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VOC, CO, and NOx, Emissions Test Report

Prepared for:

North American Natural Resources, Inc.

Birch Run, Michigan

North American Natural Resources
4143 East Rathbun Road
Birch Run, Michigan 48415

Project No. 15-4711.00
August 28, 2015

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

EXECUTIVE SUMMARY

AIR QUALITY DIV.

BT Environmental Consulting, Inc. (BTEC) was retained by North American Natural Resources (NANR) to evaluate oxides of nitrogen (NO_x), carbon monoxide (CO), and volatile organic compounds (VOC) emission rates from five engines located at the North American Natural Resources (NANR) People's Generating Station in Birch Run, Michigan. Field sampling for this emission test program was conducted on June 29-30 and July 1, 2015. 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 five engines at the facility. The emissions test program was required by Michigan Renewable Operating Permit No. MI-ROP-P0415-2015. The results of the emission test program are summarized by Table E-I.

**Table E-I
Overall Emission Rates Summary**

Source	Pollutant	Test Result	Emission Limitation
Engine 1	NO _x	0.66 g/hp-hr	1.5 g/hp-hr
		1.63 lbs/hr	15.43 lbs/hr
	CO	1.88 g/hp-hr	2.7 g/hp-hr
		4.62 lbs/hr	27.77 lbs/hr
	VOC*	0.00 g/hp-hr	0.84 g/hp-hr
0.00 lbs/hr	8.64 lbs/hr		
Engine 2	NO _x	1.23 g/hp-hr	1.5 g/hp-hr
		3.04 lbs/hr	15.43 lbs/hr
	CO	2.00 g/hp-hr	2.7 g/hp-hr
		4.93 lbs/hr	27.77 lbs/hr
	VOC	0.05 g/hp-hr	0.84 g/hp-hr
0.13 lbs/hr		8.64 lbs/hr	
Engine 3	NO _x	0.89 g/hp-hr	1.5 g/hp-hr
		2.19 lbs/hr	15.43 lbs/hr
	CO	2.06 g/hp-hr	2.7 g/hp-hr
		5.09 lbs/hr	27.77 lbs/hr
	VOC*	0.00 g/hp-hr	0.84 g/hp-hr
0.00 lbs/hr		8.64 lbs/hr	
Engine 4	NO _x	0.79 g/hp-hr	1.5 g/hp-hr
		1.93 lbs/hr	15.43 lbs/hr
	CO	1.63 g/hp-hr	2.7 g/hp-hr
		3.99 lbs/hr	27.77 lbs/hr
	VOC	0.01 g/hp-hr	0.84 g/hp-hr
0.01 lbs/hr		8.64 lbs/hr	
Engine 5	NO _x	4.95 lbs/hr	15.43 lbs/hr
	CO	16.07 lbs/hr	27.77 lbs/hr

* All VOC emissions were determined to be Methane (CH₄)

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1. Introduction

BT Environmental Consulting, Inc. (BTEC) was retained by North American Natural Resources (NANR) to evaluate oxides of nitrogen (NO_x), carbon monoxide (CO), and volatile organic compounds (VOC) emission rates from five engines located at the North American Natural Resources (NANR) People's Generating Station in Birch Run, Michigan. Field sampling for this emission test program was conducted on June 29-30 and July 1, 2015. 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" (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 June 29-30 and July 1, 2015 at the North American Natural Resources People's Generating Station in Birch Run, 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 (NO_x), carbon monoxide (CO), and non-methane volatile organic compounds (VOC) emissions from five landfill gas-fired reciprocating engines.

1.b Purpose of Testing

Michigan Renewable Operating Permit (ROP) No. MI-ROP-P0415-2015 includes the emission limitations listed in Table 1. The purpose of the testing was to quantify NO_x, CO, and VOC emission rates in terms of g/bhp-hr. These emission rates will be utilized to demonstrate compliance with ROP No. MI-ROP-P0415-2015 as well as the requirements of Title 40, Part 60, Subpart JJJJ of the Code of Federal Regulations (40 CFR 60, Subpart JJJJ).

1.c Source Description

The People's Generating Station facility includes five landfill gas-fired, spark-ignition, lean-burn reciprocating engines. Engine Nos. 1, 2, 3, and 4 are rated at 1,145 bhp each. Engine No. 5 is rated at 2250 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) 719-1322

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-P0415-2015.

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 are 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

Engine Nos. 1, 2, 3, and 4 are rated at 1,145 bhp each. Engine No. 5 is rated at 2250 bhp.

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 O₂, CO, & CO₂ 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 4-second intervals on a PC equipped with data acquisition software.

A USEPA Method 7E NO₂ to NO conversion efficiency test was performed on July 1, 2015. 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 6.

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.

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 4-8.



5.b Discussion of Results

Emission limitations for the Michigan ROP No. MI-ROP-P0415-2015 are summarized by Table 1. The results of the emissions test program are summarized by Table 3.

5.c Sampling Procedure Variations

During Run 3 on Engine 1 the flame on the J.U.M. 109a VOC analyzer extinguished. The flame was relit and VOC testing was resumed and extended to collect 60 minutes of data.

There was an inlet air filter blockage during Run 1 on Engine 2. The air filter was changed between Run 1 and Run 2. An additional test run was performed on Engine 2, and Run 1 results have been reported in Table 5, but excluded from the average. Analyzer raw data files are provided in Appendix E.

