EXECUTIVE SUMMARY

Montrose Air Quality Services, LLC. (MAQS) was retained by Western Michigan University (WMU) to evaluate emission rates from an emergency generator set located outside Sangren Hall (Sangren). Sangren is located on WMU's campus at 1903 West Michigan Avenue in Kalamazoo, Michigan. The generator set is a Gaseous Fuel Generator Set Model GTA50 CC Engine Series rated for a maximum of 600 kW at a gross engine power output of 1,035 hp and manufactured by Cummins.

Testing consisted of triplicate 60-minute test runs. The generator set is owned and operated by WMU and is included in Renewable Operating Permit No. MI-ROP-K2131-2015a as EU-138-EMERGEN-01. The emissions testing is required by the Standards of Performance for Stationary Spark Ignition Internal Combustion Engines codified at Title 40, Part 60, Subpart JJJJ of the Code of Federal Regulations (40 CFR 60, Subpart JJJJ). Emission limitations included in Subpart JJJJ that are applicable to this generator set are summarized in Table I in addition to test program summary results.

Table I
Western Michigan University
Sangren Hall Emergency Generator
Compliance Test Program Results Summary
Test Date February 27, 2019

Source	Pollutant	Test Result (ppmvd @15% O_2)	Emission Limitation (ppmvd @15% O_2)
Sangren Hall GTA50 CC Generator Set EU-138-EMERGEN-01	NOx	47	160
	CO	111	540
	VOC	0	86

Note: The measured total hydrocarbon concentration, minus methane, was negative and, therefore, is reported as zero.

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1. Introduction

Montrose Air Quality Services, LLC. (MAQS) was retained by Western Michigan University (WMU) to evaluate emission rates from an emergency generator set located outside Sangren Hall (Sangren). Sangren is located on WMU's campus at 1903 West Michigan Avenue in Kalamazoo, Michigan. The generator set is a Gaseous Fuel Generator Set Model GTA50 CC Engine Series rated for a maximum of 600 kW at a gross engine power output of 1,035 hp and manufactured by Cummins.

The Air Quality Division (AQD) of Michigan's Department of Environmental Quality has published a guidance document entitled "Format for Submittal of Source Emission Test Plans and Reports" (March 2018). The following is a summary of the emissions test program and results in the format outlined by the AQD document.

1.a Identification, Location, and Dates of Test

Field-sampling for this emission test program was conducted on February 27, 2019 at Sangren Hall on WMU's campus at 1903 West Michigan Avenue in Kalamazoo, Michigan. The purpose of this report is to document the results of the emissions test program.

1.b Purpose of Testing

The generator set is owned and operated by WMU and is included in Renewable Operating Permit No. MI-ROP-K2131-2015a as EU-138-EMERGEN-01. The emissions testing is required by the Standards of Performance for Stationary Spark Ignition Internal Combustion Engines codified at Title 40, Part 60, Subpart JJJJ of the Code of Federal Regulations (40 CFR 60, Subpart JJJJ). Emission limitations included in Subpart JJJJ that are applicable to this generator set are summarized by Table 2 (see Section 2.d).

The purpose of the testing was to quantify emission levels of oxides of nitrogen (NOx), carbon monoxide (CO), and volatile organic compounds (VOC) (as propane). In addition, the concentrations of oxygen (O_2) and methane (CH_4) in the engine exhaust were measured during the emissions test program.

1.c Test Program Contact

The contacts for the test program are:

Mr. Todd Wessel
Client Project Manager
Montrose Air Quality Services, LLC
4949 Fernlee Ave.
Royal Oak, MI 48073
(616) 885-4013

Mr. Mark Weiss
Director of Environmental Health and Safety
Western Michigan University
1903 W. Michigan Ave
Kalamazoo MI 49008-5485
(269) 387-5588

Ms. Rhiana Dornbos
Project Manager
NTH Consultants, Ltd.
1010 Front Ave. NW
Grand Rapids, Michigan 49504
(616) 265-5755

1.d Test Personnel

Names and affiliations for personnel who were present during the testing program are summarized by Table 1.

