BTEC Inc.

Riverview Turbine and Landfill Gas Emissions Report

Prepared for:

Riverview Energy Systems, LLC

Riverview, Michigan

Project No. 049AS-226818
January 31, 2018

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

EXECUTIVE SUMMARY

BT Environmental Consulting, Inc. (BTEC) was retained by DTE Energy Services (DTEES) to evaluate nitrogen oxides (NOx) and carbon monoxide (CO) emission rates from two turbines at the Riverview Energy Systems, LLC (RES) located in Riverview, Michigan. The two turbines were also tested for total hydrogen chloride (HCl) on the inlet gas stream. The emissions test program was conducted on December 14, 2017.

Testing of the two turbines consisted of triplicate 60-minute test runs for NO_x and CO on each of the two turbines and triplicate 60-minute test runs for Cl_2 on the inlet. The emissions test program was required by 40 CFR 75, Appendix E. The results of the emission test program are summarized by Table 1.

Table I
RES Turbines 1 &2
Test Date: December 14, 2017

Source	Pollutant	Emissions
Inlet	HCl	4.97E-03 lbs/hr
Turbine 1	NO_x	25.1 tpy
Turbine 1	CO	2.6 pph
Turbine 2	NO_x	27.6 tpy
Turbine 2	CO	2.7 pph

1. Introduction

BT Environmental Consulting, Inc. (BTEC) was retained by DTE Energy Services (DTEES) to evaluate nitrogen oxides (NOx) and carbon monoxide (CO) emission rates from two turbines at the Riverview Energy Systems, LLC (RES) located in Riverview, Michigan. The two turbines were also tested for total hydrogen chloride (HCl) on the inlet gas stream. The emissions test program was conducted on December 14, 2017.

AQD has published a guidance document entitled "Format for Submittal of Source Emission Test Plans and Reports" (December 2013). The following is a summary of the emissions test program and results in the format suggested by the aforementioned document.

1.a Identification, Location, and Dates of Test

Sampling and analysis for the emission test program was conducted on October 20, 2017 at the GWEC facility located in Avoca, Michigan. The test program included evaluation of NOx and CO emissions from peaker unit 11-1.

1.b Purpose of Testing

AQD issued Renewable Operating Permit No. MI-ROP-M4469-2015a to RES. This permit limits emissions from each turbine as summarized by Table 1.

Table 1
CO, NO_x, and HCl Emission Limitations
Riverview Energy Systems

Source	Permit No.	Pollutant	Emission Limits
Inlet	MI-ROP-M4469-2015a	HCl	2.05 pph
Turbine 1	MI-ROP-M4469-2015a	NO_x	64.6 tpy
Turbine 1	MI-ROP-M4469-2015a	CO	15.78 pph
Turbine 2	MI-ROP-M4469-2015a	NO_x	64.6 tpy
Turbine 2	MI-ROP-M4469-2015a	CO	15.78 pph

1.c Source Description

Combustion turbines consume landfill gas for the generation of electricity. Each Solar gas turbine operates at a maximum flow rate of 3.8 MMscf/day and has a heat input design capacity of 56.33 MMBtu/hr.

1.d Test Program Contacts

The contact for the source and test report is:

Mr. Rob Sanch
Riverview Energy Systems, LLC.
Environmental Supervisor
414 South Main Street
Suite 600
Ann Arbor, Michigan 48104
(734) 302-5392

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

Table 2
Test Personnel

Name and Title	Affiliation	Telephone
Mr. Nick Diedrich, P.E. Senior Environmental Engineer	414 South Main St. Suite 600 Ann Arbor, MI 48104	(734)302-5392
Mr. Mark Dziadosz Environmental Quality Analyst	MDEQ Air Quality Division	(586) 753-3745
Mr. Matthew Young Project Manager	BTEC 4949 Fernlee Royal Oak, MI 48073	(586)744-9133
Mr. Mason Sakshaug Field Technician	BTEC 4949 Fernlee Royal Oak, MI 48073	(989)323-0355

2. Summary of Results

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

2.a Operating Data

Process data to be collected during testing will include fuel flowrate (pounds per second), power generation (MW), inlet guide vane angle (%), compressor discharge temperature

(°F), compressor discharge pressure (psi), and exhaust temperature (°F).

2.b Applicable Permit

The applicable permit for this emissions test program is Renewable Operating Permit No. MI-ROP-M4469-2015a.

