BTEC Inc.

VOC, CO, and NOx, Emissions Test Report

Prepared for:

North American Natural Resources, Inc.

Okemos, Michigan

N5910

North American Natural Resources
9536 East Lennon Road
Lennon, Michigan 48449

Project No. 13-4424.00
November 4, 2013

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

EXECUTIVE SUMMARY

BT Environmental Consulting, Inc. (BTEC) was retained by North American Natural Resources (NANR) to evaluate oxides of nitrogen (NOx), carbon monoxide (CO), and volatile organic compounds (VOC) emission rates from two reciprocating engines located at the North American Natural Resources (NANR) Venice Park Generating Station in Lennon, Michigan. Field sampling for this emission test program was conducted on September 10 and 11, 2013. The purpose of this report is to document the results of the emissions compliance test program.

Testing consisted of triplicate 60-minute test runs on two engines at the facility. The emissions test program was required Michigan Renewable Operating Permit No. MI-ROP-N5910-2010. The results of the emission test program are summarized by Table E-I.

Table E-I
North American Natural Resources – Venice Park Facility
Landfill Gas-Fired Reciprocating Engines 9 and 10
Compliance Test Program Results Summary

Source	Pollutant	Test Result	Emission Limitation
Reciprocating Engine 9	NOx	0.4 g/bhp-hr	0.6 g/bhp-hr
	NOx	2.19 lbs/hr	2.96 lbs/hr
	CO	2.5 g/bhp-hr	3.3 g/bhp-hr
	CO	12.41 lbs/hr	16.25 lbs/hr
	VOC	0.00 g/bhp-hr	0.63 g/bhp-hr
Reciprocating Engine 10	NOx	0.5 g/bhp-hr	0.6 g/bhp-hr
	NOx	2.32 lbs/hr	2.96 lbs/hr
	CO	2.8 g/bhp-hr	3.3 g/bhp-hr
	CO	13.95 lbs/hr	16.25 lbs/hr
	VOC	0.00 g/bhp-hr	0.63 g/bhp-hr

* All VOC emissions were determined to be Methane (CH_4)

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1. Introduction

BT Environmental Consulting, Inc. (BTEC) was retained by North American Natural Resources
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(NANR) to evaluate oxides of nitrogen (NOx), carbon monoxide (CO), and volatile organic compounds (VOC) emission rates from two reciprocating engines located at the NANR Venice Park Generating Station in Lennon, Michigan. Field sampling for this emission test program was conducted on September 10 and 11, 2013. The purpose of this report is to document the results of the emissions compliance test program.

The Air Quality Division (AQD) of Michigan's Department of Natural Resources and Environment has published a guidance document entitled "Format for Submittal of Source Emission Test Plans and Reports" (February 2008, 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 September 10 and 11, 2013 at the North American Natural Resources Venice Park Generating Station in Lennon, Michigan. The purpose of this report is to document the results of the emissions determined during compliance test program.

The emission test program included the evaluation of oxides of nitrogen (NOx), carbon monoxide (CO), and non-methane volatile organic compounds (VOC) emissions from three landfill gas-fired reciprocating engines.

1.b Purpose of Testing

Michigan Renewable Operating Permit (ROP) No. MI-ROP-N5910-2010 includes the emission limitations listed in Table 1. The purpose of the testing was to quantify NOx, CO, and VOC emission rates in terms of g/bhp-hr and lbs/hr. These emission rates will be utilized to demonstrate compliance with ROP No. MI-ROP-N5910-2010 as well as the requirements of Title 40, Part 60, Subpart JJJ of the Code of Federal Regulations (40 CFR 60, Subpart JJJ).

1.c Source Description

The Venice Park facility includes two *(Caterpillar 3520)* landfill gas-fired, spark-ignition, lean-burn reciprocating engines. Each reciprocating engine produces approximately 1,600 kilowatts (kW) at 2,250 bhp. Normal operation of the engine includes operation at constant speed near 100% load conditions.