Table 1
Test Personnel

Name and Title	Affiliation	Telephone
Ms. Rhiana Dornbos Project Engineer	NTH Consultants, Ltd. 1010 Front Ave. NW Grand Rapids, Michigan 49504	(517) 702-2953
Ms. Chloe Palajac Staff Engineer	NTH Consultants, Ltd. 1010 Front Ave. NW Grand Rapids, Michigan 49504	(616) 265-5757
Mark Weiss Director of Environmental Health and Safety	Western Michigan University 1903 W. Michigan Ave Kalamazoo MI 49008-5485	(269) 387-5588
Mr. Todd Wessel Client Project Manager	MAQS 4949 Fernlee Avenue Royal Oak, MI 48073	(616) 885-4013
Mr. Shane Rabideau Field Technician	MAQS 4949 Fernlee Avenue Royal Oak, MI 48073	(248) 548-8070
Mr. Tom Gasloli Environmental Quality Analyst	MDEQ Air Quality Division Lansing District Office	(517) 248-6778

Ms. Monica Brothers Environmental Quality Analyst	MDEQ Air Quality Division Kalamazoo District Office	(269) 567-3552

2. Summary of Results

Sections 2.a through 2.d summarize the results of the emissions compliance test program.

2.a Operating Data

The generator set was run prior to testing to ensure proper internal temperature could be reached for the onboard non-selective catalytic reduction (NSCR) system and to adjust the fuel/air mix ratio for optimal emissions control system performance. As specified by 40 CFR 60.4244(a), emissions testing was conducted with the engine operating within 10 percent of 100 percent peak load. The power generation rate during the emissions test program was approximately 546 kW. Operating data is provided in Appendix E.

2.b Applicable Permit

The generator set is owned and operated by WMU and is included in Renewable Operating Permit No. MI-ROP-K2131-2015a as EU-138-EMERGEN-01. The emissions testing is required by the Standards of Performance for Stationary Spark Ignition Internal Combustion Engines codified at Title 40, Part 60, Subpart JJJJ of the Code of Federal Regulations (40 CFR 60, Subpart JJJJ).

2.c Results

The overall results of the emissions compliance test program are summarized by Table 3 (see Section 5.a).

2.d Emission Regulation Comparison

Emission limitations for the Sangren Hall emergency generator set are summarized by Table 2.

Table 2
Emission Limitations for Emergency Generators Greater Than 130 hp

Pollutant	Emission Limitation (ppmv@15% O_2)	Emission Limitation (g/bhp-hr)
NOx	160	2.0
CO	540	4.0
VOC	86	1.0

Note: Emission Limitations are expressed in two separate units. Either set of emission limitations can be used to demonstrate compliance with 40 CFR 60, Subpart JJJJ. Emissions were determined in terms of concentration (ppmvd@15% O_2).

As summarized by Table 3 (Section 5.a), the emissions test result for each pollutant was less than the corresponding emission limitation.

3. Source Description

Sections 3.a through 3.e provide a detailed description of the process.

3.a Process Description

The emission unit is a natural gas-fired emergency generator set manufactured by Cummins. The generator set (Model GTA50 CC) is rated for a maximum of 600 kW at a gross engine power output of 1,035 bhp.

3.b Raw and Finished Materials

The only raw material supplied to the generator set is natural gas.

3.c Process Capacity

The only raw material supplied to the generator set is natural gas. The generator is rated for 600 kW.

3.d Process Instrumentation

The engine is equipped with controls to adjust the fuel-air ratio of the engine intake manifold.

4. Sampling and Analytical Procedures

Sections 4.a through 4.d provide a summary of the sampling and analytical procedures used to verify emissions from the emergency generator.

4.a Sampling Train and Field Procedures

Sampling and analysis procedures followed the methodologies of the following emissions test methods codified at Title 40, Part 60, Appendix A of the Code of Federal Regulations (40 CFR 60, Appendix A):

- Method 3A - *"Determination of Oxygen and Carbon Dioxide Concentrations in Emissions from Stationary Sources"* was used to evaluate the O_2 content of the engine exhaust
- Method 7E - *"Determination of Nitrogen Oxides Emissions from Stationary Sources"* was used to measure NOx concentrations in the exhaust gas
- Method 10 - *"Determination of Carbon Monoxide Emissions from Stationary Sources"* was used to measure CO concentrations in the exhaust gas
- Method 25A - *"Determination of Total Gaseous Organic Concentration Using Flame Ionization Analyzer"* was used to measure VOC concentrations in the exhaust gas

The O_2 content and the CO content were measured using a Teledyne 300E CO/O_2 gas analyzer. The NOx content of the gas stream was measured using a TECO Model 42C NOx gas analyzer. A sample of the gas stream was drawn through an insulated stainless-steel probe with an in-line glass fiber filter to remove any particulate, a heated Teflon® sample line, and through an electronic sample conditioner to remove the moisture from the sample before it enters the analyzers. Data was recorded at 10-second intervals on a PC equipped with data acquisition software. A schematic drawing of the Methods 3A, 7E, and 10 sampling train is provided as Figure 1.

