BTEC Inc.

Compressor Engine Emissions Test Report

Prepared for:

SEMCO Energy Gas Company

Port Huron, Michigan

Engine Location: SEMCO Energy Gas Company
1100 Gratiot Avenue
Marysville, Michigan

Project No. 14-4504.00
June 27, 2014

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

EXECUTIVE SUMMARY

BT Environmental Consulting, Inc. (BTEC) was retained by SEMCO Energy Gas Company (SEMCO) to evaluate emission rates from a new natural gas compressor engine located at SEMCO's Morton facility at 1100 Gratiot Avenue in Marysville, Michigan. The compressor engine is a Gas Engine Model 3516B manufactured by Caterpillar.

Testing consisted of triplicate 60-minute test runs. Emissions test results and corresponding emission limitations for the Morton facility Engine 4 are summarized by Table I.

Table I
SEMCO Energy
Morton Engine 4
Compliance Test Program Results Summary

Source	Pollutant	Test Result (g/bhp-hr)	Emission Limitation (g/bhp-hr)
Model 3516B Compressor Engine	NOx	0.6	1.0
	CO	0.0	2.0
	VOC	0.0	0.7

1. Introduction

BT Environmental Consulting, Inc. (BTEC) was retained by SEMCO Energy Gas Company (SEMCO) to evaluate emission rates from a new natural gas compressor engine located at SEMCO's Morton facility at 1100 Gratiot Avenue in Marysville, Michigan. The compressor engine is a Gas Engine Model 3516B manufactured by Caterpillar.

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 May 9, 2014 at 1100 Gratiot Avenue in Marysville, Michigan. The purpose of this report is to document the results of the emissions determined during the compliance test program.

1.b Purpose of Testing

The engine (EUENGINE4) is included in AQD Permit to Install No. 126-07A. The emissions testing is required by Permit No. 126-07A and 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).

The purpose of the testing was to quantify emission rates of oxides of nitrogen (NOx), carbon monoxide (CO), and VOC (as propane). In addition, exhaust gas flowrates were measured as well as concentrations of oxygen (O_2), carbon dioxide (CO_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:

Ms. Elisabeth Barr
Transmission Engineer III
SEMCO Energy Gas Company
1411 3rd Street, Suite A
Port Huron, Michigan 48060
(810) 887-3081

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. Mark Dziadosz Environmental Quality Analyst	MDEQ-AQD 27700 Donald Court Warren, Michigan 48092	(586) 753-3745
Mr. Robert Elmouchi Environmental Quality Analyst	MDEQ-AQD 27700 Donald Court Warren, Michigan 48092	(586) 753-3736
Ms. Elisabeth Barr Transmission Engineer III	SEMCO Energy Gas Company 1411 3rd Street, Suite A Port Huron, Michigan 48060	(810) 887-3081
Mr. Matthew L. Young Project Manager	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
Mr. Paul Draper 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

Operating data included operating load (% of maximum bhp), exhaust catalyst pressure drop (in. H_2O), and catalyst inlet temperature ($^{\circ}F$). Operating data is provided in Appendix B.

2.b Applicable Permit

The engine (EUENGINE4) is included in AQD Permit to Install No. 126-07A. The emissions testing is required by Permit No. 126-07A and 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 Morton facility compressor engine are summarized by Table 2.

Table 2
EUENGINE4 Emission Limitations

Pollutant	Emission Limitation (g/bhp-hr)
NOx	1.0
CO	2.0
VOC	0.7

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 compressor engine manufactured by Caterpillar. The compressor engine (Model 3516B LE) is rated for a maximum of 1,380 bhp. Engine specifications are provided in Appendix B.

3.b Raw and Finished Materials

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

3.c Process Capacity

The compressor engine (Model 3516B LE) is rated for a maximum of 1,380 bhp.

3.d Process Instrumentation

Process instrumentation includes engine operating load (% of maximum bhp), exhaust catalyst pressure drop (in. H_2O), and catalyst inlet temperature (^oF).

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 engine.

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 1 - *"Sample and Velocity Traverses for Stationary Sources"* were used to determine the sampling locations and velocity traverse points
- Method 2 - *"Determination of Stack Gas Velocity and Volumetric Flowrate"* was used to determine exhaust gas velocity and volumetric flowrate
- Method 3A - *"Determination of Oxygen and Carbon Dioxide Concentrations in Emissions from Stationary Sources"* was used to evaluate the O_2 and CO_2 content of the engine exhaust
- Method 4 - *"Determination of Moisture Content in Stack Gases"* was used to measure exhaust gas moisture content
- Method 7E - *"Determination of Nitrogen Oxides Emissions from Stationary Sources"* was used to measure exhaust gas NOx concentrations
- Method 10 - *"Determination of Carbon Monoxide Emissions from Stationary Sources"* was used to measure exhaust gas CO concentrations
- Method 25A - *"Determination of Total Gaseous Organic Concentration using a Flame Ionization Analyzer"* was used to measure exhaust gas hydrocarbon and methane concentrations

Stack gas velocity traverses were conducted in accordance with the procedures outlined in Methods 1 and 2. An S-type pitot tube and thermocouple assembly calibrated in accordance with Method 2, Section 4.1.1 was used to measure exhaust gas velocity pressures and temperatures during testing of the engine.