1.d Test Program Contact

The contact for the source and test plan is:

Mr. Richard Spranger
Environmental Manager
North American Natural Resources
4516 Rathburn Rd.
Birch Run, Michigan 48415
(517) 347-4048

1.e Testing Personnel

Names and affiliations for personnel who were present during the testing program are summarized by Table 2.

2. Summary of Results

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

2.a Operating Data

Inlet gas flowrate, exhaust temperature, methane content, and generator power load (kW) were monitored during the testing.

2.b Applicable Permit

The applicable permit for this emissions test program is MI-ROP-N5910-2010.

2.c Results

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

2.d Emission Regulation Comparison

Emission limitations for NANR are summarized by Table 1.

3. Source Description

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

3.a Process Description

Landfill gas is compressed, filtered, and chilled to 50 degrees Fahrenheit. Gas enters the main header where flowrate, temperature, and methane content and measured. The

engines burn the landfill gas to produce electricity. As methane content fluctuates throughout the day, the engines gas jets are adjusted to minimize emissions.

3.b Raw and Finished Materials

The raw material supplied to the engine includes landfill gas. The finished material is electricity.

3.c Process Capacity

The Engines produce approximately 1,600 kW with an inlet pressure of 225 kpa. If methane changes, the inlet pressure changes, and the operators adjust the engines fuel ratio to bring up boost or kPa to maintain an average of 9 % oxygen in the exhaust. Each engine is rated at 1148 bhp-hr.

3.d Process Instrumentation

Engines performance is determined by methane input and kW output.

4. Sampling and Analytical Procedures

Sections 4.a through 4.d provide a summary of the sampling and analytical procedures used to verify emission rates from the engines.

4.a Sampling Train and Field Procedures

Sampling and analysis procedures utilized the following 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"
- Method 2 - "Determination of Stack Gas Velocity and Volumetric Flowrate"
- Method 3A - "Determination of Molecular Weight of Dry Stack Gas"
- Method 4 - "Determination of Moisture Content in Stack Gases"
- Method 7E - "Determination of Nitrogen Oxide Emissions from Stationary Sources"
- Method 10 - "Determination of Carbon Monoxide Emissions from Stationary Sources"
- Method 25A - "Determination of total gaseous organic concentration using a flame ionization analyzer"

The NO_x content of the exhaust gas was measured using a TECO 42hi NO_x gas analyzer and the O_2, CO, & CO_2 content was measured using M&C and Teledyne analyzers. 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 a Universal Analyzers 3080PV electronic sample conditioner to remove the moisture from the sample before it entered the analyzer. Data was recorded at 10-second intervals on a PC equipped with data acquisition software.

A USEPA Method 7E NO2 to NO conversion efficiency test was performed on July 29, 2013. The results are presented in Appendix C.

The VOC content of the exhaust was measured using a J.U.M. Model 109A 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 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.

For analyzer calibrations, calibration gases were mixed to desired concentrations using an Environics Series 4040 Computerized Gas Dilution System. The Series 4040 consisting 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. Schematic drawings of the flow traverse points, continuous emission systems, and the moisture sampling train are provided as Figures 1 through 4.

USEPA Method 205 Verification of Gas Dilution Systems for Field Instrument Calibrations was performed. The results of this verification can be found in Appendix C.

It should be noted that, with the approval of the on-site MDEQ-AQD representative, exhaust gas O_2 and CO_2 content was measured using the Fyrite analysis procedures of Method 3 for the third test run conducted on September 10, 2013 and all three test runs conducted on September 11, 2013.

4.b Recovery and Analytical Procedures

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

4.c Sampling Ports

Sampling port locations met the minimum criteria of Method 1.

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. Detailed data for each test run can be found in Tables 4 and 5.

5.b Discussion of Results

Emission limitations for the Michigan ROP No. MI-ROP-N5910-2010 are summarized by Table 1. The results of the emissions test program are summarized by Table 3.

5.c Sampling Procedure Variations

No sampling procedure variations were employed during this emissions test program. However, it should be noted that, with the approval of the on-site MDEQ-AQD representative, exhaust gas O_2 and CO_2 content was measured using the Fyrite analysis procedures of Method 3 for the third test run conducted on September 10, 2013 and all three test runs conducted on September 11, 2013.

