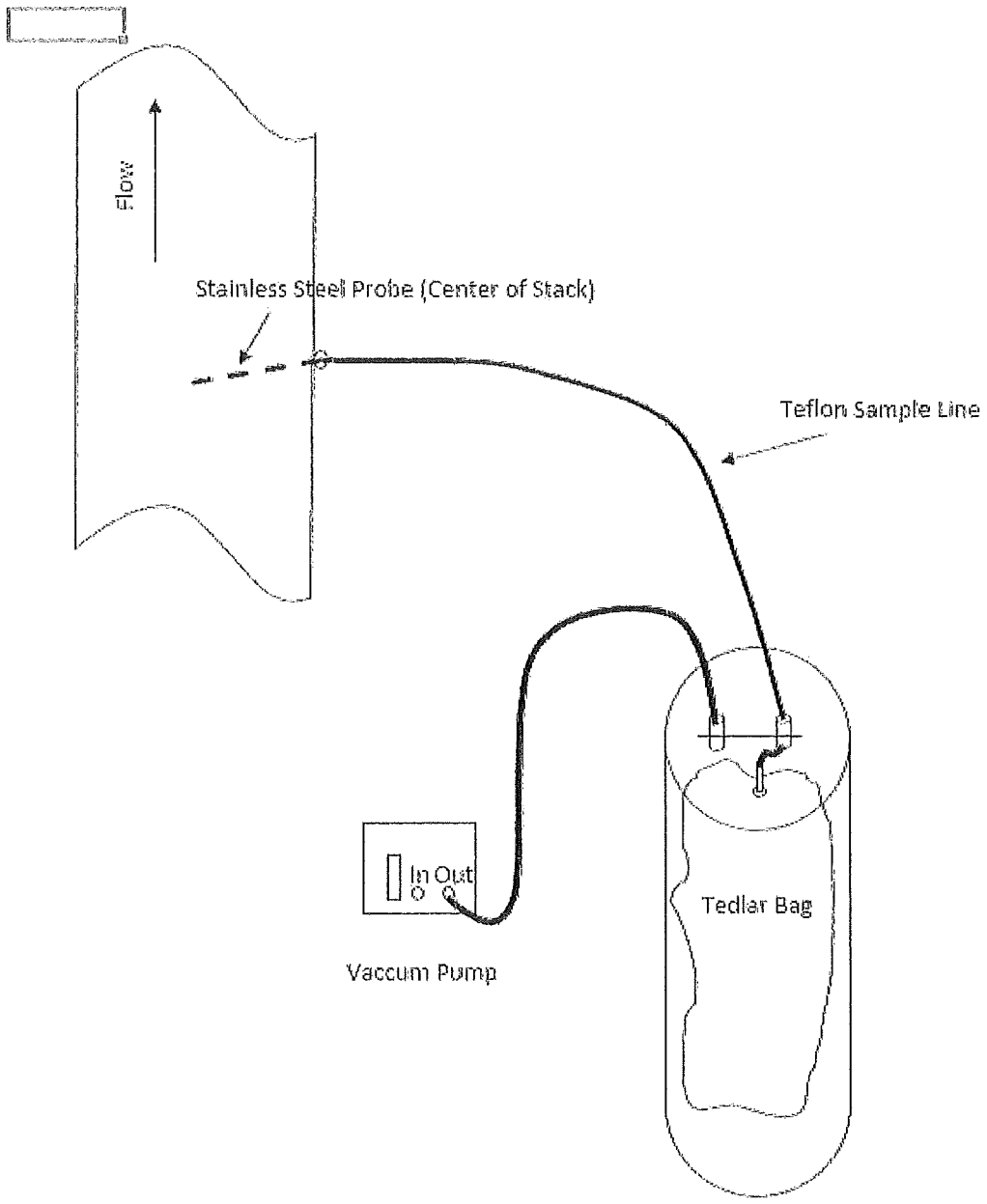
Figure 5 – EPA Method 18
Willow Compressor Station
October 21, 2021



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APPENDIX A

EGLE TEST PLAN