

EMISSIONS TEST REPORT

for

OXIDES OF NITROGEN (NO_x), CARBON MONOXIDE (CO) AND NON-METHANE ORGANIC COMPOUNDS (NMOC)

UNIT 1100

DTE-Gas Willow Compressor Station
Ypsilanti, Michigan

June 20, 2018

RECEIVED

AUG 01 2018

AIR QUALITY DIVISION

Prepared By
Environmental Management & Resources
Environmental Field Services Group
DTE Corporate Services, LLC
7940 Livernois H-136
Detroit, MI 48210

DTE Energy®





CONTENTS

<u>Section</u>	<u>Page</u>
EXECUTIVE SUMMARY.....	IV
1.0 INTRODUCTION	1
2.0 SOURCE DESCRIPTION	1
3.0 SAMPLING AND ANALYTICAL PROCEDURES.....	2
3.1 OXYGEN (USEPA METHOD 3A)	2
3.1.1 Sampling Method.....	2
3.1.2 Sampling Train Calibration	3
3.1.3 Quality Control and Assurance.....	3
3.1.4 Data Reduction.....	3
3.2 CARBON MONOXIDE (USEPA METHOD 10).....	3
3.2.1 Sampling Method.....	3
3.2.2 Sampling Train Calibration	3
3.2.3 Quality Control and Assurance.....	4
3.2.4 Data Reduction.....	4
3.3 VOLATILE ORGANIC COMPOUNDS (USEPA METHOD 25A).....	4
3.3.1 Sampling Method.....	4
3.3.2 Sampling Train Calibration	5
3.3.3 Quality Control and Assurance.....	5
3.3.4 Data Reduction.....	5
3.4 MOISTURE (ASTM METHOD D6348).....	5
3.4.1 Sampling Method.....	5
3.5 OXIDES OF NITROGEN, CARBON MONOXIDE, METHANE, AND ETHANE (ASTM METHOD D6348).....	5
3.5.1 Sampling Method.....	5
3.5.2 Sampling Train Calibration	6
3.5.3 Quality Control and Assurance.....	7
3.5.4 Data Reduction.....	7
4.0 OPERATING PARAMETERS	8
5.0 DISCUSSION OF RESULTS.....	8
6.0 CERTIFICATION STATEMENT	9



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 June 20, 2018 was conducted to satisfy requirements of the Michigan Permit to Install No. 246-07. Emission testing was performed on Unit 1100 for oxides of nitrogen (NO_x), carbon monoxide (CO) and non-methane organic compounds (NMOC).

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

**NO_x, CO and NMOC Emissions Test Results
Willow Compressor Station – Unit 1100
Ypsilanti, Michigan
June 20, 2018**

	BHp (%)	Oxides of Nitrogen (gram/B-Hp)	Carbon Monoxide (gram/B-Hp)	Carbon Monoxide (DE)	NMOC (gram/B-Hp)
Unit 1100	4,310	0.39	0.02	98.6%	ND
Permit Limit		0.9	2.5	>93%	1.0

ND = Non-Detect



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 June 20, 2018, was conducted to satisfy requirements of the Michigan Permit to Install No. 246-07. Emission testing was performed on Unit 1100 for oxides of nitrogen (NO_x), carbon monoxide (CO) and non-methane organic compounds (NMOC).

Testing was performed pursuant to Title 40, *Code of Federal Regulations*, Part 60, Appendix A (40 CFR §60 App. A), Methods 3A, 10, 19, 25 and ASTM D6348A.

The fieldwork was performed in accordance with EPA Reference Methods and EMR's Intent to Test¹, Test Plan Submittal. The following EM&R Field Services personnel participated in the testing program: Mr. Mark Grigereit, Principal Engineer and Mr. Thomas Snyder, Environmental Specialist. Mr. Grigereit was the project leader. Ms. Regina Hines and Mr. Zachary Durham with the Air Quality Division of the Michigan Department of Environmental Quality (MDEQ) witnessed the testing. Ms. Hines and approved the Test Plan².

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 (Unit 1100). 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.