5.d Process or Control Device Upsets

A single process upset condition occurred during the emissions test program as summarized by the Memo included in Appendix B.

5.e Control Device Maintenance

No control device maintenance was performed.

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 in 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 B.

5.j Laboratory Data

There are no laboratory results for this test program. Analyzer raw data files are provided in Appendix E.

TABLES

Table 1
North American Natural Resources – Venice Park Facility
Landfill Gas-Fired Reciprocating Engines 9 and 10
Compliance Test Program Emission Limitations Summary

Source	Pollutant	Emission Limitation
Reciprocating Engine 9	NOx	0.6 g/bhp-hr
	NOx	2.96 lbs/hr
	CO	3.3 g/bhp-hr
	CO	16.25 lbs/hr
	VOC	0.63 g/bhp-hr
Reciprocating Engine 10	NOx	0.6 g/bhp-hr
	NOx	2.96 lbs/hr
	CO	3.3 g/bhp-hr
	CO	16.25 lbs/hr
	VOC	0.63 g/bhp-hr

Table 2
Test Personnel

Name and Title	Affiliation	Telephone
Mr. Richard Spranger Environmental Manager	North American Natural Resources - Zeeland, Michigan	(269) 362-5546
Mr. Ken Lievense Senior Project Manager	BTEC 4949 Fernlee Royal Oak, MI 48073	(248) 548-8070
Mr. Paul Molenda Senior Project Manager	BTEC 4949 Fernlee Royal Oak, MI 48073	(248) 548-8070
Mr. Paul Draper Environmental Technician	BTEC 4949 Fernlee Royal Oak, MI 48073	(248) 548-8070

Table 3
North American Natural Resources – Venice Park Facility
Landfill Gas-Fired Reciprocating Engines 9 and 10
Compliance Test Program Results Summary

Source	Pollutant	Test Result	Emission Limitation
Reciprocating Engine 9	NOx	0.4 g/bhp-hr	0.6 g/bhp-hr
	NOx	2.19 lbs/hr	2.96 lbs/hr
	CO	2.5 g/bhp-hr	3.3 g/bhp-hr
	CO	12.41 lbs/hr	16.25 lbs/hr
	VOC	0.00 g/bhp-hr	0.63 g/bhp-hr
Reciprocating Engine 10	NOx	0.5 g/bhp-hr	0.6 g/bhp-hr
	NOx	2.32 lbs/hr	2.96 lbs/hr
	CO	2.8 g/bhp-hr	3.3 g/bhp-hr
	CO	13.95 lbs/hr	16.25 lbs/hr
	VOC	0.00 g/bhp-hr	0.63 g/bhp-hr

* All VOC emissions were determined to be Methane (CH_4)

Table 4
Engine 9 NOx, VOC, and CO Emission Rates
North American Natural Resources
Venice Park Landfill
BTEC Project No. 13-4424.00
Sampling Date: 9-11-13