2.c Results

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

3. Source Description

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

3.a Process Description

Combustion turbines consume landfill gas for the generation of electricity. Each Solar gas turbine operates at a maximum flow rate of 3.8 MMscf/day and has a heat input design capacity of 56.33 MMBtu/hr.

3.b Process Flow Diagram

Due to the simplicity of the Peaker unit, a process flow diagram is not necessary.

3.c Raw and Finished Materials

The raw material used by the process is landfill gas. The limit for landfill gas combusted is 7.6 MMscf/day.

3.d Process Capacity

Each turbine has a maximum flow rate of 3.8 MMscf/day and has a heat input design capacity of 56.33 MMBtu/hr.

3.e Process Instrumentation

Process data to be collected during testing will include fuel flowrate (pounds per second), power generation (MW), inlet guide vane angle (%), compressor discharge temperature (°F), compressor discharge pressure (psi), and exhaust temperature (°F).

4. Sampling and Analytical Procedures

Sections 4.a through 4.d provide a summary of the sampling and analytical procedures used.

4.a Sampling Train and Field Procedures

The following U.S. EPA reference test methods found in 40 CFR, Part 60, Appendix A were used:

- 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" (Analyzer)*
- Method 4 - *"Determination of Moisture Content in Stack Gases"*

Stack gas velocity traverses were conducted in accordance with the procedures outlined in Method 1 and Method 2. S-type pitot tubes with thermocouple assemblies, calibrated in accordance with Method 2 were used to measure exhaust gas velocity pressures (using a manometer) and temperatures during testing. The s-type pitot tube dimensions were within specified limits, therefore, a baseline pitot tube coefficient of 0.84 (dimensionless) were assigned.

Cyclonic flow checks were performed at the sampling location. The existence of cyclonic flow is determined by measuring the flow angle at each sample point. The flow angle is the angle between the direction of flow and the axis of the stack. If the average of the absolute values of the flow angles is greater than 20 degrees, cyclonic flow exists.

Molecular weight determinations were evaluated according to USEPA Method 3A, "Gas Analysis for the Determination of Dry Molecular Weight." The equipment used for this evaluation consisted of a 4100 Servomex CO_2/O_2 analyzer.

Exhaust gas moisture content was evaluated using Method 4. Exhaust gas was extracted as part of the moisture sampling (see Section 3.2) and passed through (i) two impingers, each with 100 ml deionized water, (ii) an empty impinger, and (iii) an impinger filled with silica gel. Exhaust gas moisture content was then determined gravimetrically.

USEPA Method 7E was used to determine the NO_x concentrations; BTEC used a zero gas along with US EPA protocol 1 calibration gases with 40-60%, and 80-100% of the span value. Prior to the start of testing a NO to NO_2 conversion efficiency test was performed.

USEPA Method 10 was used to determine the CO concentrations; BTEC used a zero gas along with USEPA protocol 1 calibration gases with 40-60%, and 80-100% of the span value.

USEPA Method 26, "*Determination of Hydrogen Halide and Halogen Emissions from Stationary Sources*" was used to evaluate Cl_2 concentrations. The Method 26 sampling train consists of: (1) a teflon liner; (2) a set of four mini impingers with the first two each containing 15 ml of 0.1 Normal Sulfuric Acid (0.1 N H_2SO_4) and the second two containing 15 ml of 0.1 N Sodium Hydroxide (NaOH), (3) a mini impinger containing a known weight of silica gel desiccant; (4) a length of sample line, and (5) a Nutech control case equipped with a pump, dry gas meter, and calibrated orifice. Figure 5 provides an illustration of the Method 26 sample train.

After completion of the final leak test for each test run, the impinger train was carefully disassembled. The teflon sample line was rinsed with deionized water (DI H_2O) and added to the sample jar. The liquid volume of each impinger was measured gravimetrically and any mass increase was noted on field sheets. The impinger catch solutions will then be transferred to pre-cleaned sample containers. The impingers were triple rinsed with DI H_2O, and the rinses added to the H_2SO_4 sample container for the first two impingers. Then the second set of NaOH impingers were triple rinsed with DI H_2O and added to the NaOH sample container.

BTEC labeled each container with the test number, test location, and test date, and marked the level of liquid on the outside of the container. In addition, blank samples of the DI water, H_2SO_4, and NaOH were collected. DI water, H_2SO_4, and NaOH samples were delivered to Enthalpy Labs in Durham, North Carolina for analysis.