5.d Process or Control Device Upsets

No process upset condition occurred during the emissions test program.

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.

Table 1
Permit No. MI-ROP-N0514-2015 Emission Limitations

Engines	Pollutant	Emission Limitation	Emission Limit Units
1 - 4	NOx	1.5	g/hp-hr
	NOx	15.43	lbs/hr
	CO	2.7	g/hp-hr
	CO	27.77	lbs/hr
	VOC	0.84	g/hp-hr
	VOC	8.64	lbs/hr
5	NOx	5.9	lbs/hr
	CO	25.4	lbs/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 Project Manager	BTEC 4949 Fernlee Royal Oak, MI 48073	(248) 548-8070
Mr. Paul Molenda Environmental Technician	BTEC 4949 Fernlee Royal Oak, MI 48073	(248) 548-8070
Mr. Paul Diven Environmental Technician	BTEC 4949 Fernlee Royal Oak, MI 48073	(248) 548-8070

Table 3
Overall Emission Rates Summary

Source	Pollutant	Test Result	Emission Limitation
Engine 1	NOx	0.66 g/hp-hr	1.5 g/hp-hr
		1.63 lbs/hr	15.43 lbs/hr
	CO	1.88 g/hp-hr	2.7 g/hp-hr
		4.62 lbs/hr	27.77 lbs/hr
	VOC*	0.00 g/hp-hr	0.84 g/hp-hr
		0.00 lbs/hr	8.64 lbs/hr
Engine 2	NOx	1.23 g/hp-hr	1.5 g/hp-hr
		3.04 lbs/hr	15.43 lbs/hr
	CO	2.00 g/hp-hr	2.7 g/hp-hr
		4.93 lbs/hr	27.77 lbs/hr
	VOC	0.05 g/hp-hr	0.84 g/hp-hr
		0.13 lbs/hr	8.64 lbs/hr
Engine 3	NOx	0.89 g/hp-hr	1.5 g/hp-hr
		2.19 lbs/hr	15.43 lbs/hr
	CO	2.06 g/hp-hr	2.7 g/hp-hr
		5.09 lbs/hr	27.77 lbs/hr
	VOC*	0.00 g/hp-hr	0.84 g/hp-hr
		0.00 lbs/hr	8.64 lbs/hr
Engine 4	NOx	0.79 g/hp-hr	1.5 g/hp-hr
		1.93 lbs/hr	15.43 lbs/hr
	CO	1.63 g/hp-hr	2.7 g/hp-hr
		3.99 lbs/hr	27.77 lbs/hr
	VOC	0.01 g/hp-hr	0.84 g/hp-hr
		0.01 lbs/hr	8.64 lbs/hr
Engine 5	NOx	4.95 lbs/hr	15.43 lbs/hr
	CO	16.07 lbs/hr	27.77 lbs/hr

* All VOC emissions were determined to be Methane (CH₄)

Table 4
Engine 1 NOx, VOC, and CO Emission Rates
North American Natural Resources
Birch Run, MI
BTEC Project No. 15-4711.00
Sampling Date: 6/30/15

Parameter	Run 1	Run 2	Run 3	Average
Test Run Date	6/30/2015	6/30/2015	6/30/2015	
Test Run Time	13:35-14:35	15:05-16:05	16:30-17:30	
VOC Run 3 Test Time**			16:30-17:07 17:25-17:48	
Outlet Flowrate (dsefm)	2,241	2,196	2,197	2,211
Outlet Flowrate (sefm)	2,602	2,551	2,534	2,562
bhp	1,118	1,112	1,120	1,117
Outlet Oxides of Nitrogen Concentration (ppmv)	102.74	113.89	98.07	104.90
Outlet NOx Concentration (ppmv, corrected as per USEPA 7E)	100.59	111.97	96.73	103.10
NOx Emission Rate (lb/hr)	1.64	1.79	1.54	1.66
NOx Emission Rate (lb/hr) (corrected as per USEPA 7E)	1.61	1.76	1.52	1.63
Outlet Carbon Monoxide Concentration (ppmv)	467.62	476.97	452.79	465.79
Outlet CO Concentration (ppmv, corrected as per USEPA 7E)	480.20	491.25	470.09	480.52
CO Emission Rate (lb/hr)	4.56	4.55	4.32	4.48
CO Emission Rate (lb/hr) (corrected as per USEPA 7E)	4.68	4.69	4.49	4.62
Outlet VOC Concentration (ppmv as propane)	390.29	382.80	391.62	388.24
Outlet Methane Concentration (ppmv as methane)	922.30	894.68	971.98	929.65
Outlet VOC Concentration (ppmv, corrected as per USEPA 7E)	396.76	386.93	394.32	392.67
Outlet Methane Concentration (ppmv, corrected as per USEPA 7E)	928.71	886.87	954.98	923.52
Outlet VOC Concentration (-Methane) *	0.00	0.00	0.00	0.00
Outlet Methane Concentration (-Methane, corrected as per USEPA 7E) *	0.00	0.00	0.00	0.00
VOC Emission Rate as Propane (lb/hr)*	0.00	0.00	0.00	0.00
VOC Emission Rate as Propane(lb/hr) (corrected as per USEPA 7E)*	0.00	0.00	0.00	0.00
NOX (g/bhp-hr)	0.65	0.72	0.61	0.66
CO (g/bhp-hr)	1.90	1.91	1.82	1.88
VOC (g/bhp-hr)	0.00	0.00	0.00	0.00

*: Methane subtraction resulted in a negative value, which has been replaced with zero for calculations.