¹ MDEQ, Test Plan, Submitted May 3, 2018. (Attached-Appendix A)

² MDEQ, Approval Letter, Received May 23, 2018. (Attached-Appendix A)



A schematic representation of the engine 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	NDIR
USEPA Method 25A	Non-Methane Organic Compounds	FID (w/Cutter) Instrumental Analyzer Method
ASTM Method D6348	NO _x , CO, Methane, Ethane, and Moisture Content	FTIR

3.1 OXYGEN (USEPA METHOD 3A)

3.1.1 Sampling Method

Oxygen (O₂) 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 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 1400 O₂/CO₂ gas analyzer
- (6) Appropriate USEPA Protocol 1 calibration gases
- (7) Data Acquisition System



3.1.2 Sampling Train Calibration

The O₂ 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 O₂ 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 Unit 4-6 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 engine 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 located 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 VOLATILE ORGANIC COMPOUNDS (USEPA METHOD 25A)

3.3.1 Sampling Method

volatile organic compound (VOC) emissions were evaluated using USEPA Method 25A, "Determination of Total Hydrocarbon Emissions from Stationary Sources (Instrumental Analyzer Method)". The VOC analyzer utilizes a flame ionization detector (FIDs).

Triplicate 60-minute tests were performed on each 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 (located in centroid of the exhaust stack)
- (2) Heated Teflon™ sampling line
- (3) JUM 109A® Total Hydrocarbon gas analyzer
- (4) Appropriate certified methane calibration gases
- (5) pDaqview® Data Acquisition System



3.3.2 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.

3.3.3 Quality Control and Assurance

The VOC sampling equipment was calibrated 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 80-100% of span). Analyzer calibrations and calibration gas certification sheets are in Appendix C.

3.3.4 Data Reduction

Data collected during the emissions testing was recorded at 10-second intervals and averaged in 1-minute increments. The VOC emissions were recorded in parts per million (ppm) as propane (C₃H₈). The 1-minute readings collected can be found in Appendix B.

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

3.4 MOISTURE (ASTM METHOD D6348)

3.4.1 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)".

3.5 OXIDES of NITROGEN, CARBON MONOXIDE, METHANE, AND ETHANE (ASTM METHOD D6348)

3.5.1 Sampling Method

Oxides of Nitrogen, Carbon Monoxide, Methane, and Ethane 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 rotometer and pressure transducer. All data was collected at 0.5 cm^{-1} resolution.

3.5.2 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 $\pm 5\%$ 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 engine 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.



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

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

DF = Dilution factor of the spike gas

$SF_{6(\text{direct})}$ = SF₆ concentration measured directly in undiluted spike gas

$SF_{6(\text{spike})}$ = Diluted SF₆ 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 C₃H₈ spike recoveries were within the ASTM Method D6348 allowance of ±30%.

3.5.3 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 two of the sources (one from each engine type). The data validation reports are in Appendix F.

3.5.4 Data Reduction

Each spectrum was derived from the coaddition of 64 scans, with a new data point generated approximately every one 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 (%).



4.0 OPERATING PARAMETERS

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

Operational data is located in Appendix D.

5.0 DISCUSSION OF RESULTS

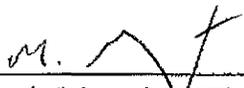
The Results of the NO_x, CO and NMOC testing for Unit 1100 are presented in Table 1. The NO_x and NMOC emissions are presented in ppm and g/Bhp-Hr. The CO emissions are presented in ppm, g/Bhp-Hr, and Destruction Efficiency (%). Process data presented includes the Unit load (%), Engine Torque (Brake-hp), and Heat Input (MMBtu/hr) for each test.

The results of the testing indicate that Unit 1100 meets the emissions limits established in Michigan Permit to Install No. 246-07.

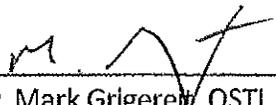


6.0 CERTIFICATION STATEMENT

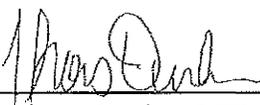
"I certify that I believe the information provided in this document is true, accurate, and complete. Results of testing are based on the good faith application of sound professional judgment, using techniques, factors, or standards approved by the Local, State, or Federal Governing body, or generally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



Mark Grigeret, QSTI

This report prepared by: 

Mr. Mark Grigeret, QSTI
Principal Engineer, Field Services Group
Environmental Management and Resources
DTE Energy Corporate Services, LLC

This report reviewed by: 

for Mr. Thom Snyder, QSTI
Environmental Specialist, Field Services Group
Environmental Management and Resources
DTE Energy Corporate Services, LLC

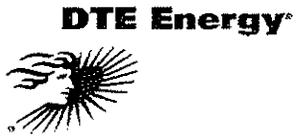


TABLE NO. 1
NO_x, CO and NMOC EMISSION TESTING RESULTS
 Willow Compressor Station - Unit 1100 Exhaust Stack
 June 20, 2018