4.b Recovery and Analytical Procedures

Samples were recovered in accordance with USEPA Method 26 and were sent to Enthalpy Labs in Durham, North Carolina for analysis.

4.c Sampling Ports

Figures 1 and 2 show relevant sampling ports and traverse point locations.

4.d Traverse Points

The traverse points are included in the stack drawings as figures 1 and 2.

5. Test Results and Discussion

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

5.a Results Tabulation

The overall results of the emissions test program are summarized by Table 3. Detailed results for the emissions test program are summarized by Tables 4-6.

Table 3
Riverview Energy Systems Overall Emission Summary
Test Date: December 14, 2017

Source	Pollutant	Emissions
Inlet	HCl	4.97E-03 lbs/hr
Turbine 1	NO_x	25.1 tpy
Turbine 1	CO	2.6 pph
Turbine 2	NO_x	27.6 tpy
Turbine 2	CO	2.7 pph

5.b Discussion of Results

The overall results of the emission test program are summarized by Table 3 (see Section 5.a and detailed in tables 4-6.

5.c Sampling Procedure Variations

A 60 liter tedlar bag was filled via a valve from the inlet of the turbines. The meter pulled at a constant rate from the tedlar bag for 60 minutes for each test. Due to the total HCl output being so low, the blank was not subtracted from the sample results.

5.d Process or Control Device Upsets

No upset conditions occurred during testing.

5.e Control Device Maintenance

There was no control equipment maintenance performed during the emissions test program.

5.f Re-Test

The emissions test program was not a re-test.

5.g Audit Sample Analyses

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

5.h Calibration Sheets

Relevant equipment calibration documents are provided in Appendix B.

5.i Sample Calculations

Sample calculations are provided in Appendix C.

5.j Field Data Sheets

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

5.k Laboratory Data

There are no laboratory results for this test program. Raw CEM data is provided electronically in Appendix E.

Table 4
Landfill Turbine 1 Nox and CO Emission Rates
DTE Energy
Riverview, MI
BTEC Project No. 049AS-2268188
Sampling Dates: 12-14-17

Parameter	Run 1	Run 2	Run 3	Average
Test Run Date	12/14/2017	12/14/2017	12/14/2017	
Test Run Time	12:40	13:55	15:10	
Outlet Flowrate (dscfm)	32,507	33,149	35,334	**33,663**
Oxygen Concentration (%)	16	16	16	**15.7**
Oxygen Concentration (%, drift corrected as per USEPA 7E)	16.1	16.1	16.1	**16.1**
Carbon Dioxide Concentration (%)	4.3	4	4	**4.3**
Carbon Dioxide Concentration (%, drift corrected as per USEPA 7E)	4.4	4.3	4.3	**4.3**
Outlet Oxides of Nitrogen Concentration (ppmv)	23.8	23.7	24.0	**23.8**
Outlet NOx Concentration (ppmv, corrected as per USEPA 7E)	23.7	23.7	24.1	**23.8**
NOx Emission Rate (lb/hr)	5.5	5.6	6.0	**5.7**
NOx Emission Rate (lb/hr) (corrected as per USEPA 7E)	5.5	5.6	6.1	**5.7**
NOx Emission Rate (tpy)	**24.2**	**24.6**	**26.5**	**25.1**
NOx Emission Rate (tpy) (corrected as per USEPA 7E)	**24.0**	**24.5**	**26.7**	**25.1**
Nox	0.00290	0.00292	0.00294	
Outlet Carbon Monoxide Concentration (ppmv)	16.8	17.1	17.0	**17.0**
Outlet CO Concentration (ppmv, corrected as per USEPA 7E)	17.4	17.7	17.6	**17.6**
CO Emission Rate (lb/hr)	**2.4**	**2.5**	**2.6**	**2.5**
CO Emission Rate (lb/hr) (corrected as per USEPA 7E)	**2.5**	**2.6**	2.7	**2.6**

O_2 Correction			
Co	0.09	0.04	0.01
Cma	10.03	10.03	10.03
Cm	9.80	9.77	9.75

CO_2 Correction			
Co	0.14	0.15	0.13
Cma	19.91	19.91	19.91
Cm	19.23	19.20	19.59

NOx Correction			
Co	0.78	0.75	0.39
Cma	48.78	48.78	48.78
Cm	48.26	48.05	48.03

CO Correction			
Co	0.27	0.28	0.22
Cma	51.08	51.08	51.08
Cm	48.76	48.88	48.90

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)
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