** VOC Run 3 run time: 16:30-17:07; 17:25-17:48 due to FID flameout

response factor = 2.29

sefm = standard cubic feet per minute

dsefm = 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, C₃H₈ = 44.10)

24.14 = molar volume of air at standard conditions (70°F, 29.92" Hg)

35.31 = ft³ per m³

453600 = mg per lb

g/bhp-hr = grams per brake horse power hour

Equations

$$\text{lb/hr} = \text{ppmv} * \text{MW}/24.14 * 1/35.31 * 1/453,600 * \text{sefm} * 60 \text{ for VOC}$$

$$\text{lb/hr} = \text{ppmv} * \text{MW}/24.14 * 1/35.31 * 1/453,600 * \text{dsefm} * 60$$

NOx Correction			
Co	2.07	2.07	1.91
Cma	249	249	249
Cm	251.27	250.75	249.45

CO Correction			
Co	-1.08	-0.78	-1.54
Cma	497	497	497
Cm	484.02	482.56	478.80

VOC Correction			
Co	1.73	1.37	1.23
Cma	498	498	498
Cm	489.44	492.30	494.27

Methane Correction			
Co	5.56	4.57	3.61
Cma	996	996	996
Cm	988.72	1004.21	1013.57

Table 5
 Engine 2 NOx, VOC, and CO Emission Rates
 North American Natural Resources
 Birch Run, MI
 BTEC Project No. 15-4711.00
 Sampling Date: 6/29/15

Parameter	Run 1*	Run 2	Run 3	Run 4	Average
Test Run Date	6/29/2015	6/29/2015	6/29/2015	6/30/2015	
Test Run Time	14:00-15:00	15:25-16:25	16:50-17:50	18:15-19:15	
Outlet Flowrate (dscfm)	2,103	2,113	2,100	2,138	2,117
Outlet Flowrate (scfm)	2,425	2,418	2,439	2,452	2,436
bhp	1,124	1,119	1,120	1,121	1,120
Outlet Oxides of Nitrogen Concentration (ppmv)	510.80	243.69	182.90	159.70	195.43
Outlet NOx Concentration (ppmv, corrected as per USEPA 7E)	532.54	250.33	189.06	165.11	201.50
NOx Emission Rate (lb/hr)	7.67	3.68	2.74	2.44	2.95
NOx Emission Rate (lb/hr) (corrected as per USEPA 7E)	8.00	3.78	2.83	2.52	3.04
Outlet Carbon Monoxide Concentration (ppmv)	668.51	536.39	502.66	484.73	507.93
Outlet CO Concentration (ppmv, corrected as per USEPA 7E)	692.96	564.90	530.18	512.30	535.79
CO Emission Rate (lb/hr)	6.11	4.93	4.59	4.50	4.67
CO Emission Rate (lb/hr) (corrected as per USEPA 7E)	6.33	5.19	4.84	4.76	4.93
Outlet VOC Concentration (ppmv as propane)	307.74	410.98	457.10	465.87	444.65
Outlet Methane Concentration (ppmv as methane)	679.16	930.96	1025.37	1052.27	1002.87
Outlet VOC Concentration (ppmv, corrected as per USEPA 7E)	311.50	426.26	468.12	473.81	456.06
Outlet Methane Concentration (ppmv, corrected as per USEPA 7E)	682.89	957.62	1044.23	1062.74	1021.53
Outlet VOC Concentration (-Methane)	9.86	2.66	7.38	4.35	4.80
Outlet Methane Concentration (-Methane, corrected as per USEPA 7E)	11.98	6.25	10.12	7.70	8.02
VOC Emission Rate as Propane (lb/hr)	0.16	0.04	0.12	0.07	0.08
VOC Emission Rate as Propane(lb/hr) (corrected as per USEPA 7E)	0.20	0.10	0.17	0.13	0.13
NOX (g/bhp-hr)	3.23	1.53	1.15	1.02	1.23
CO (g/bhp-hr)	2.56	2.10	1.96	1.93	2.00
VOC (g/bhp-hr)	0.08	0.04	0.07	0.05	0.05

* Not included in average due to inlet air filter blockage
 response factor = 2.28
 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, C₃H₈ = 44.10)
 24.14 = molar volume of air at standard conditions (70°F, 29.92" Hg)
 35.31 = ft³ per m³
 453600 = mg per lb
 g/bhp-hr = grams per brake horse power hour

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 * dscfm * 60

NOx Correction				
Co	2.19	1.97	1.16	0.65
Cma	249	249	249	249
Cm	240.00	242.41	240.52	240.51

CO Correction				
Co	-4.26	-6.45	-7.83	-8.77
Cma	499	499	499	499
Cm	480.20	473.07	472.64	471.92

VOC Correction				
Co	1.23	2.74	3.43	3.79
Cma	498	498	498	498
Cm	491.26	479.69	486.06	489.46

Methane Correction				
Co	3.67	6.94	8.25	8.28
Cma	996	996	996	996
Cm	988.87	967.99	978.39	986.71

Table 6
Engine 3 NOx, VOC, and CO Emission Rates
North American Natural Resources
Birch Run, MI
BTEC Project No. 15-4711.00
Sampling Date: 6/30/15