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	20-Jun-18	9:38-10:38	97	956	4,373	27,160	28.8	0.38	0.38	98.0
2		10:54-11:54	97	938	4,305	26,886	28.5	0.00	0.39	99.0
3		12:10-13:10	<u>97</u>	<u>925</u>	<u>4,251</u>	<u>26,642</u>	<u>28.2</u>	<u>0.00</u>	<u>0.41</u>	<u>98.9</u>
<i>Average:</i>			97	940	4,310	26,896	28.5	0.13	0.39	98.6

(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

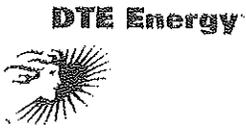
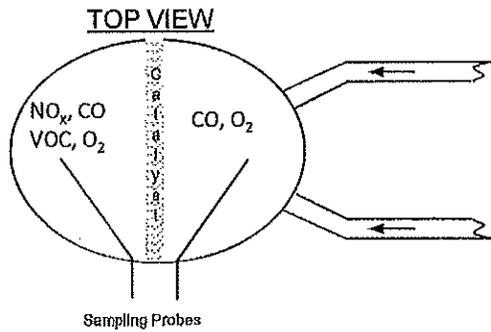
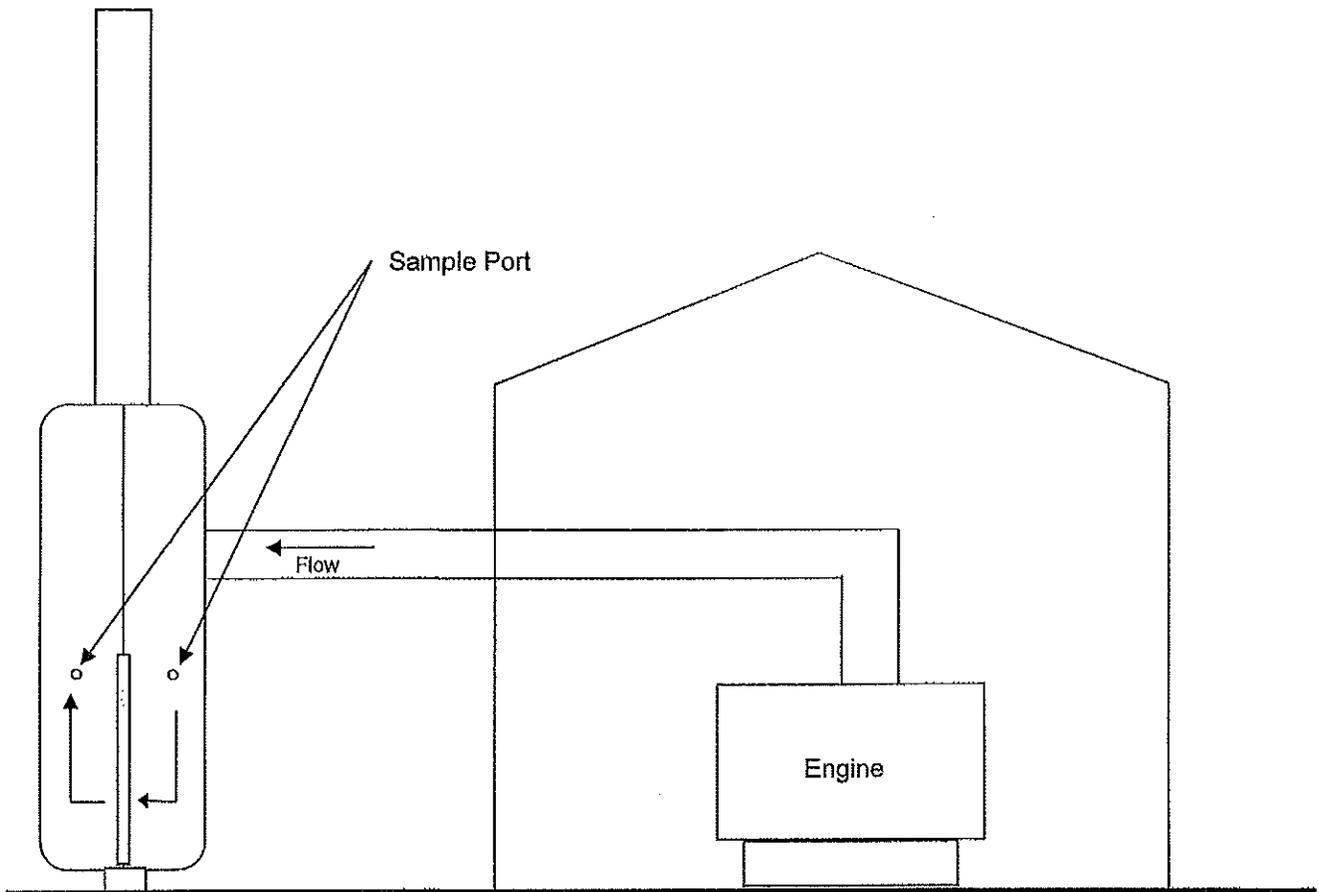