Volatile Organic compound (VOC) concentrations were measured according to 40 CFR 60, Appendix A, Method 25A. A sample of the gas stream was drawn through a stainless steel probe with an in-line glass fiber filter to remove any particulate, and a heated Teflon® sample line to prevent the condensation of any moisture from the sample before it enters the analyzer. Data was recorded at 10-second intervals on a PC equipped with data acquisition software. MAQS will use a JUM Model 109A Methane/Non-Methane THC hydrocarbon analyzer to determine the VOC concentration.

The JUM Model 109A analyzer utilizes two flame ionization detectors (FIDs) in order to report the average ppmv for total hydrocarbons (THC), as propane, as well as the average

ppmv for methane (as methane). Upon entry, the analyzer splits the gas stream. One FID ionizes all of the hydrocarbons in the gas stream sample into carbon, which is then detected as a concentration of total hydrocarbons. Using an analog signal, specifically voltage, the concentration of THC is then sent to the data acquisition system (DAS), where recordings are taken at 4-second intervals to produce an average based on the overall duration of the test. This average is then used to determine the average ppmv for THC reported as the calibration gas, propane, in equivalent units.

The second FID reports methane only. The sample enters a chamber containing a catalyst that destroys all of the hydrocarbons present in the gas stream other than methane. As with the THC sample, the methane gas concentration is sent to the DAS and recorded. The methane concentration, reported as methane, can then be converted to methane, reported as propane, by dividing the measured methane concentration by the analyzer's response factor.

The analyzer's response factor is obtained by introducing a methane calibration gas to the calibrated J.U.M. 109A. The response of the analyzer's THC FID to the methane calibration gas, in ppmv as propane, is divided by the Methane analyzer's response to the methane calibration gas, in ppmv as methane. A schematic drawing of the Method 25A sampling train is provided as Figure 2.

For analyzer calibrations, calibration gases were mixed to desired concentrations using an Environics Series 4040 Computerized Gas Dilution System. The Series 4040 consists of a single chassis with four mass flow controllers. The mass flow controllers are factory-calibrated using a primary flow standard traceable to the United State's National Institute of Standards and Technology (NIST). Each flow controller utilizes an 11 point calibration table with linear interpolation, to increase accuracy and reduce flow controller nonlinearity.

All analyzers were calibrated in accordance with the procedures of Methods 3A, 7E, 10, and 25A.

4.b Recovery and Analytical Procedures

Recovery and analytical procedures were described in Section 4.a.

4.c Sampling Ports

All sampling took place at the engine exhaust ducts. The entire run time was spent in one of two exhaust ducts, with the sampling probe being switched between ducts at the halfway point of the test run (based on time, not sample volume). Readings from approximately three minutes of time required for switchover were removed from the MAQS analysis averages.

4.d Traverse Points

The exhaust ducts are 8.25 inches in diameter. The north exhaust duct was traversed at three points across the duct for a total of 10 minutes each during each emissions test run. The south exhaust duct was sampled at a single point for thirty minutes during each emissions test run.

5. Test Results and Discussion

Sections 5.a through 5.k provide a summary of the test results.

5.a Results Tabulation

The results of the emissions test program are summarized by Table 3.

Table 3
Western Michigan University
Sangren Hall Emergency Generator
Compliance Test Program Results Summary

Source	Pollutant	Test Result (ppmvd @15%/O_2)	Emission Limitation (ppmvd @15%/O_2)
GTA50 CC Generator Set	NOx	47	160
	CO	111	540
	VOC	0	86

Note: The measured total hydrocarbon concentration, minus methane, was negative and, therefore, is reported as zero.