Parameter	Run 1	Run 2	Run 3	Average
Test Run Date	6/30/2015	6/30/2015	6/30/2015	
Test Run Time	9:00-10:00	10:35-11:35	12:00-13:00	
Outlet Flowrate (dscfm)	2,320	2,344	2,305	2,323
Outlet Flowrate (scfm)	2,651	2,719	2,677	2,682
bhp	1,121	1,120	1,122	1,121
Outlet Oxides of Nitrogen Concentration (ppmv)	104.65	111.98	180.84	132.49
Outlet NOx Concentration (ppmv, corrected as per USEPA 7E)	106.07	110.96	179.74	132.26
NOx Emission Rate (lb/hr)	1.73	1.87	2.98	2.19
NOx Emission Rate (lb/hr) (corrected as per USEPA 7E)	1.76	1.86	2.96	2.19
Outlet Carbon Monoxide Concentration (ppmv)	472.14	479.40	534.67	495.40
Outlet CO Concentration (ppmv, corrected as per USEPA 7E)	477.80	488.00	546.11	503.97
CO Emission Rate (lb/hr)	4.76	4.88	5.36	5.00
CO Emission Rate (lb/hr) (corrected as per USEPA 7E)	4.82	4.97	5.47	5.09
Outlet VOC Concentration (ppmv as propane)	489.37	509.19	442.44	480.33
Outlet Methane Concentration (ppmv as methane)	1137.58	1228.64	1066.30	1144.17
Outlet VOC Concentration (ppmv, corrected as per USEPA 7E)	491.59	518.03	455.33	488.32
Outlet Methane Concentration (ppmv, corrected as per USEPA 7E)	1133.67	1221.24	1064.97	1139.96
Outlet VOC Concentration (-Methane) *	0.00	0.00	0.00	0.00
Outlet Methane Concentration (-Methane, corrected as per USEPA 7E) *	0.00	0.00	0.00	0.00
VOC Emission Rate as Propane (lb/hr)*	0.00	0.00	0.00	0.00
VOC Emission Rate as Propane(lb/hr) (corrected as per USEPA 7E)*	0.00	0.00	0.00	0.00
NOx (g/bhp-hr)	0.71	0.75	1.20	0.89
CO (g/bhp-hr)	1.95	2.01	2.21	2.06
VOC (g/bhp-hr)	0.00	0.00	0.00	0.00

NOx Correction			
Co	1.35	2.38	2.41
Cma	249	249	249
Cm	243.85	248.34	249.60

CO Correction			
Co	0.90	0.95	-0.39
Cma	497	497	497
Cm	491.08	488.23	486.55

VOC Correction			
Co	3.81	3.21	1.94
Cma	498	498	498
Cm	495.70	489.63	483.72

Methane Correction			
Co	8.43	7.15	5.08
Cma	996	996	996
Cm	1000.46	1003.35	997.57

*: Methane subtraction resulted in a negative value, which has been replaced with zero for calculations.

response factor = 2.29

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, C₃H₈ = 44.10)

24.14 = molar volume of air at standard conditions (70°F, 29.92" Hg)

35.31 = ft³ per m³

453600 = mg per lb

g/bhp-hr = grams per brake horse power hour

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 * dscfm * 60

Table 7
Engine 4 NOx, VOC, and CO Emission Rates
North American Natural Resources
Birch Run, MI
BTEC Project No. 15-4711.00
Sampling Date: 7/1/15

Parameter	Run 1	Run 2	Run 3	Average
Test Run Date	7/1/2015	7/1/2015	7/1/2015	
Test Run Time	9:05-10:05	10:30-11:30	11:55-12:55	
Outlet Flowrate (dscfm)	2,320	2,310	2,279	2,303
Outlet Flowrate (scfm)	2,676	2,649	2,650	2,658
bhp	1,119	1,117	1,102	1,113
Outlet Oxides of Nitrogen Concentration (ppmv)	108.90	114.95	125.97	116.61
Outlet NOx Concentration (ppmv, corrected as per USEPA 7E)	111.02	115.47	125.68	117.39
NOx Emission Rate (lb/hr)	1.80	1.90	2.05	1.92
NOx Emission Rate (lb/hr) (corrected as per USEPA 7E)	1.84	1.90	2.05	1.93
Outlet Carbon Monoxide Concentration (ppmv)	391.12	394.74	399.78	395.21
Outlet CO Concentration (ppmv, corrected as per USEPA 7E)	393.26	398.71	403.31	398.42
CO Emission Rate (lb/hr)	3.94	3.96	3.96	3.96
CO Emission Rate (lb/hr) (corrected as per USEPA 7E)	3.97	4.00	4.00	3.99
Outlet VOC Concentration (ppmv as propane)	489.37	501.84	491.02	494.08
Outlet Methane Concentration (ppmv as methane)	1132.18	1214.78	1231.22	1192.73
Outlet VOC Concentration (ppmv, corrected as per USEPA 7E)	484.93	496.87	491.12	490.97
Outlet Methane Concentration (ppmv, corrected as per USEPA 7E)	1115.51	1204.09	1214.47	1178.02
Outlet VOC Concentration (-Methane) *	0.00	0.00	0.00	0.00
Outlet Methane Concentration (-Methane, corrected as per USEPA 7E) *	2.03	0.00	0.00	0.68
VOC Emission Rate as Propane (lb/hr)*	0.00	0.00	0.00	0.00
VOC Emission Rate as Propane(lb/hr) (corrected as per USEPA 7E)*	0.04	0.00	0.00	0.01
NOx (g/bhp-hr)	0.75	0.77	0.84	0.79
CO (g/bhp-hr)	1.61	1.63	1.64	1.63
VOC (g/bhp-hr)	0.02	0.00	0.00	0.01