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The O_2 content was measured using an O_2 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.

The CO_2 content was measured using a CO_2 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.

Exhaust gas moisture content was evaluated using Method 4. Exhaust gas was extracted and passed through (i) two impingers, each with 100 ml deionized water, (ii) an empty impinger, and (iii) an impinger filled with silica gel. The impingers were in an ice water bath and the air volume extracted was measured using a calibrated meter box. Exhaust gas moisture content was determined gravimetrically.

The NOx content of the gas stream was measured using a Thermo Model 42i NOx gas analyzer (or equivalent). The gas stream was drawn through a stainless-steel probe with a heated in-line filter to remove any particulate, a heated Teflon® sample line, through a refrigerated Teflon® sample conditioner to remove the moisture from the sample before it entered the NOx analyzer. Data was recorded on a PC equipped with data acquisition software.

The CO content of the exhaust gas was evaluated according to procedures outlined in 40 CFR 60, Appendix A, Method 10. The CO content of the gas stream was measured using a TECO 48 CO gas analyzer (or equivalent). The gas stream was drawn through a stainless-steel probe with a heated in-line filter to remove any particulate, a heated Teflon® sample line, through a refrigerated sample conditioner with a peristaltic pump to remove the moisture from the sample before it entered the analyzer. Data was recorded on a PC equipped with data acquisition software.

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 used 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.

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 States 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. A field quality assurance check of the system was performed pursuant to Method 205 by setting the diluted concentration to a value identical to a Protocol 1 calibration gas and then verifying that the analyzer response is the same with the diluted gas as with the Protocol 1 gas.

Schematic drawings of the Methods 3A/7E/10 and 25A sampling trains are included as Figures 1 and 2.

4.b Recovery and Analytical Procedures

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

4.c Sampling Ports

Exhaust gas flowrate/gas sampling ports are located approximately twelve feet from the end of the 13-inch diameter exhaust stack and approximately 9 feet after the last flow disturbance. For each test run, the gas sampling probes were moved to three points across the exhaust stack (2.2, 6.5, and 10.8 inches).

4.d Traverse Points

Exhaust gas flowrate/gas sampling ports are located approximately twelve feet from the end of the 13-inch diameter exhaust stack and approximately 9 feet after the last flow disturbance. For each test run, the gas sampling probes were moved to three points across the exhaust stack (2.2, 6.5, and 10.8 inches).

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
SEMCO Energy
Morton Engine 4
Compliance Test Program Results Summary

Source	Pollutant	Test Result (g/bhp-hr)	Emission Limitation (g/bhp-hr)
Model 3516B Compressor Engine	NOx	0.6	1.0
	CO	0.0	2.0
	VOC	0.0	0.7

Detailed emissions test results are summarized by Table 4.

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).

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 C.

5.h Sample Calculations

Sample calculations are provided in Appendix D.

5.i Field Data Sheets

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

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 F.

TABLES

Table 4
Morton Station Engine 4
SEMCO Energy
Marysville, Michigan
BTEC Project No. 14-4504.00
Sampling Date: 5-9-14

Parameter	Run 1	Run 2	Run 3	Average
Test Run Date	5/9/2014	5/9/2014	5/9/2014	5/9/2014
Exhaust Gas Flowrate (dscfm)	1,600	1,657	1,644	1,634
Exhaust Gas Moisture Content (vol%)	13.1	12.6	12.9	12.9
Engine Load (bhp):	842	842	842	842
Outlet NOx Concentration, corrected for drift per Method 7E (ppmvd):	99.7	98.4	97.8	98.6
Outlet CO Concentration, corrected for drift per Method 10 (ppmvd):	5.4	5.7	5.6	5.6
Outlet VOC Concentration (ppmv as propane)	125.3	114.0	120.3	119.8
Outlet Methane Concentration (ppmv as methane)	466.7	541.0	563.6	523.8
Outlet VOC Concentration (ppmv, corrected as per USEPA 7E)	119.7	109.3	117.6	115.6
Outlet Methane Concentration (ppmv, corrected as per USEPA 7E)	463.6	528.4	555.6	515.9
Outlet VOC Concentration (ppmv propane, -Methane)	-67.6	-109.6	-112.6	-96.6
Outlet VOC Concentration (ppmv propane, -Methane, corrected as per USEPA 7E)	-71.9	-109.0	-112.0	-97.6
Nox Emission Rate (lbs/hr):	1.14	1.17	1.15	1.15
CO Emission Rate (lbs/hr):	0.04	0.04	0.04	0.04
VOC Emission Rate (lbs/hr):	0.00	0.00	0.00	0.00
Nox Emission Rate (g/bhp-hr):	0.6	0.6	0.6	0.6
CO Emission Rate (g/bhp-hr):	0.0	0.0	0.0	0.0
VOC Emission Rate (g/bhp-hr):	0.0	0.0	0.0	0.0