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

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

Table 5
Landfill Turbine 2 Nox and CO Emission Rates
DTE Energy
Riverview, MI
BTEC Project No. 049AS-2268188
Sampling Dates: 12-14-17

Parameter	Run 1	Run 2	Run 3	Average
Test Run Date	12/14/2017	12/14/2017	12/14/2017	
Test Run Time	8:15	10:00	11:15	
Outlet Flowrate (dscfm)	35.763	37.552	37.253	**36.856**
Oxygen Concentration (%)	16	16	16	**15.9**
Oxygen Concentration (%, drift corrected as per USEPA 7E)	16.1	16.2	16.3	**16.2**
Carbon Dioxide Concentration (%)	4.1	4	4	**4.1**
Carbon Dioxide Concentration (%, drift corrected as per USEPA 7E)	4.1	4.1	4.1	**4.1**
Outlet Oxides of Nitrogen Concentration (ppmv)	23.8	23.8	23.8	**23.8**
Outlet NOx Concentration (ppmv, corrected as per USEPA 7E)	24.1	24.1	23.8	**24.0**
NOx Emission Rate (lb/hr)	6.1	6.4	6.3	**6.3**
NOx Emission Rate (lb/hr) (corrected as per USEPA 7E)	6.1	6.5	6.3	**6.3**
NOx Emission Rate (tpy)	**26.6**	**28.0**	**27.8**	**27.4**
NOx Emission Rate (tpy) (corrected as per USEPA 7E)	**26.9**	**28.3**	**27.7**	**27.6**
Nox	0.00298	0.00304	0.00306	
Outlet Carbon Monoxide Concentration (ppmv)	16.7	16.3	16.0	**16.3**
Outlet CO Concentration (ppmv, corrected as per USEPA 7E)	17.4	17.3	16.7	**17.1**
CO Emission Rate (lb/hr)	**2.6**	**2.7**	**2.6**	**2.6**
CO Emission Rate (lb/hr) (corrected as per USEPA 7E)	**2.7**	**2.8**	**2.7**	**2.7**
Outlet CO Concentration (ppmv, corrected to 15% O_2)	21.6	21.8	21.5	**21.6**

O_2 Correction			
Co	0.22	0.30	0.16
Cma	10.03	10.03	10.03
Cm	9.92	9.94	9.86

CO2 Correction			
Co	0.07	0.09	0.11
Cma	19.91	19.91	19.91
Cm	19.61	19.56	19.57

NOx Correction			
Co	0.25	0.38	0.58
Cma	48.78	48.78	48.78
Cm	47.90	47.84	48.36

CO Correction			
Co	0.24	0.18	0.19
Cma	51.08	51.08	51.08
Cm	48.50	47.98	48.50

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)
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

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

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
$Conc_{@15\%O2} = Conc * (20.9 - 15)/(20.9 - \%O_2)$

