BTEC Inc.

Emergency Generator Engine Emissions Test Report

Prepared for:

The University of Michigan

Ann Arbor, Michigan

Engine Location: The University of Michigan
South Quadrangle Residence Hall
600 East Madison
Ann Arbor, Michigan

Project No. 14-4606.00
December 15, 2014

BT Environmental Consulting, Inc.
4949 Fernlee Avenue
Royal Oak, Michigan 48073
(248) 548-8070

DEQ

MICHIGAN DEPARTMENT OF ENVIRONMENTAL QUALITY
AIR QUALITY DIVISION

RENEWABLE OPERATING PERMIT REPORT CERTIFICATION

Authorized by 1994 P.A. 451, as amended. Failure to provide this information may result in civil and/or criminal penalties.

Reports submitted pursuant to R 336.1213 (Rule 213), subrules (3)(c) and/or (4)(c), of Michigan's Renewable Operating (RO) Permit program must be certified by a responsible official. Additional information regarding the reports and documentation listed below must be kept on file for at least 5 years, as described in General Condition No. 22 in the RO Permit and be made available to the Department of Environmental Quality, Air Quality Division upon request.

Source Name: The University of Michigan — County: Washtenaw

Source Address: 1239 Kipke Drive — City: Ann Arbor

AQD Source ID (SRN): M0675 — RO Permit No.: MI-ROP-M0675-2014 — RO Permit Section No.:

Please check the appropriate box(es):

☐ **Annual Compliance Certification (General Condition No. 28 and No. 29 of the RO Permit)**

Reporting period (provide inclusive dates): From _____ To _____

☐ 1. During the entire reporting period, this source was in compliance with **ALL** terms and conditions contained in the RO Permit, each term and condition of which is identified and included by this reference. The method(s) used to determine compliance is/are the method(s) specified in the RO Permit.

☐ 2. During the entire reporting period this source was in compliance with all terms and conditions contained in the RO Permit, each term and condition of which is identified and included by this reference, **EXCEPT** for the deviations identified on the enclosed deviation report(s). The method used to determine compliance for each term and condition is the method specified in the RO Permit, unless otherwise indicated and described on the enclosed deviation report(s).

☐ **Semi-Annual (or More Frequent) Report Certification (General Condition No. 23 of the RO Permit)**

Reporting period (provide inclusive dates): From _____ To _____

☐ 1. During the entire reporting period, **ALL** monitoring and associated recordkeeping requirements in the RO Permit were met and no deviations from these requirements or any other terms or conditions occurred.

☐ 2. During the entire reporting period, all monitoring and associated recordkeeping requirements in the RO Permit were met and no deviations from these requirements or any other terms or conditions occurred, **EXCEPT** for the deviations identified on the enclosed deviation report(s).

☒ **Other Report Certification**

Reporting period (provide inclusive dates): From 11/25/14 To 11/25/14

Additional monitoring reports or other applicable documents required by the RO Permit are attached as described:

South Quadrangle Residence Hall emergency generator emissions test report.

I certify that, based on information and belief formed after reasonable inquiry, the statements and information in this report and the supporting enclosures are true, accurate and complete.

Terrance G. Alexander	Executive Director	734-647-1143
Name of Responsible Official (print or type)	Title	Phone Number
Signature of Responsible Official		1/21/2015 Date

* Photocopy this form as needed.

EQP 5736 (Rev 9/01)

EXECUTIVE SUMMARY

BT Environmental Consulting, Inc. (BTEC) was retained by The University of Michigan (UM) to evaluate emission rates from an emergency generator set located outside the South Quadrangle Residence Hall (South Quad). The South Quad is located at 600 East Madison Street in Ann Arbor, Michigan. The generator set is a Gaseous Fuel Generator Set Model GTA38 CC Engine Series manufactured by Cummins.