VOC Correction			
Co	1.60	2.26	1.81
Cma	124.5	124.5	124.5
Cm	130.19	129.48	127.20

Methane Correction			
Co	2.60	2.88	1.86
Cma	498	498	498
Cm	501.09	510.01	505.40

ppmv = parts per million on a volume-to-volume basis

ppm as propane (-Methane) = ppm propane - (ppm Methane)/Response factor

Response factor obtained from introducing propane into methane analyzer:	2.42

FIGURES

BTEC Inc.

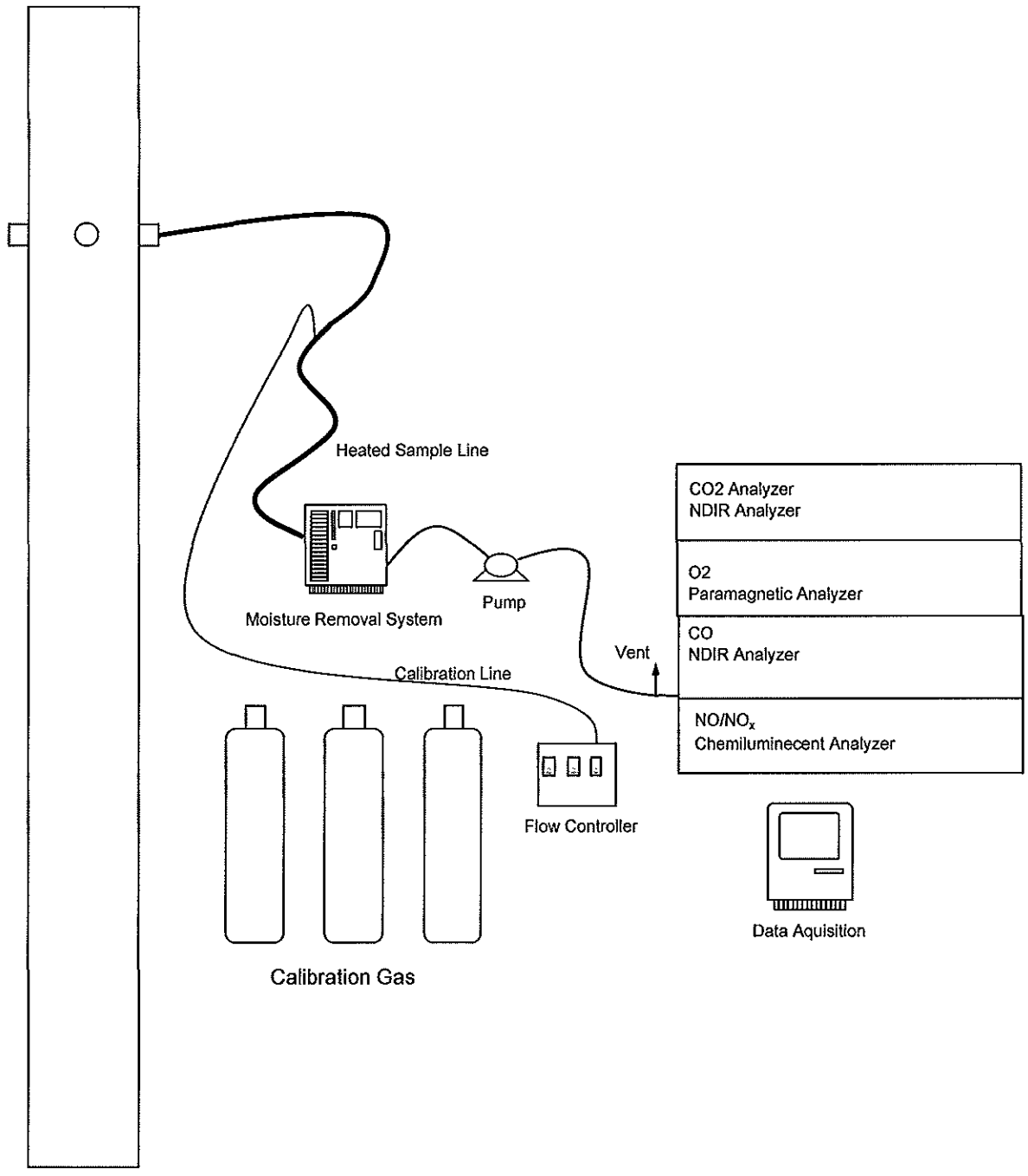

Figure 1

Site: **USEPA Method 3A/7E/10** **SEMCO Energy** **Morton Engine 4 Emissions Test**	**Sampling Date:** **May 9, 2014**	**BT Environmental Consulting Inc.** **4949 Fernlee Avenue** **Royal Oak, MI 48073**

BTEC Inc.