Table 6
Turbine Inlet HCl Emission Rates

Company	**DTE Riverview**			
Source Designation	**Landfill Inlet**			
Test Date	**12/14/2017**	**12/14/2017**	**12/14/2017**	
Meter/Nozzle Information	Run 1	Run 2	Run 3	Average
Meter Temperature Tm (F)	46.6	49.4	47.7	47.9
Meter Pressure - Pm (in. Hg)	29.4	29.4	29.4	29.4
Measured Sample Volume (Vm)	2.3	2.2	2.5	2.3
Sample Volume (Vm-Std ft3)	2.3	2.3	2.6	2.4
Sample Volume (Vm-Std m3)	0.07	0.06	0.07	0.07
Condensate Volume (Vw-std)	0.047	0.047	0.047	0.047
Gas Density (Ps(std) lbs/ft3) (wet)	0.0719	0.0718	0.0719	0.0719
Gas Density (Ps(std) lbs/ft3) (dry)	0.0724	0.0724	0.0724	0.0724
Total weight of sampled gas (m g lbs) (wet)	0.17	0.17	0.19	0.17
Total weight of sampled gas (m g lbs) (dry)	0.17	0.16	0.19	0.17
Stack Data				
Percent Moisture (Bws)	2.01	2.03	1.80	1.95
Water Vapor Volume (fraction)	0.0201	0.0203	0.0180	0.0195
Reported Inlet Gas Flowrate				
	Gas flowrates were reported by DTE.			
Flowrate (scfm)	3,335	3,335	3,335	3,335
Flowrate (cfh)	200,100	200,100	200,100	200,100
Total Chlorine Weight				
Total (ug)	16	23	16	18
Total (lbs)	3.42E-08	5.14E-08	3.57E-08	4.E-08
Total HCl Weight				
Total (ug)	24	16	22	
Total (lbs)	5.25E-08	3.53E-08	4.92E-08	
Total Chlorine Concentration				
lb/ft^3	1.49E-08	2.26E-08	1.39E-08	1.710E-08
Total HCl Concentration				
lb/ft^3	6.47E-09	9.90E-09	5.41E-09	7.26E-09
Total HCl Emission Rate				
lb/ hr from Chlorine	3.06E-03	4.64E-03	2.86E-03	3.52E-03
lb/hr from HCl	1.29E-03	1.98E-03	1.08E-03	1.45E-03
lb/hr Total	4.35E-03	6.62E-03	3.94E-03	4.97E-03

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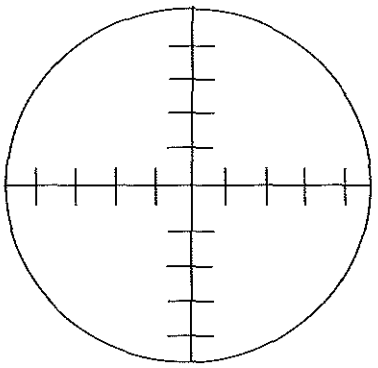
diameter = 30 inches

Points	Distance "
1	1.0
2	3.2
3	5.8
4	9.7
5	20.3
6	24.2
7	26.9
8	29.0



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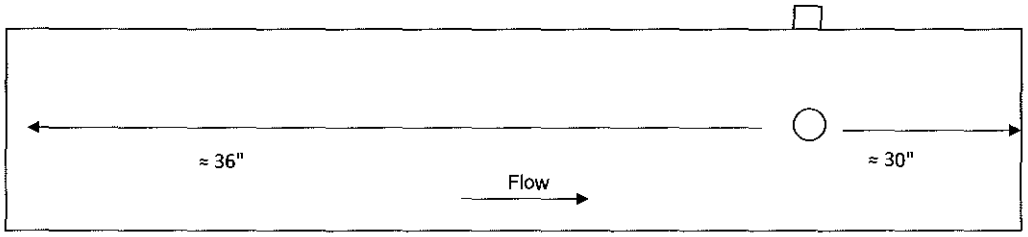

Figure No. 1

Site: **Turbine 1** **DTE Energy** **Riverview, MI**	**Sampling Date:** **December 14, 2017**	**BT Environmental Consulting, Inc.** **4949 Fernlee Avenue** **Royal Oak, Michigan 48073**

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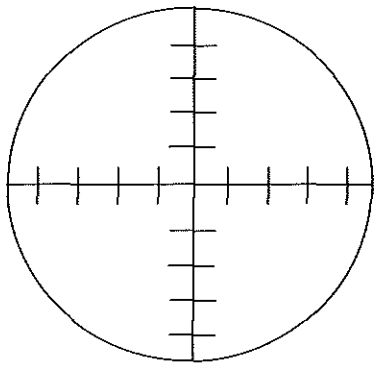
diameter = 30 inches

Points	Distance "
1	1.0
2	3.2
3	5.8
4	9.7
5	20.3
6	24.2
7	26.9
8	29.0



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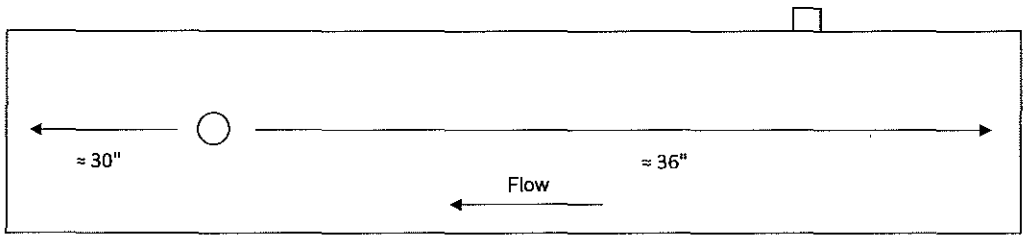