Testing consisted of triplicate 60-minute test runs. The generator set is owned and operated by UM. Because the engine qualifies for exemption from permitting pursuant to R 336.1285(g) and R 336.1212(4)(d), it is not included in a permit. 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
University of Michigan
South Quad Emergency Generator
Compliance Test Program Results Summary

Source	Pollutant	Test Result (ppmvd @15%/O_2)	Emission Limitation (ppmvd @15%/O_2)
GTA38 CC Generator Set	NOx	45	160
	CO	122	540
	VOC	1	86

RECEIVED
JAN 2 3 2015
AIR QUALITY DIV.

1. Introduction

BT Environmental Consulting, Inc. (BTEC) was retained by The University of Michigan (UM) to evaluate emission rates from an emergency generator set located outside the South Quadrangle Residence Hall (South Quad). The South Quad is located at 600 East Madison Street in Ann Arbor, Michigan. The generator set is a Gaseous Fuel Generator Set Model GTA38 CC Engine Series 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" (December 2013, see Appendix A). 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 November 25, 2014 at 600 East Madison Street in Ann Arbor, 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 UM. Because the engine qualifies for exemption from permitting pursuant to R 336.1285(g) and R 336.1212(4)(d), it is not included in a permit. 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), CO, and VOC (as propane). In addition, the concentrations of oxygen (O_2), methane (CH_4), and moisture in the engine exhaust were measured during the emissions test program.

1.c Test Program Contact

The contact for the test program is:

Mr. Stephen M. O'Rielly
Manager
The University of Michigan
Occupational Safety & Environmental Health Department
Environmental Protection & Permitting Program
Campus Safety Services Building
1239 Kipke Drive
Ann Arbor, Michigan 48109
(734) 763-4642

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
Mr. Steve Polloni Power Generation Field Technician	Cummins Bridgeway, LLC 21810 Clessie Court New Hudson, Michigan 48165	(313) 215-3746
Ms. Brandi Campbell Environmental Specialist	University of Michigan Occupational Safety & Environmental Health Dept.	(734) 647-9017
Mr. Nathan Hude Technical Programs Unit	MDEQ Technical Programs Unit Air Quality Division	(517) 284-6779
Mr. Todd Wessel Project Manager	BTEC 4949 Fernlee Avenue Royal Oak, MI 48073	(616) 885-4013
Mr. Randal Tysar Senior Environmental Engineer	BTEC 4949 Fernlee Avenue Royal Oak, MI 48073	(248) 548-8070
Mr. Paul Diven Environmental Technician	BTEC 4949 Fernlee Avenue Royal Oak, MI 48073	(248) 548-8070

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 545 kW.

2.b Applicable Permit

The engine qualifies for exemption from permitting pursuant to R 336.1285(g) and R 336.1212(4)(d), it is not included in a permit. 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 South Quad 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 Cummins NPower GF-series commercial generator set is a fully integrated power generation system for stationary standby or prime power applications.

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 a maximum natural gas usage rate of 8,268 cfh at 550 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"* will be used to evaluate the O_2 content of the engine exhaust
- Method 7E - *"Determination of Nitrogen Oxides Emissions from Stationary Sources"* will be used to measure NOx concentrations in the exhaust gas
- Method 10 - *"Determination of Carbon Monoxide Emissions from Stationary Sources"* will be used to measure CO concentrations in the exhaust gas
- Method 25A - *"Determination of Total Gaseous Organic Concentration Using Flame Ionization Analyzer"* will be used to measure VOC concentrations in the exhaust gas

The O_2 content was measured using a Servomex 4100 O_2 gas analyzer. The NOx content of the gas stream was measured using a TECO Model 42hi NOx gas analyzer. The CO content of the gas stream was measured using a TECO Model 48i CO 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 4-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 4-second intervals on a PC equipped with data acquisition software. BTEC 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. For the Method 25A calibrations, the calibration gases will be propane balanced with nitrogen and methane balanced with nitrogen (rather than balanced with air).

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 BTEC analysis averages.

4.d Traverse Points

The exhaust duct is ten inches in diameter and was traversed at three points (1.7 inches, 5 inches, and 8.3 inches) across the duct for a total of 20 minutes each 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
University of Michigan
South Quad Emergency Generator
Compliance Test Program Results Summary

Source	Pollutant	Test Result (ppmv @15%/O_2)	Emission Limitation (ppmv @15%/O_2)
GTA38 CC Generator Set	NOx	45	160
	CO	122	540
	VOC	1	86

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

No control device maintenance was performed during the testing.