Parameter	Run 1	Run 2	Run 3	Average
Test Run Date	9/11/2013	9/11/2013	9/11/2013	
Test Run Time	8:26-9:26	9:55-10:55	11:24-12:24	
Outlet Flowrate (dscfm)	4,467	4,445	4,436	**4,449**
Outlet Flowrate (scfm)	5,065	5,133	5,046	**5,081**
bhp-hr	2,250	2,250	2,250	
Outlet Oxides of Nitrogen Concentration (ppmv)	67.4	69.0	61.3	**65.9**
Outlet NOx Concentration (ppmv, corrected as per USEPA 7E)	71.0	72.3	63.9	**69.1**
NOx Emission Rate (lb/hr)	**2.2**	**2.2**	**1.9**	**2.1**
NOx Emission Rate (lb/hr) (corrected as per USEPA 7E)	**2.3**	**2.3**	**2.0**	**2.19**
Outlet Carbon Monoxide Concentration (ppmv)	628.3	625.6	600.7	**618.2**
Outlet CO Concentration (ppmv, corrected as per USEPA 7E)	651.2	652.4	622.0	**641.9**
CO Emission Rate (lb/hr)	**12.2**	**12.1**	**11.6**	**12.0**
CO Emission Rate (lb/hr) (corrected as per USEPA 7E)	**12.6**	**12.6**	**12.0**	**12.41**
Outlet VOC Concentration (ppmv as propane)	495.9	469.7	481.9	**482.5**
Outlet Methane Concentration (ppmv as methane)	1212.7	1271.9	1318.6	**1267.7**
Outlet VOC Concentration (ppmv, corrected as per USEPA 7E)	506.0	489.6	498.8	**498.1**
Outlet Methane Concentration (ppmv, corrected as per USEPA 7E)	1213.9	1248.3	1268.0	**1243.4**
Outlet VOC Concentration (-Methane)	0.0	0.0	0.0	**0.0**
VOC Emission Rate as Propane (lb/hr)	**0.0**	**0.0**	**0.0**	**0.0**
VOC Emission Rate as Propane(lb/hr) (corrected as per USEPA 7E)	**0.0**	**0.0**	**0.0**	**0.0**
NOX (g/bhp-hr)	0.46	0.46	0.41	**0.44**
CO (g/bhp-hr)	2.55	2.54	2.42	**2.50**
VOC (g/bhp-hr)	0.00	0.00	0.00	**0.00**

NOx Correction			
Co	-0.17	-0.03	0.38
Cma	44.7	44.7	44.7
Cm	42.38	42.66	42.98

CO Correction			
Co	-2.45	-5.28	-3.95
Cma	398	398	398
Cm	383.05	379.58	382.96

VOC Correction			
Co	0.54	0.77	0.69
Cma	497	497	497
Cm	487.09	476.75	480.20

Methane Correction			
Co	0.92	2.65	3.71
Cma	996	996	996
Cm	995.24	1015.36	1036.59

response factor = 2.23
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 (70 °F, 29.92" Hg)
and C_{meas} = concentration as measured (as propane)
[1]emission rate calculated on dry basis
[2]emission rate calculated on wet basis

Table 5
Engine 10 NOx, VOC, and CO Emission Rates
North American Natural Resources
Venice Park Landfill
BTEC Project No. 13-4424.00
Sampling Date: 9-10-13

Parameter	Run 1	Run 2	Run 3	Average
Test Run Date	9/10/2013	9/10/2013	9/10/2013	
Test Run Time	8:59-9:59	10:48-11:48	12:16-13:16	
Outlet Flowrate (dscfm)	5,341	4,673	4,535	**4,850**
Outlet Flowrate (scfm)	6,083	5,384	5,183	**5,550**
bhp-hr	2,250	2,250	2,250	
Outlet Oxides of Nitrogen Concentration (ppmv)	64.3	64.8	67.8	**65.7**
Outlet NOx Concentration (ppmv, corrected as per USEPA 7E)	65.9	65.9	69.8	**67.2**
NOx Emission Rate (lb/hr)	**2.5**	**2.2**	**2.2**	**2.3**
NOx Emission Rate (lb/hr) (corrected as per USEPA 7E)	**2.5**	**2.2**	**2.3**	**2.32**
Outlet Carbon Monoxide Concentration (ppmv)	647.2	632.6	649.1	**643.0**
Outlet CO Concentration (ppmv, corrected as per USEPA 7E)	666.8	651.5	666.3	**661.5**
CO Emission Rate (lb/hr)	**15.0**	**12.9**	**12.8**	**13.6**
CO Emission Rate (lb/hr) (corrected as per USEPA 7E)	**15.5**	**13.2**	**13.1**	**13.95**
Outlet VOC Concentration (ppmv as propane)	437.2	456.5	497.9	**463.9**
Outlet Methane Concentration (ppmv as methane)	1099.0	1117.8	1056.4	**1091.1**
Outlet VOC Concentration (ppmv, corrected as per USEPA 7E)	435.3	452.1	493.0	**460.1**
Outlet Methane Concentration (ppmv, corrected as per USEPA 7E)	1090.5	1107.0	1072.2	**1089.9**
Outlet VOC Concentration (-Methane)	0.0	0.0	0.0	**0.0**
VOC Emission Rate as Propane (lb/hr)	**0.0**	**0.0**	**0.0**	**0.0**
VOC Emission Rate as Propane(lb/hr) (corrected as per USEPA 7E)	**0.0**	**0.0**	**0.0**	**0.0**
NOX (g/bhp-hr)	0.51	0.44	0.46	**0.47**
CO (g/bhp-hr)	3.12	2.67	2.65	**2.81**
VOC (g/bhp-hr)	0.00	0.00	0.00	**0.00**