Figure No. 2

Site: **Turbine 2** **DTE Energy** **Riverview, MI**	**Sampling Date:** **December 14, 2017**	**BT Environmental Consulting, Inc.** **4949 Fernlee Avenue** **Royal Oak, Michigan 48073**

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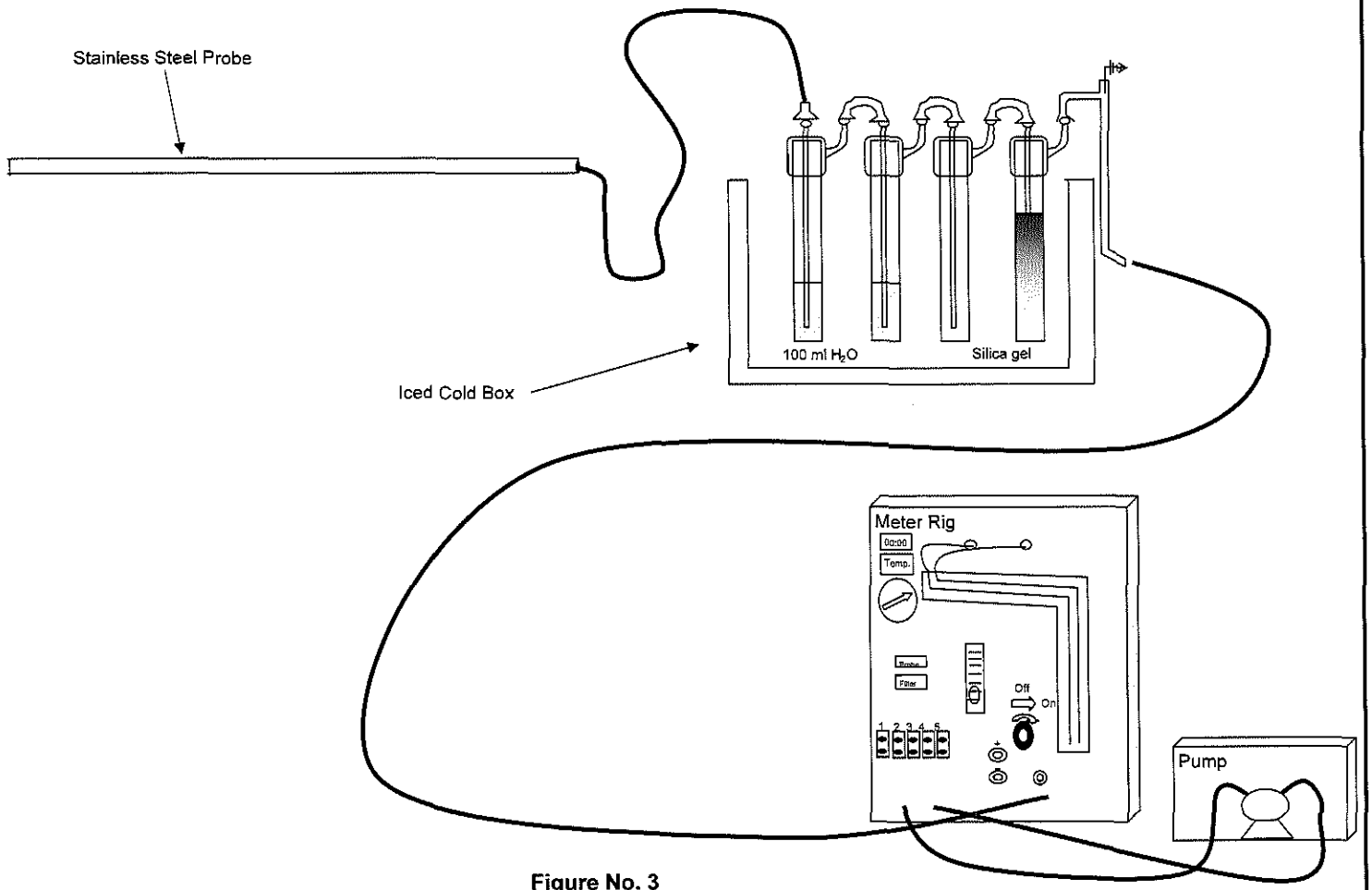