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 B.

5.h Sample Calculations

Sample calculations are provided in Appendix C.

5.i Field Data Sheets

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

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 E.

TABLES

Table 4
South Quad Emergency Generator Engine NOx, VOC, and CO Emission Rates
The University of Michigan
Ann Arbor, Michigan
BTEC Project No. 14-4606.00
Sampling Date: 11/25/14

Parameter	Run 1	Run 2	Run 3	Average
Test Run Date	11/25/2014	11/25/2014	11/25/2014	
Test Run Time	13:05-14:05	15:00-16:00	16:36-17:36	
Outlet Oxygen Concentration (%)	0.00	0.06	0.39	0.15
Outlet O_2 Concentration (ppmv, corrected as per USEPA 7E)	0.00	-0.05	0.09	0.02
Outlet Oxides of Nitrogen Concentration (ppmv)	283.11	109.48	76.69	156.43
Outlet NOx Concentration (ppmv, corrected as per USEPA 7E)	291.17	110.82	75.88	159.29
NOx Emission Rate (ppmvd@15% O_2)	82.2	31.2	21.5	**45.0**
Outlet Carbon Monoxide Concentration (ppmv)	207.00	211.45	892.54	437.00
Outlet CO Concentration (ppmv, corrected as per USEPA 7E)	203.61	207.32	880.56	430.49
CO Emission Rate (ppmvd@15% O_2)	57.5	58.4	249.7	**121.85**
Outlet VOC Concentration (ppmv as propane)	55.07	47.71	90.81	64.53
Outlet Methane Concentration (ppmv as methane)	166.12	143.25	281.25	196.87
Outlet VOC Concentration (ppmv, corrected as per USEPA 7E)	54.38	47.08	89.56	63.67
Outlet Methane Concentration (ppmv, corrected as per USEPA 7E)	156.94	135.01	270.99	187.64
Outlet VOC Concentration (ppmv as Propane -Methane)	2.8	2.7	0.4	1.9
Exhaust Gas Mositure Content (% v/v)	11.5	16.3	15.0	14.3
Outlet VOC Concentration (ppmvd as Propane -Methane)	3.1	3.2	0.5	2.3
VOC Emission Rate (ppmvd@15% O_2)	0.9	0.9	0.1	**0.6**

O2 Correction			
Co	0.00	0.11	0.30
Cma	10	10	10
Cm	9.74	9.89	10.13

NOx Correction			
Co	1.54	1.07	0.76
Cma	500	500	500
Cm	485	490	501

CO Correction			
Co	2.36	2.28	2.29
Cma	2000	2000	2000
Cm	2013	2020	2024

VOC Correction			
Co	1.17	0.98	0.71
Cma	500	500	500
Cm	497	497	504

CH4 Correction			
Co	8.19	7.42	7.50
Cma	2500	2500	2500
Cm	2524	2523	2533

response factor = 3.04
scfm = standard cubic feet per minute
dscfm = dry standard cubic feet per minute
ppmv = parts per million on a volume-to-volume basis
lb/hr = pounds per hour
MW = molecular weight (CO = 28.01, NOx = 46.01, C_3H_8 = 44.10)
24.14 = molar volume of air at standard conditions (70F, 29.92" Hg)
35.31 = ft^3 per m^3
453600 = mg per lb
g/bhp-hr = grams per brake horse power hour
Co= Average of initial and final zero gases
Cma=Actual concentration of the calibration gas
Cm= 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)
[1]emission rate calculated on dry basis
[2]emission rate calculated on wet basis

FIGURES

BTEC Inc.