NOx Correction			
Co	1.08	1.38	2.26
Cma	249	249	249
Cm	242.91	246.29	247.36

CO Correction			
Co	0.41	-0.26	-1.10
Cma	497	497	497
Cm	494.19	492.12	492.91

VOC Correction			
Co	1.47	2.19	1.95
Cma	498	498	498
Cm	502.52	502.98	497.87

Methane Correction			
Co	5.00	5.89	4.95
Cma	996	996	996
Cm	1011.42	1005.86	1010.63

*. Methane subtraction resulted in a negative value, which has been replaced with zero for calculations.

response factor = 2.31

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, C₃H₈ = 44.10)

24.14 = molar volume of air at standard conditions (70°F, 29.92" Hg)

35.31 = ft³ per m³

453600 = mg per lb

g/bhp-hr = grams per brake horse power hour

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 * dscfm * 60

Table 8
Engine 5 NOx, VOC, and CO Emission Rates
North American Natural Resources
Birch Run, MI
BTEC Project No. 15-4711.00
Sampling Date: 7/1/15

Parameter	Run 1	Run 2	Run 3	Average
Test Run Date	7/1/2015	7/1/2015	7/1/2015	
Test Run Time	13:40-14:40	15:10-16:10	16:40-17:40	
Outlet Flowrate (dscfm)	4,612	4,586	4,637	4,612
Outlet Flowrate (scfm)	5,277	5,289	5,349	5,305
bhp	2,224	2,230	2,230	2,228
Outlet Oxides of Nitrogen Concentration (ppmv)	152.18	152.38	147.29	150.62
Outlet NOx Concentration (ppmv, corrected as per USEPA 7E)	151.28	152.31	147.83	150.47
NOx Emission Rate (lb/hr)	5.01	4.99	4.88	4.96
NOx Emission Rate (lb/hr) (corrected as per USEPA 7E)	4.98	4.99	4.89	4.95
Outlet Carbon Monoxide Concentration (ppmv)	795.62	790.20	794.73	793.52
Outlet CO Concentration (ppmv, corrected as per USEPA 7E)	802.92	799.95	802.25	801.70
CO Emission Rate (lb/hr)	15.95	15.75	16.02	15.91
CO Emission Rate (lb/hr) (corrected as per USEPA 7E)	16.10	15.95	16.17	16.07
Outlet VOC Concentration (ppmv as propane)	494.42	491.59	512.31	499.44
Outlet Methane Concentration (ppmv as methane)	1226.55	1255.19	1282.41	1254.72
Outlet VOC Concentration (ppmv, corrected as per USEPA 7E)	497.14	497.75	513.29	502.73
Outlet Methane Concentration (ppmv, corrected as per USEPA 7E)	1202.75	1235.39	1271.24	1236.46
Outlet VOC Concentration (-Methane) *	0.00	0.00	0.00	0.00
Outlet Methane Concentration (-Methane, corrected as per USEPA 7E) *	0.00	0.00	0.00	0.00
VOC Emission Rate as Propane (lb/hr)*	0.00	0.00	0.00	0.00
VOC Emission Rate as Propane(lb/hr) (corrected as per USEPA 7E)*	0.00	0.00	0.00	0.00
NOx (g/bhp-hr)	1.02	1.01	1.00	1.01
CO (g/bhp-hr)	3.28	3.24	3.29	3.27
VOC (g/bhp-hr)	0.00	0.00	0.00	0.00

*: Methane subtraction resulted in a negative value, which has been replaced with zero.
response factor = 2.31
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, C₃H₈ = 44.10)
24.14 = molar volume of air at standard conditions (70°F, 29.92" Hg)
35.31 = ft³ per m³
453600 = mg per lb
g/bhp-hr = grams per brake horse power hour