Figure No. 3

Site: **USEPA Method 4** **DTE Energy** **Riverview, MI**	**Sampling Date:** **December 14, 2018**	**BT Environmental Consulting, Inc.** **4949 Fernlee Avenue** **Royal Oak, Michigan 48073**

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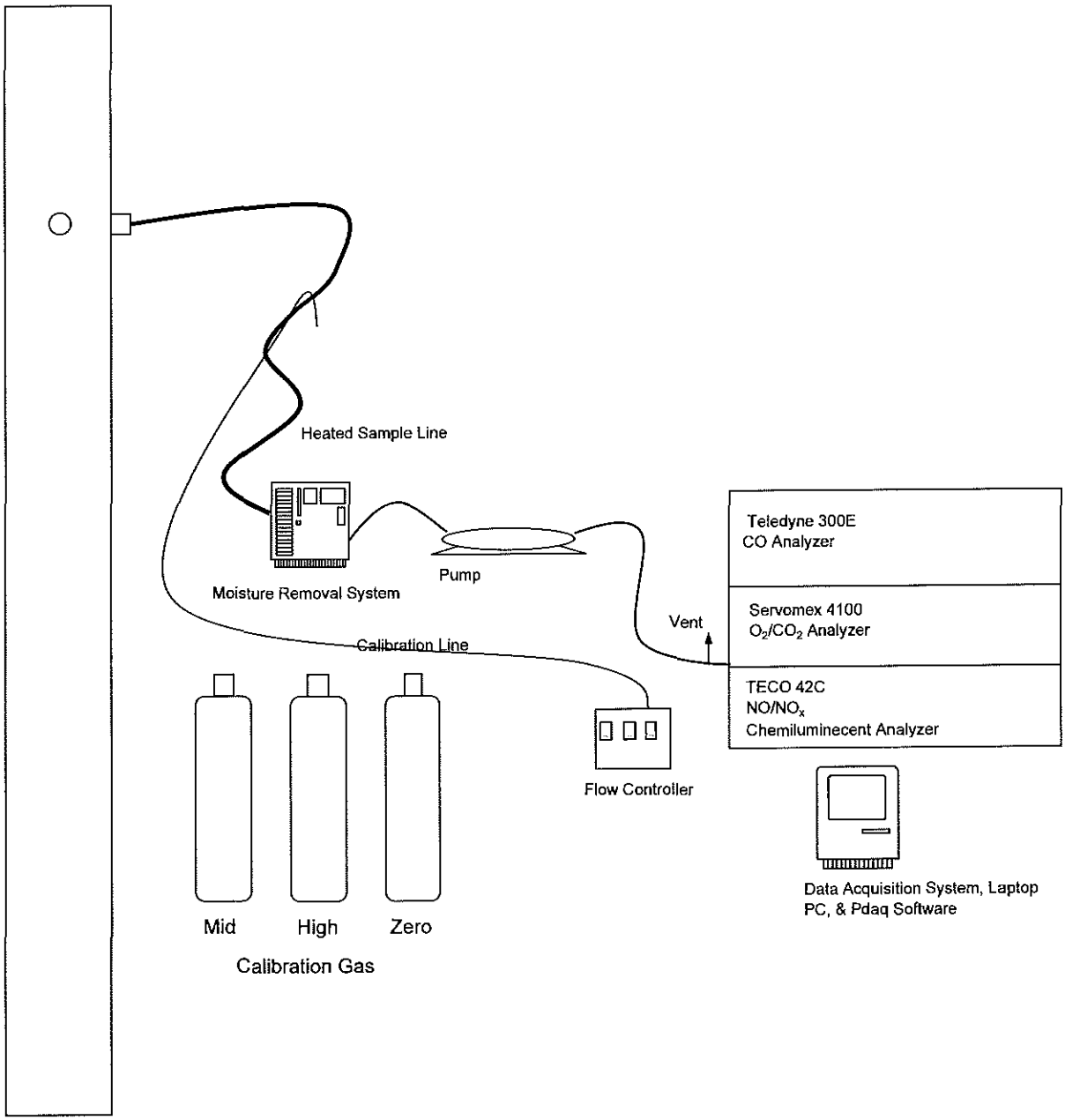