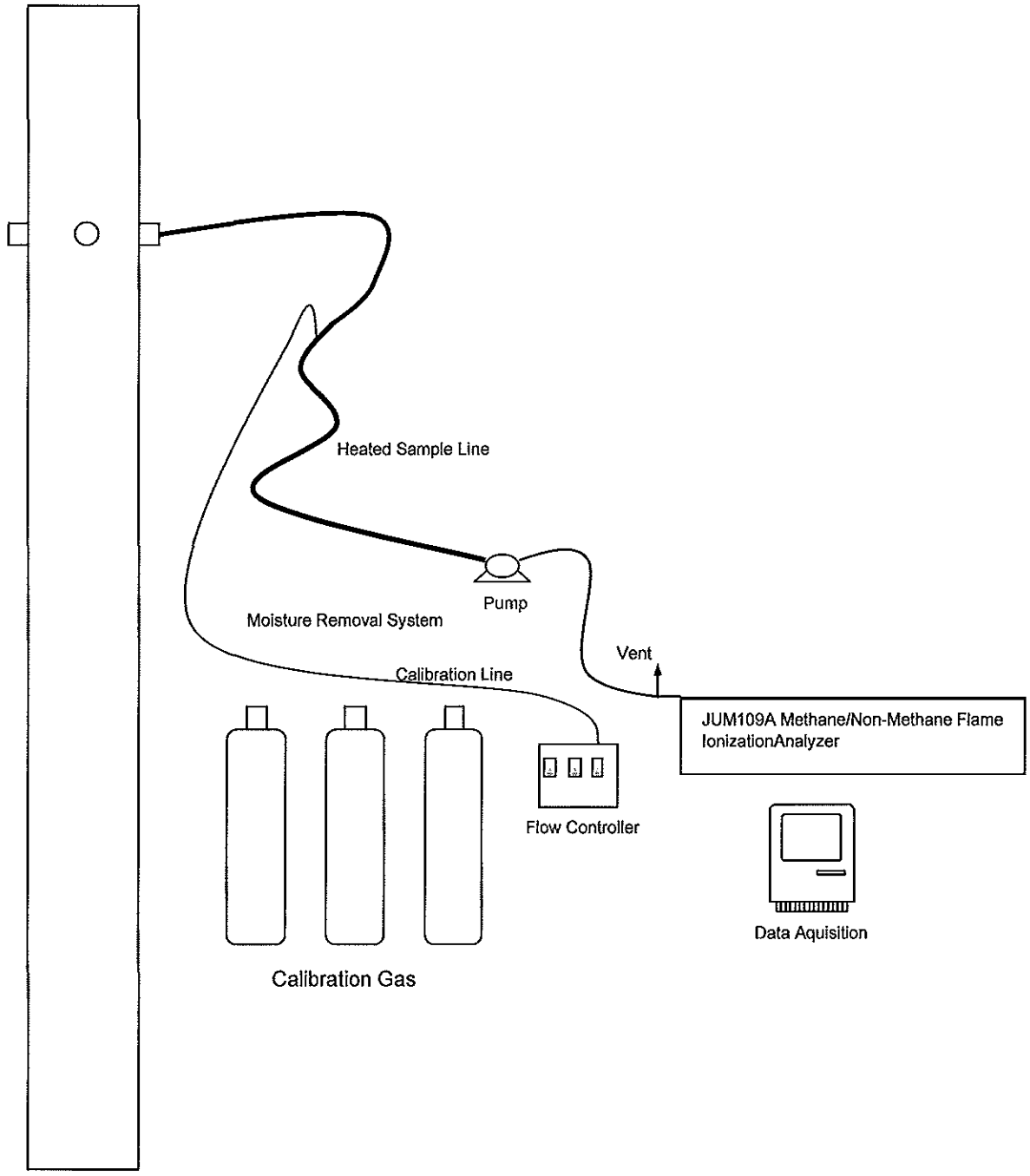

Figure 2

Site: **USEPA Method 25A** **SEMCO Energy** **Morton Engine 4 Emissions Test**	**Sampling Date:** **May 9, 2014**	**BT Environmental Consulting Inc.** **4949 Fernlee Avenue** **Royal Oak, MI 48073**