NOx Correction			
Co	-0.05	0.10	0.99
Cma	44.8	44.8	44.8
Cm	43.68	44.10	43.92

CO Correction			
Co	-1.09	-0.83	4.06
Cma	398	398	398
Cm	385.86	386.18	389.34

VOC Correction			
Co	0.88	0.76	0.75
Cma	497	497	497
Cm	498.97	501.77	501.91

Methane Correction			
Co	-1.04	0.20	0.59
Cma	993	993	993
Cm	1000.63	1002.70	978.48

response factor = 2.23
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 (70 °F, 29.92" Hg)
and C_{meas} = concentration as measured (as propane)
[1]emission rate calculated on dry basis
[2]emission rate calculated on wet basis

FIGURES

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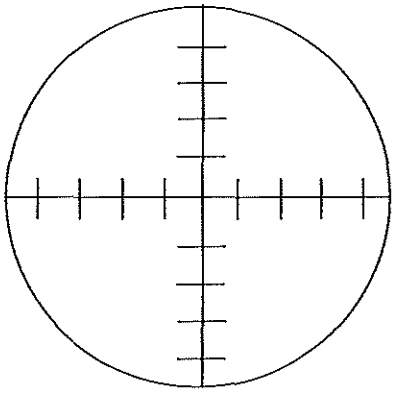
diameter = 13.5 inches

Points	Distance "
1	0.6
2	2.0
3	4.0
4	9.5
5	11.5
6	12.9



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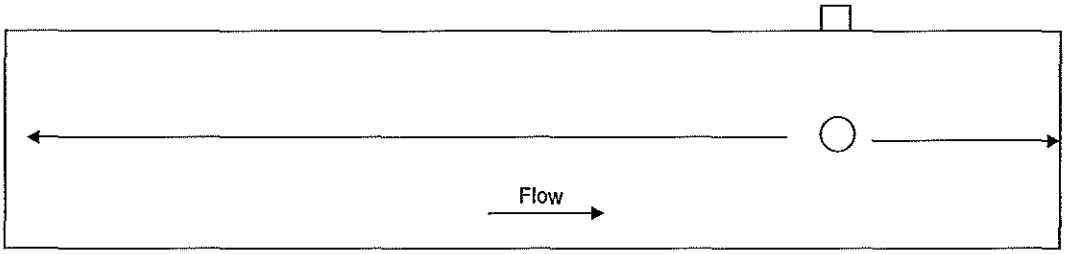

Figure 1

Site: **Engines #9 and #10 Exhaust** **North American Natural Resources** **Birch Run, Michigan**	**Sampling Date:** **September 10 and 11, 2013**	**BT Environmental Consulting, Inc.** **4949 Fernlee Avenue** **Royal Oak, Michigan 48073**

BTEC Inc.