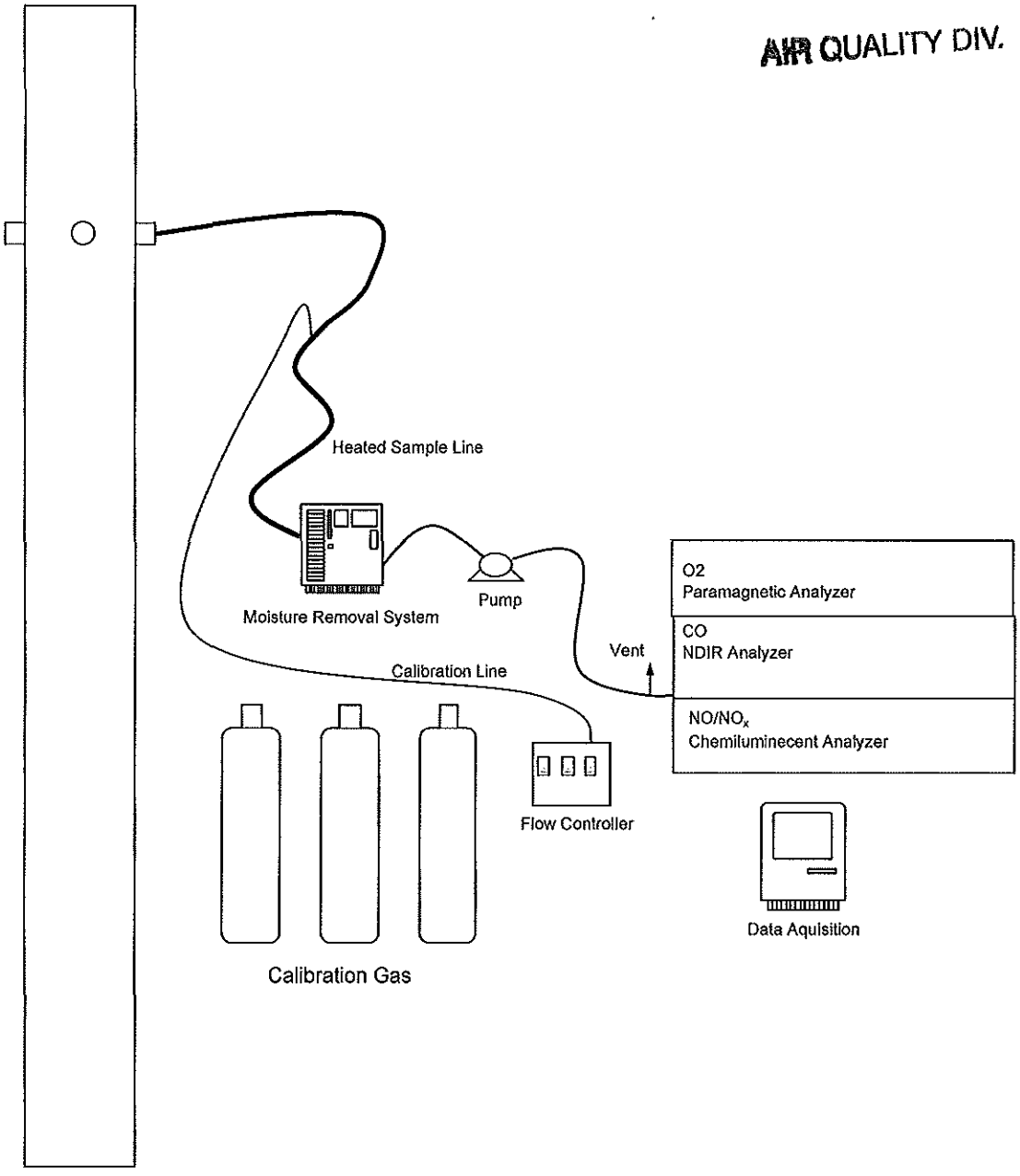

Figure 1

Site: **USEPA Method 3A/7E/10** **The University of Michigan** **South Quad Emergency Generator Test**	**Sampling Date:** **November 25, 2014**	**BT Environmental Consulting Inc.** **4949 Fernlee Avenue** **Royal Oak, MI 48073**

BTEC Inc.