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 * dscfm * 60

NOx Correction			
Co	2.53	2.00	1.83
Cma	249	249	249
Cm	248.86	247.86	246.83

CO Correction			
Co	-1.68	-1.07	0.14
Cma	497	497	497
Cm	491.85	490.54	492.40

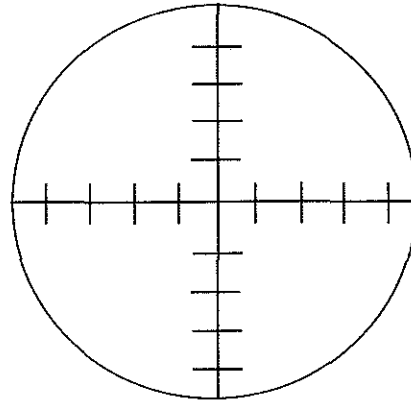
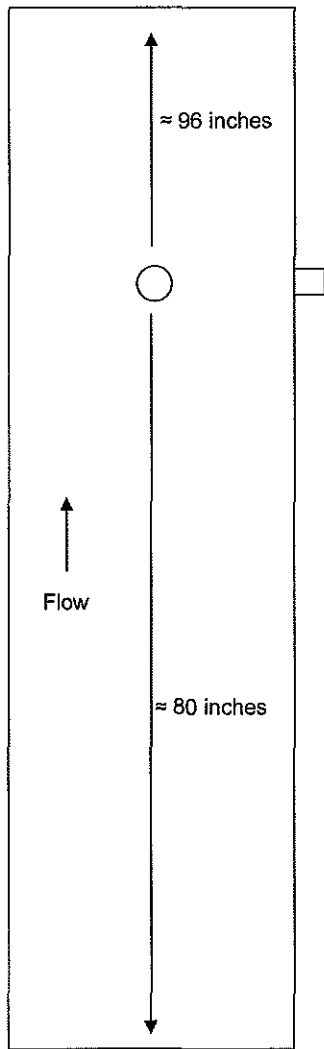
VOC Correction			
Co	2.82	3.11	2.51
Cma	498	498	498
Cm	495.27	491.84	497.12

Methane Correction			
Co	7.98	7.06	2.97
Cma	996	996	996
Cm	1017.08	1013.33	1005.40

Figures



diameter = 10 inches



Not to Scale

Points	Distance "
1	0.3
2	1.1
3	1.9
4	3.2
5	6.8
6	8.1
7	9.0
8	9.7

Engines 1-4 all have identical exhaust stack dimensions

Figure No. 1

Site: Engine 1 - Engine 4 Exhausts
North American Natural Resources
Birch Run, Michigan

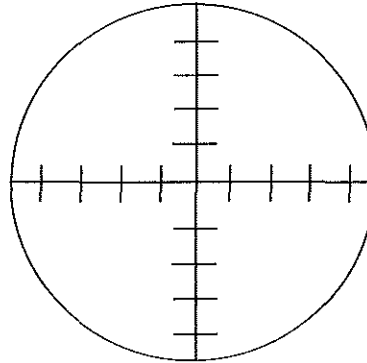
Sampling Date: June 29-30 and July 1, 2015