5.b Discussion of Results

Emission limitations are summarized by Table 2 (see Section 1.b). The results of the emissions test program are summarized by Table 3 (see Section 5.a). Detailed emissions test results are summarized by Table 4.

5.c Sampling Procedure Variations

No sampling procedure variations occurred during testing.

5.d Process or Control Device Upsets

No upset conditions occurred during testing.

5.e Control Device Maintenance

Preventative and corrective maintenance is performed per manufacturer recommendations.

5.f Audit Sample Analyses

No audit samples were collected as part of the test program.

5.g Calibration Sheets

All relevant equipment calibration documents are provided as Appendix A.

5.h Sample Calculations

Sample calculations are provided in Appendix B.

5.i Field Data Sheets

Field documents relevant to the emissions test program are presented in Appendix C.

5.j Laboratory Data

All analysis was done live through the use of online Analyzers and as such there is no laboratory data. Raw analyzer data is provided in Appendix D.

Tables

Table 4
North/South Exhaust Average
NOx, CO, and VOC Emission Rates
Western Michigan University
Kalamazoo, MI

MAQS Project No. **049AS-541981**
Sampling Date: **2/27/2019**

Parameter	Run 1	Run 2	Run 3	Average
Test Run Date	2/27/2019	2/27/2019	2/27/2019	
Test Run Time	13:08-13:38, 13:43-14:13	14:44-15:14, 15:18-15:48	16:12-16:42, 16:47-17:17	
Oxygen Concentration (%)	0	0	0	**0.0**
Oxygen Concentration (%, drift corrected as per USEPA 7E)	0.0	0.0	0.0	**0.0**
Outlet Oxides of Nitrogen Concentration (ppmv)	202.9	171.9	131.4	**168.7**
Outlet NOx Concentration (ppmv, corrected as per USEPA 7E)	200.1	170.0	127.1	**165.8**
Outlet NOx Concentration (ppmv, corrected to 15% O_2)	**56.4**	**47.9**	**35.9**	**46.7**
Outlet Carbon Monoxide Concentration (ppmv)	373.8	439.0	368.5	**393.8**
Outlet CO Concentration (ppmv, corrected as per USEPA 7E)	372.9	436.5	366.4	**391.9**
Outlet CO Concentration (ppmv, corrected to 15% O_2)	**105.1**	**123.1**	**103.4**	**110.5**
Outlet VOC Concentration (ppmv as propane)	74.5	76.9	74.9	**75.4**
Outlet Methane Concentration (ppmv as methane)	186.9	200.6	175.9	**187.8**
Outlet VOC Concentration (ppmv, corrected as per USEPA 7E)	72.6	73.5	71.9	**72.7**
Outlet Methane Concentration (ppmv, corrected as per USEPA 7E)	186.5	203.0	177.4	**189.0**
Outlet VOC Concentration (ppmv propane, -Methane)	-6.8	-10.3	-1.6	**-6.2**
Outlet VOC Concentration (ppmv propane, -Methane, corrected to 15%O2)	**-1.9**	**-2.9**	**-0.4**	**-1.8**
Outlet VOC Concentration (ppmv propane, -Methane, corrected as per USEPA 7E)	-8.5	-14.7	-5.2	**-9.5**
Outlet VOC Concentration (ppmv propane, -Methane, corrected as per USEPA 7E, corrected to 15%O2)	**-2.4**	**-4.2**	**-1.5**	**-2.7**

ppmv = parts per million on a volume-to-volume basis
lb/hr = pounds per hour
MW = molecular weight (CO = 28.01, NOx = 46.01, SO_2 = 64.05, C_3H_8 = 44.10, carbon = 12.01)
24.14 = molar volume of air at standard conditions (70°F, 29.92" Hg)
35.31 = ft^3 per m^3
453600 = mg per lb
Response factor obtained from introducing propane into methane analyzer: **2.3**

C_o= Average of initial and final zero gases
C_{ma}=Actual concentration of the calibration gas
C_m= Average of initial and final calibration gases
C_c=KC_{meas}
where Cc = Concentration as Carbon (ppmv), K= Carbon equivalent correction factor (3 for Propane)
and C_{meas} = concentration as measured (as propane)

Equations
lb/hr = ppmv * MW/24.14 * 1/35.31 * 1/453,600 * ***scfm*** * 60 *for* VOC
lb/hr = ppmv * MW/24.14 * 1/35.31 * 1/453,600 * ***dcfm*** * 60
$Conc_{@15\%O2}$ = Conc * (20.9 -15)/(20.9 - $\%O_2$)