Figure 1 - Sampling Location
Willow Compressor Station
June 20, 2018



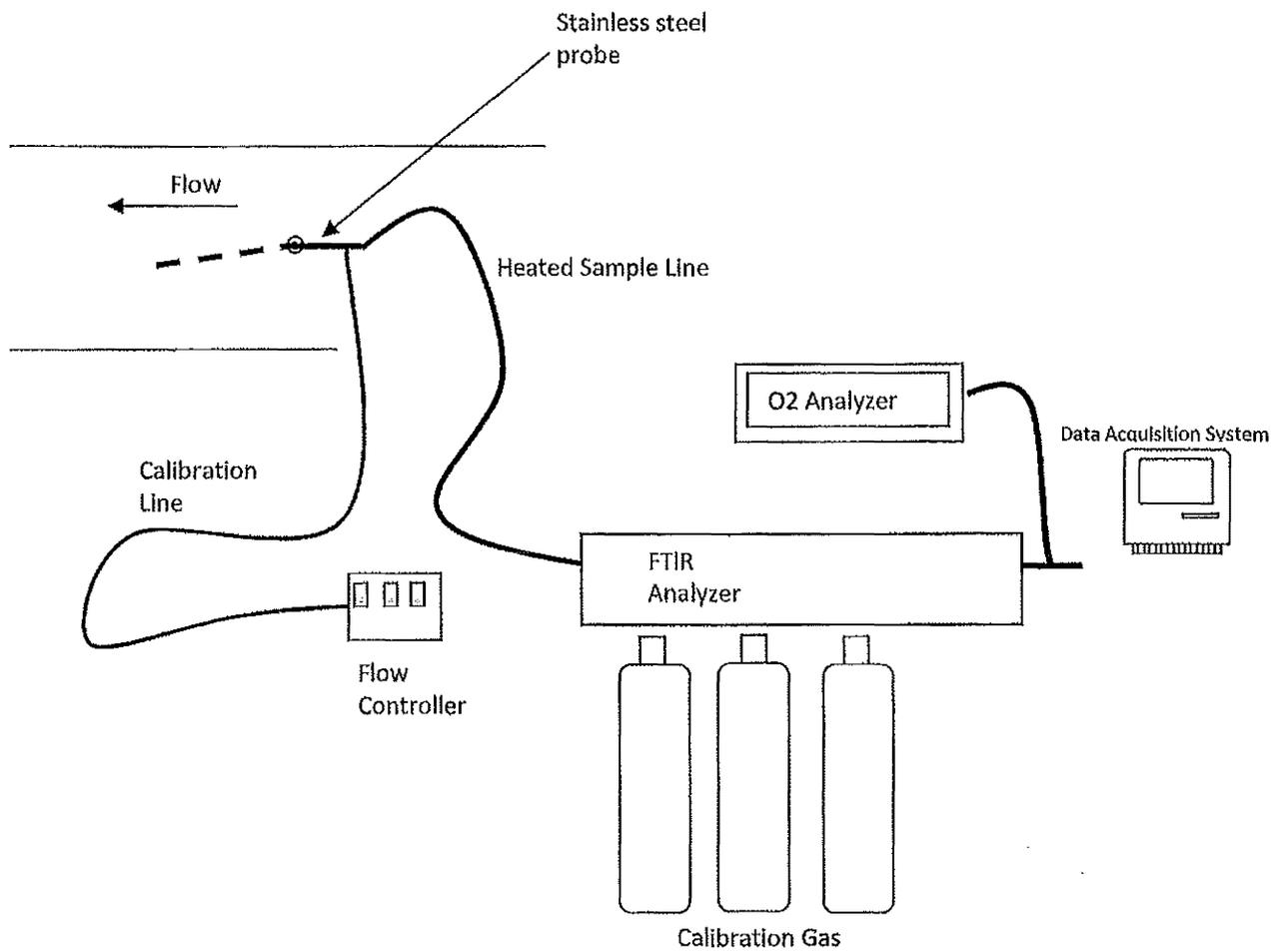
RECEIVED

AUG 01 2018

AIR QUALITY DIVISION



Figure 2– ASTM D6348
Unit 1100
Willow Compressor Station
June 20, 2018