BT Environmental Consulting, Inc.
4949 Fernlee Avenue
Royal Oak, Michigan 48073



diameter = 14 inches

Points	Distance "
1	0.4
2	1.5
3	2.7
4	4.5
5	9.5
6	11.3
7	12.5
8	13.6



Not to Scale

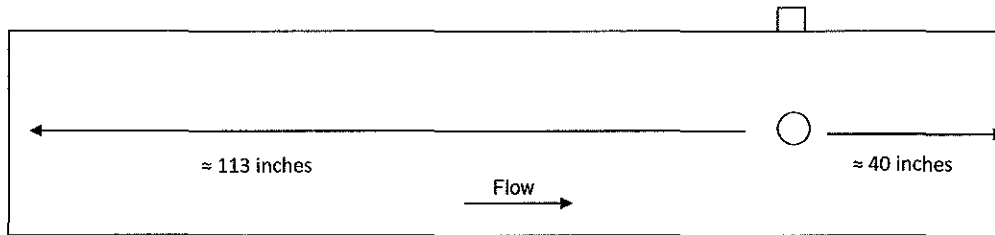


Figure No. 2

Site:
Engine 5 Exhaust
North American Natural Resources
Birch Run, Michigan

Sampling Date:
June 29-30 and July 1, 2015

BT Environmental Consulting, Inc.
4949 Fernlee Avenue
Royal Oak, Michigan 48073

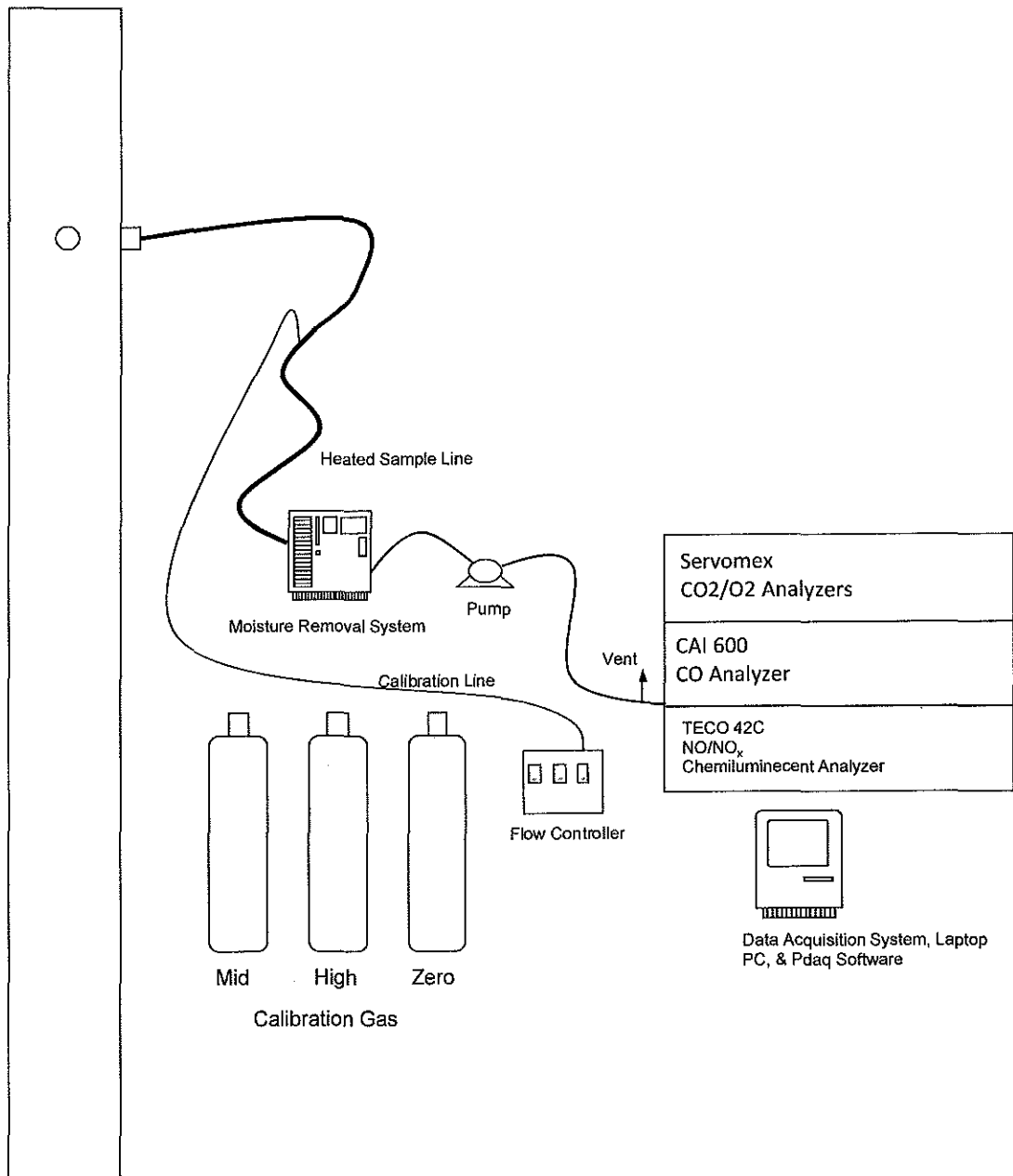


Figure 3

Site:
USEPA Method 3A/7E/10
North American Natural Resources
Buchanan, Michigan

Sampling Date:
June 29-30 and July 1, 2015

BT Environmental Consulting, Inc.
4949 Fernlee Avenue
Royal Oak, Michigan 48073