Figures

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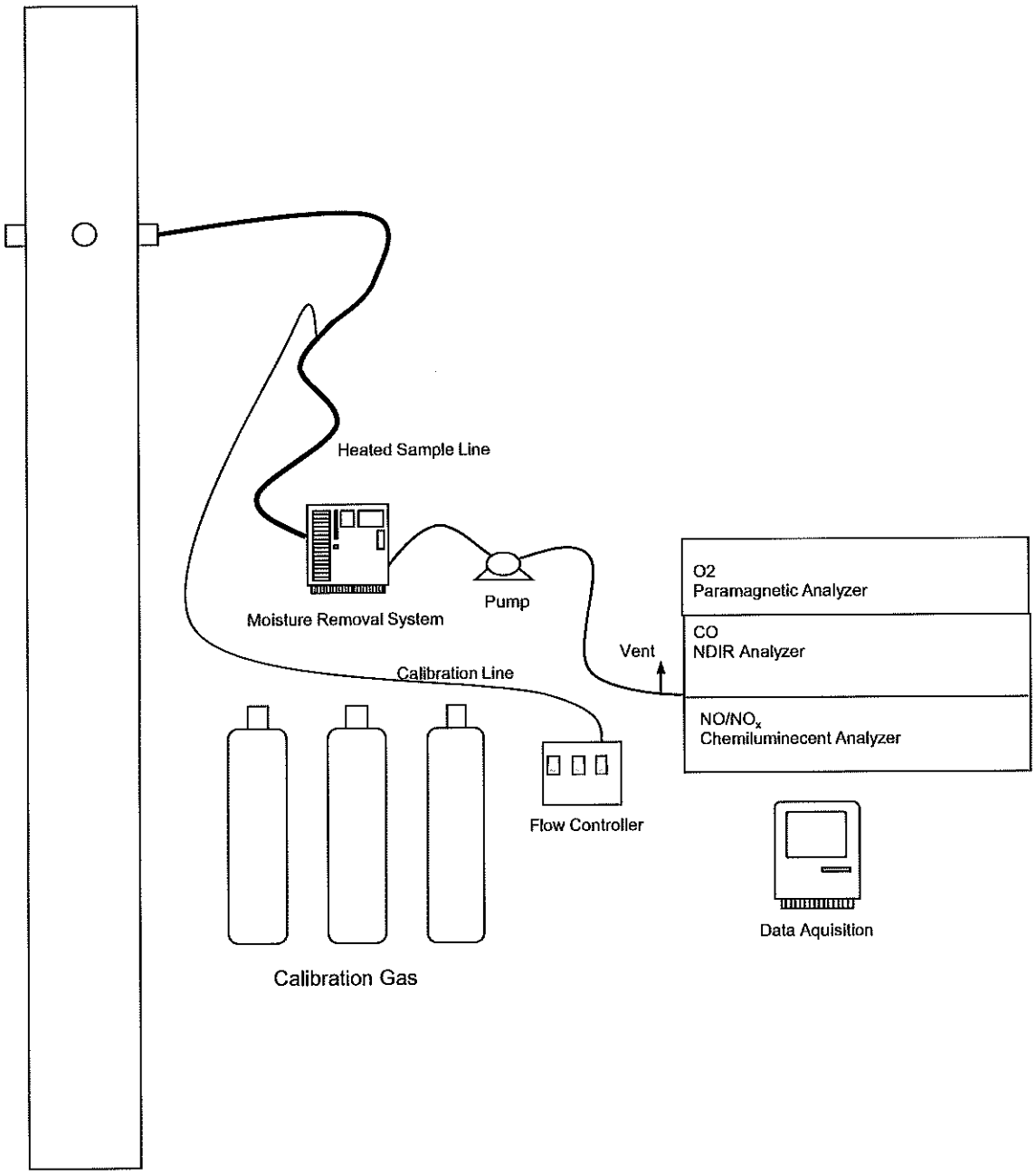

Figure 1

Site: **USEPA Method 3A/7E/10** **Western Michigan University** **Sangren Hall Emergency Generator Test**	**Sampling Date:** **February 27, 2019**
	Montrose Air Quality Services, LLC **4949 Fernlee Avenue** **Royal Oak, MI 48073**