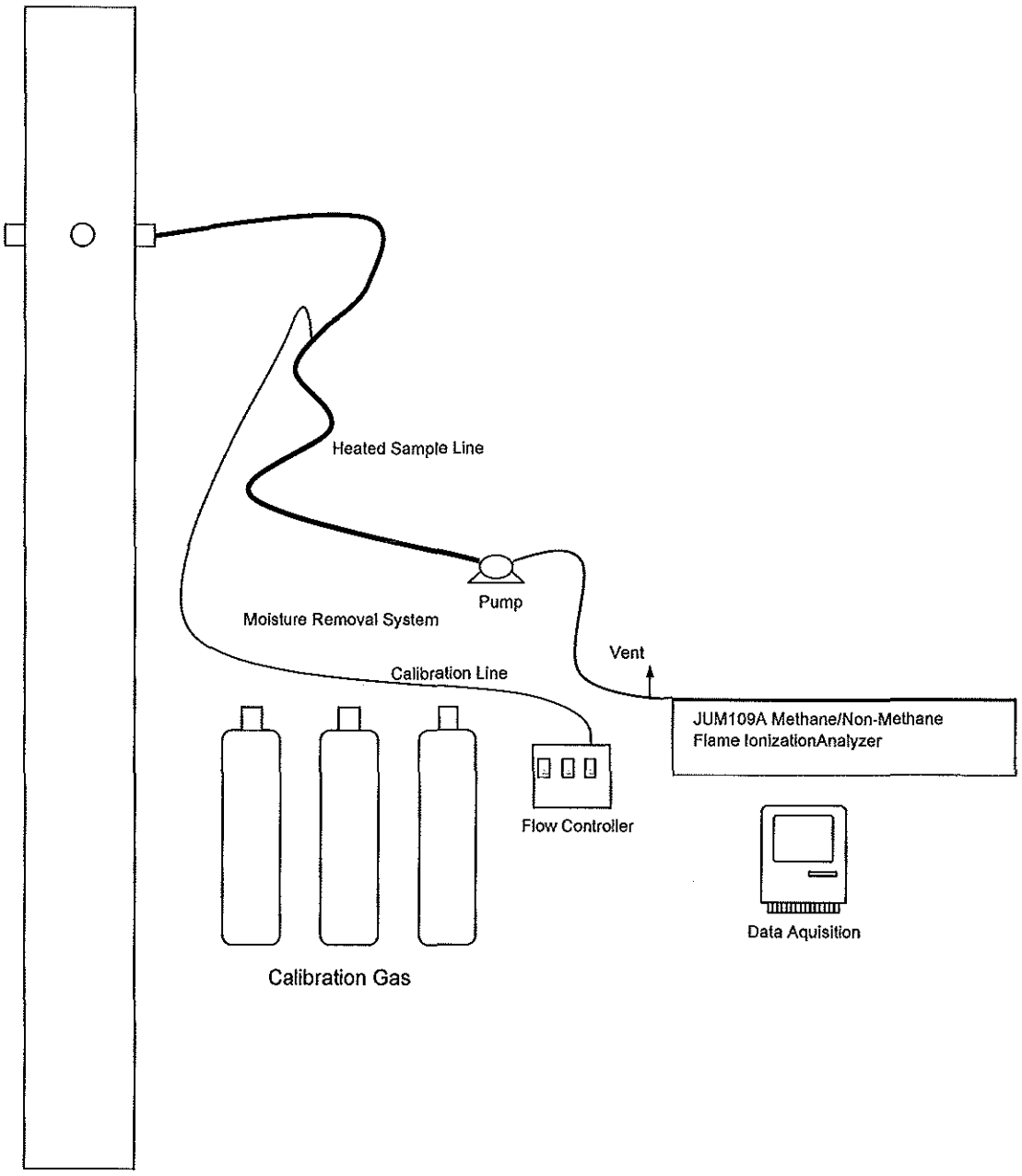

Figure 2

Site: **USEPA Method 25A** **The University of Michigan** **South Quad Emergency Generator Test**	**Sampling Date:** **November 25, 2014**	**BT Environmental Consulting Inc.** **4949 Fernlee Avenue** **Royal Oak, MI 48073**