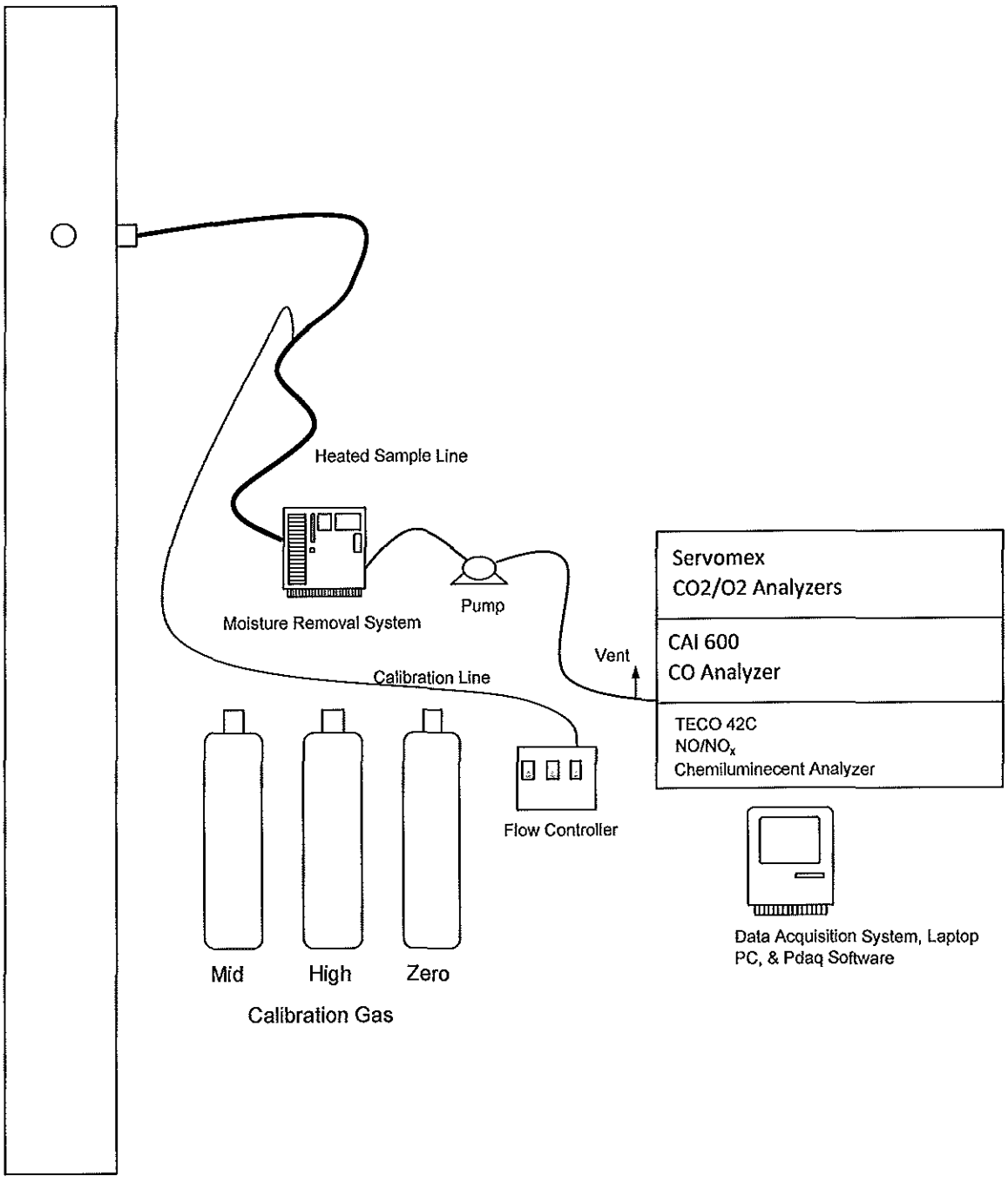

Figure 2

Site: **USEPA Method 3A/7E/10** **North American Natural Resources** **Birch Run, Michigan**	**Sampling Date:** **September 10 and 11, 2013**	**BT Environmental Consulting, Inc.** **4949 Fernlee Avenue** **Royal Oak, Michigan 48073**