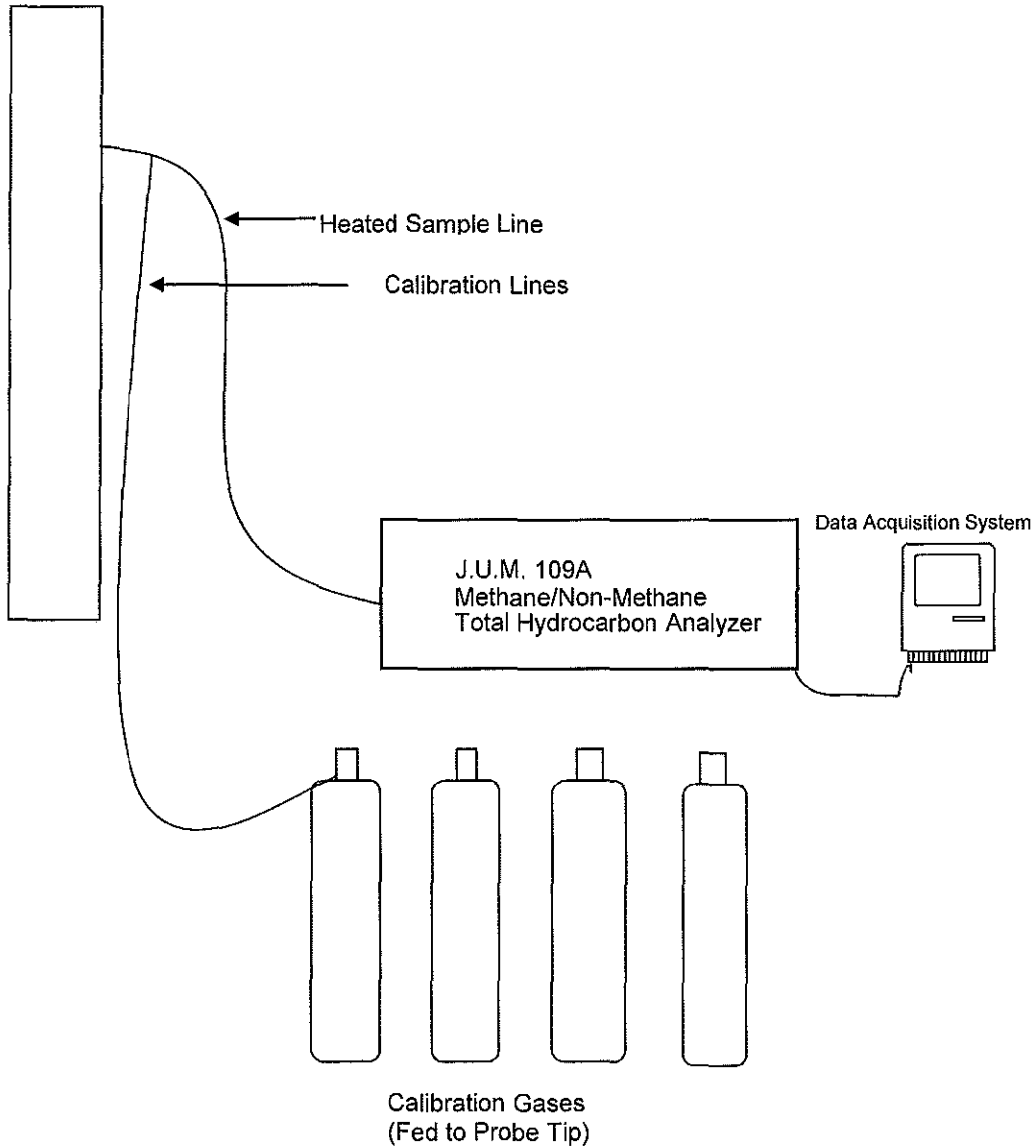
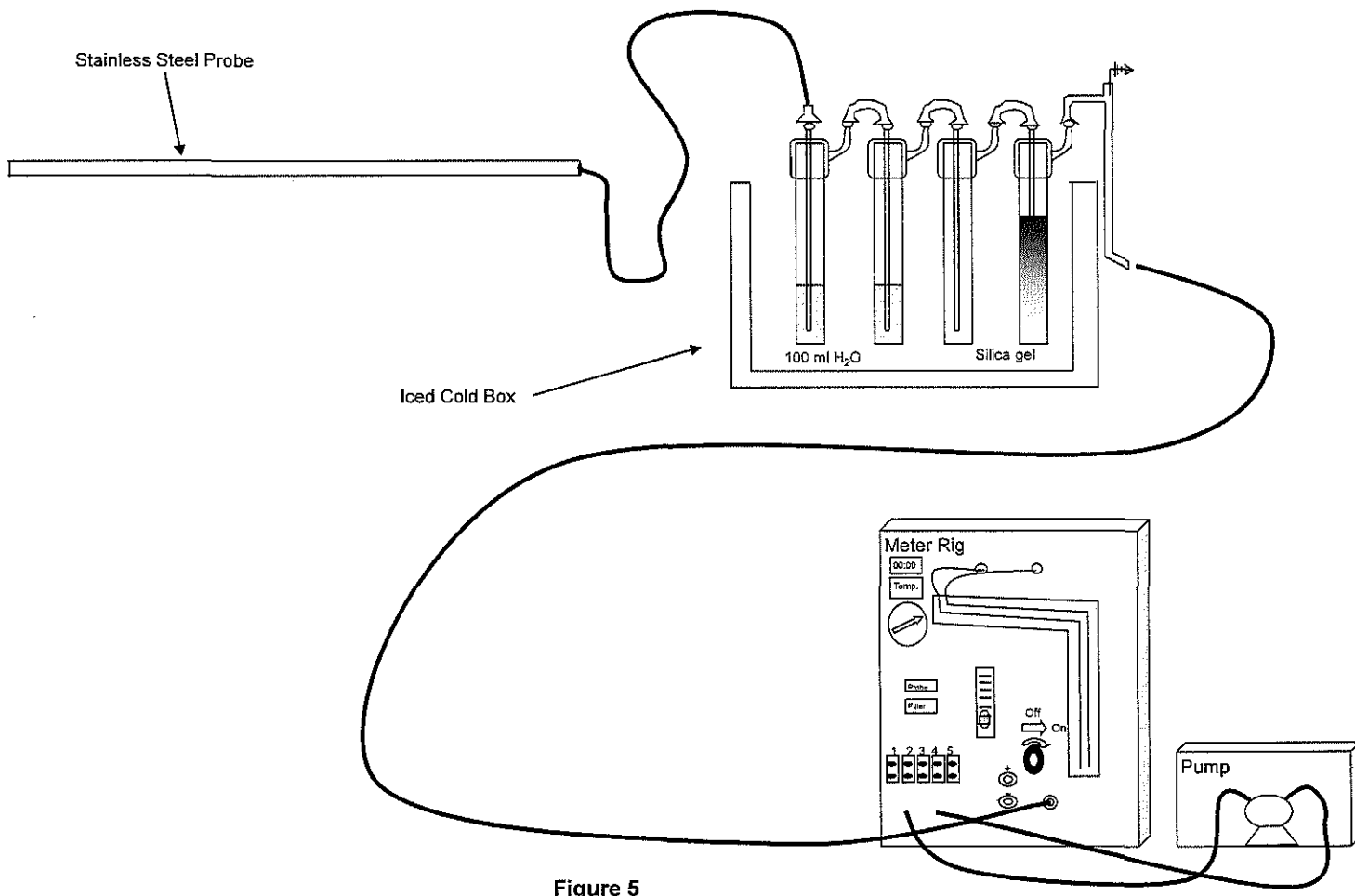


Figure 4

Site:
USEPA Method 25A
North American Natural Resources
Buchanan, Michigan

Sampling Date:
June 29-30 and July 1, 2015

BT Environmental Consulting, Inc.
4949 Fernlee Avenue
Royal Oak, Michigan 48073



Stainless Steel Probe

Iced Cold Box

100 ml H₂O

Silica gel

Meter Rig

00:00

Temp.

Flow

Filter

ON

OFF

1 2 3 4 5

+

-

Pump

Figure 5

Site:
USEPA Method 4
North American Natural Resources
Buchanan, Michigan

Sampling Date:
June 29-30 and July 1, 2015

BT Environmental Consulting, Inc.
4949 Fernlee Avenue
Royal Oak, Michigan 48073

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