Figure No. 4

Site: **USEPA Method 3A, 7E, and 10** **DTE Energy** **Riverview, MI**	**Sampling Date:** **December 14, 2017**	**BT Environmental Consulting Inc.** **4949 Fernlee Avenue** **Royal Oak, MI 48073**

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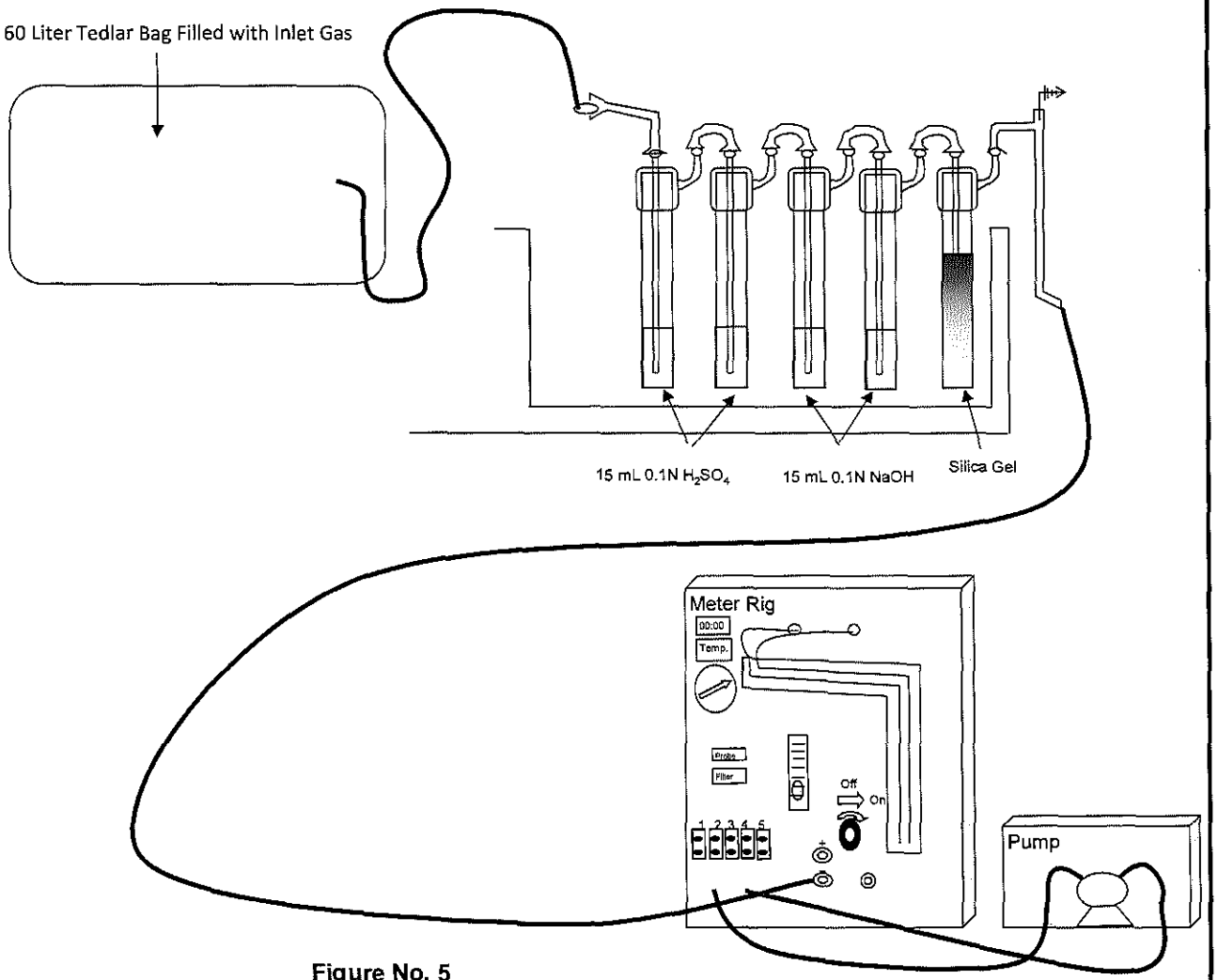

Figure No. 5

Site: USEPA Method 26 Sampling Train DTE Energy Riverview, MI	Sampling Date: December 14, 2017	BT Environmental Consulting, Inc. 4949 Fernlee Ave Royal Oak, Michigan