**Figure 3 – EPA Method 3A and 10
Unit 1100 - Inlet
Willow Compressor Station
June 20, 2018**

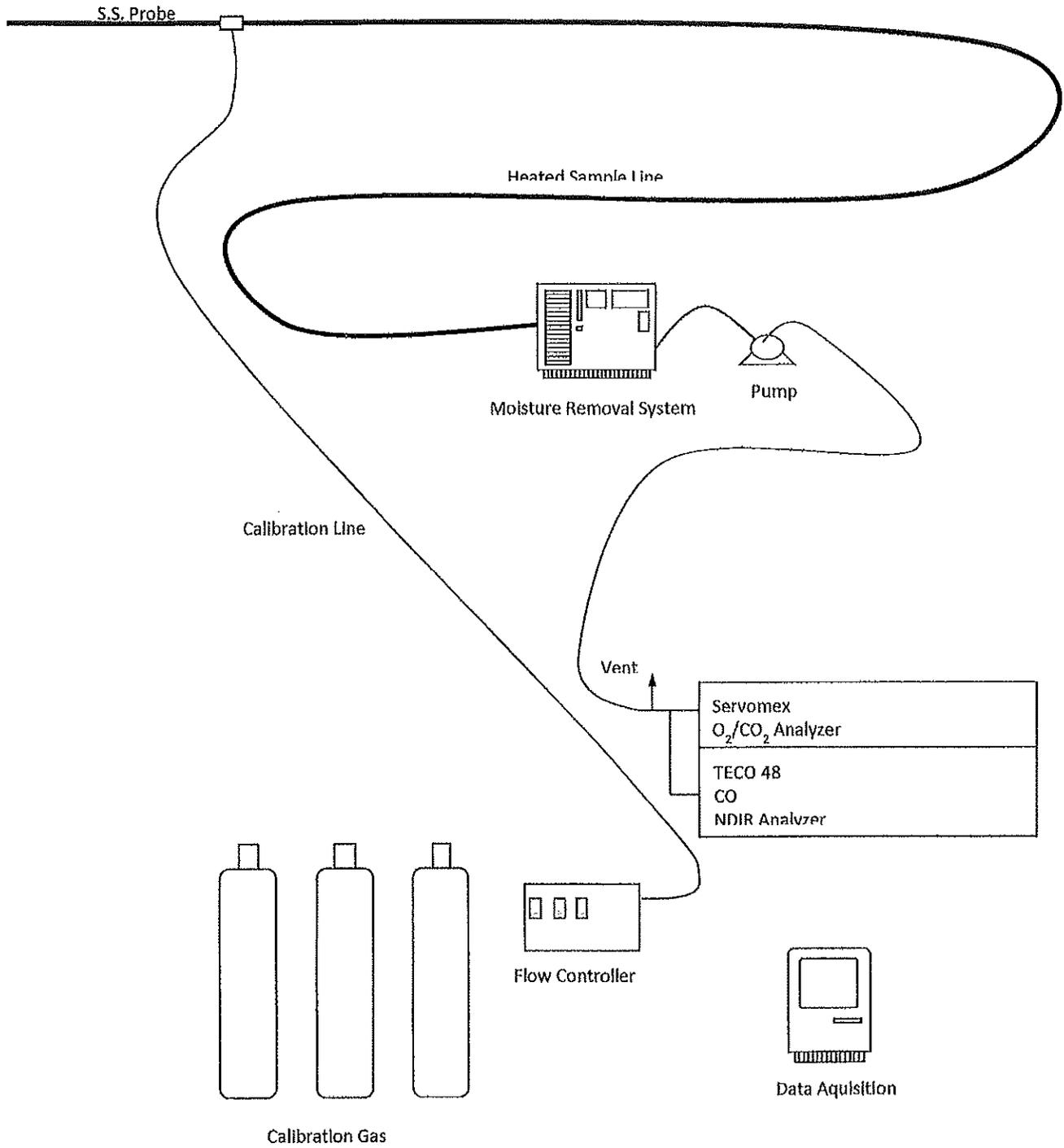




Figure 4 –EPA Method 25A Sampling Train

Unit 1100

Willow Compressor Station

June 20, 2018