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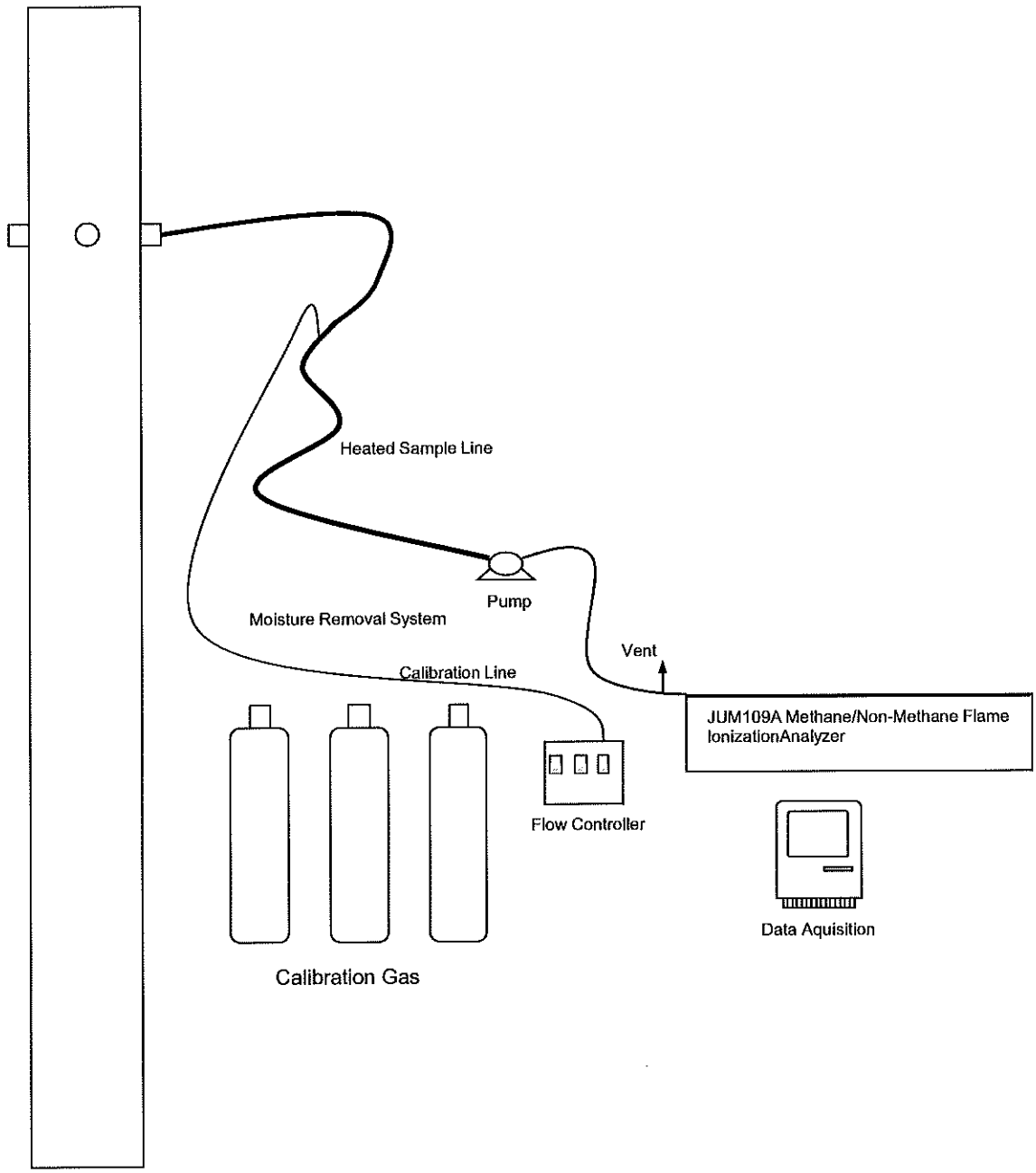

Figure 2

Site: **USEPA Method 25A** **Western Michigan University** **Sangren Hall Emergency Generator Test**	**Sampling Date:** **February 27, 2019**	**Montrose Air Quality Services, LLC** **4949 Fernlee Avenue** **Royal Oak, MI 48073**