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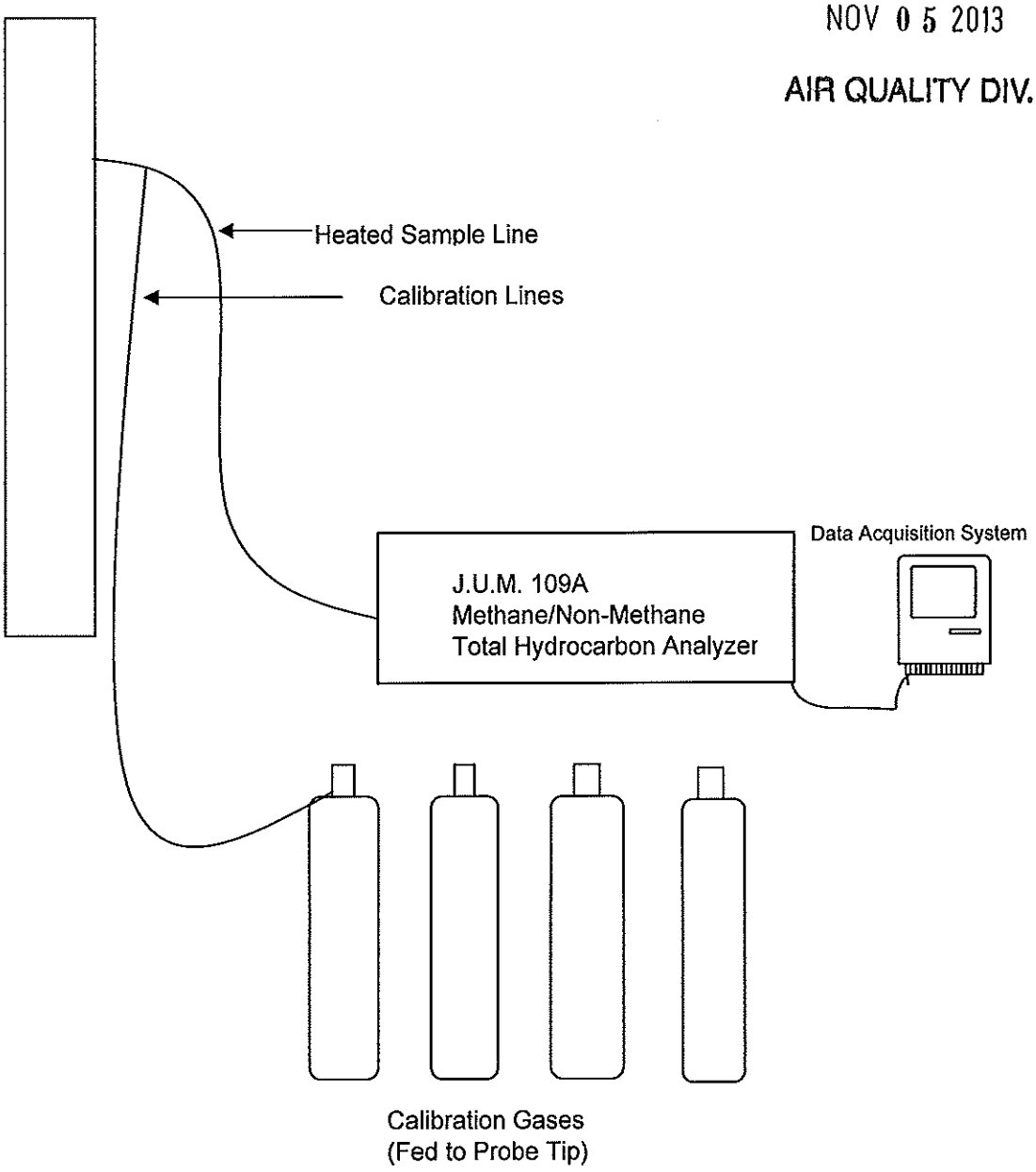

Figure 3

Site: **Sampling Date:** **USEPA Method 25A** **September 10 and 11, 2013** **North American Natural Resources** **Birch Run, Michigan**	**BT Environmental Consulting, Inc.** **4949 Fernlee Avenue** **Royal Oak, Michigan 48073**

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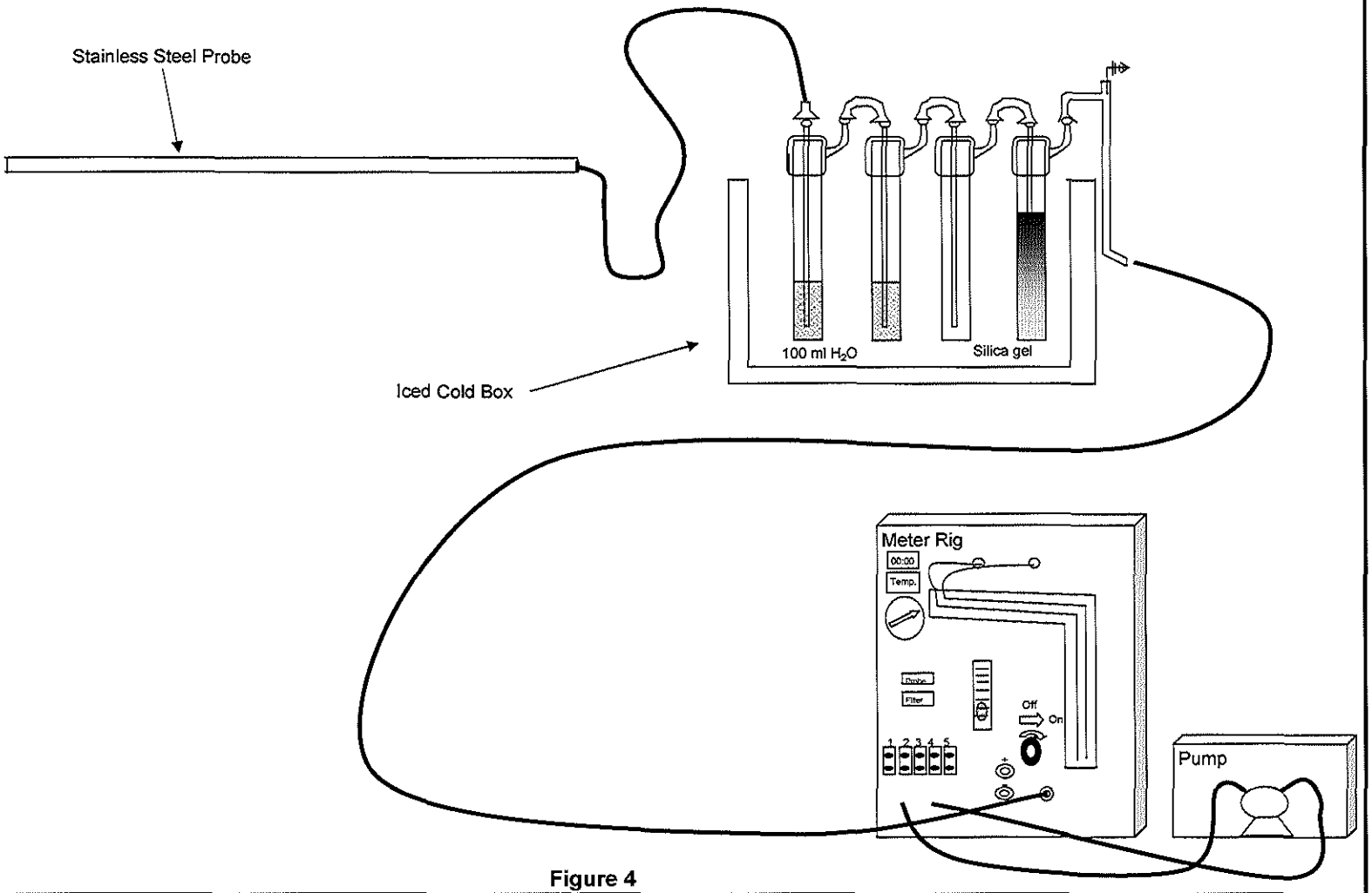

Figure 4

Site:	Sampling Date:	
USEPA Method 4 North American Natural Resources Birch Run, Michigan	September 10 and 11, 2013	BT Environmental Consulting, Inc. 4949 Fernlee Avenue Royal Oak, Michigan 48073