BTEC Inc.

Farm Lane and DCPAH Incinerator Particulate Matter Emissions Test Summary

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Prepared for:

Michigan State University

Michigan State University
East Lansing, Michigan 48825

Project No. 16-4961.00
March 20, 2017

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

BTEC Inc.

EXECUTIVE SUMMARY

BT Environmental Consulting, Inc. (BTEC) was retained by Michigan State University (MSU) to evaluate filterable particulate matter (PM) emission rates from the MSU DCPAH (EU-DCPAHINC) and Farm Lane (EU-FLNRINC) incinerators at the MSU campus located in East Lansing, Michigan. The emissions test program was conducted on January 31, 2017 and February 1, 2017.

Testing of incinerators DCPAH and Farm Lane consisted of triplicate 64-minute test runs while each unit was operating at a minimum of 90% capacity. The emissions test program was required by MDEQ Air Quality Division Renewable Operating Permit (ROP) No. MI-ROP-K3249-2016. The results of the emission test program are summarized by Table I.

Table I
Incinerators Overall Emission Summary
Test Date: January 31 - February 1, 2017

Source	Pollutant	Emission Rate	Emission Limit
Farm Lane (EU-FLNRINC)	PM	0.19 lb/1000lb (wet)[1]	0.20 lb/1000lb (wet)[1]
DCPAH (EU-DCPAHINC)	PM	0.03 gr/dscf[2]	0.10 gr/dscf[2]
		0.75 lb/hr	1.71 lb/hr

1: Corrected to 50% excess air.
2: Corrected to 7% O_2.

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1. Introduction

BT Environmental Consulting, Inc. (BTEC) was retained by Michigan State University (MSU) to evaluate filterable particulate matter (PM) emission rates from the MSU DCPAH (EU-DCPAHINC) and Farm Lane (EU-FLNRINC) incinerators at the MSU campus located in East Lansing, Michigan. The emissions test program was conducted on January 31, 2017 and February 1, 2017. The purpose of this report is to document the results of the test program.

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 January 31 and February 1, 2017 at the MSU campus located in East Lansing, Michigan. The test program included evaluation of particulate matter emissions from the Farm Lane and DCPAH incinerators.

1.b Purpose of Testing

The purpose of the testing is to comply with Renewable Operating Permit No. MI-ROP-K3429-2016. This permit limits emissions from each incinerator as summarized by Table 1.

Table 1
Particulate Emissions Limitations
MSU

Facility	Permit No.	Farm Lane Emission Limit	DCPAH Emission Limit
East Lansing	MI-ROP-K3429-2016	0.20 lb/1000lb @ 50% Excess Air	0.10 gr/dscf @ 7% O_2
			1.71 lb/hr

1.c Source Description

MSU's Farm Lane incinerator uses natural gas to burn institutional wastes with up to 10 percent medical/infectious wastes, pathological waste, low volumes of non-hazardous pharmaceutical waste, and some low-level nuclear wastes.

The DCPAH incinerator is an ASC design incinerator that is gas fired with a 1,200 lb/hr capacity at 1,800 F and 1 second retention time in secondary chamber.

1.d Test Program Contacts

The contact for the source and test report is:

Mr. Thomas Grover
Michigan State University
150 Giltner Hall
East Lansing, Michigan 48825
(517) 335-6651

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

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. Thomas Grover	Michigan State University 150 Giltner Hall East Lansing, MI 48825	(517)335-6651
Mr. Todd Wessel Senior Project Manager	BTEC 4949 Fernlee Royal Oak, MI 48073	(248) 548-8070
Mr. David Trahan Environmental Technician	BTEC 4949 Fernlee Royal Oak, MI 48073	(248) 548-8070
Mr. Jake Zott Environmental Technician	BTEC 4949 Fernlee Royal Oak, MI 48073	(248) 548-8070
Mr. Tom Gasloli	MDEQ Air Quality Division	(517) 284-6778

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 collected during the emissions test program includes inventory of waste by categorization, weight, and percentage for each charge throughout duration of test; the feed rate of waste during the course of the test in pounds; and the actual incinerator afterburner temperature.

2.b Applicable Permit

The applicable permit for this emissions test program is Renewable Operating Permit (ROP) No. MI-ROP-K3492-2016.

2.c Results

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

The average particulate emission rate for the Farm Lane incinerator was 0.19 lb/1000lb @50% excess air which is less than the limit of 0.20 lb/1000lb @50% excess air.

The average particulate emission rate for the DCPAH incinerator was 0.75 lb/hr and 0.03 gr/dscf @7% O_2 which is less than the limit of 1.71 lb/hr and 0.10 gr/dscf @7% O_2.

3. Source Description

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

3.a Process Description

MSU is a research university located in East Lansing, Michigan. MSU operates an existing Consumat Waste Incinerator (EU-FLNRINC) that uses natural gas to burn institutional wastes with up to 10 percent medical/infectious wastes, pathological waste, low volumes of non-hazardous pharmaceutical waste, and some low-level nuclear wastes. The incinerator consists of two processes that occur in a lower (primary) chamber and an upper (secondary) chamber. Waste is charged into the refractory-lined primary combustion chamber and air is automatically supplied for less than complete combustion (i.e., "starved-air" incineration). Partial combustion products including combustion gases then pass into the upper chamber. Air is automatically supplied and the temperature is higher, allowing for complete combustion. Each process is controlled independently for the maximum efficiency and minimal emissions. The incinerator contains a direct flame afterburner for emissions control.

The DCPAH Incinerator (EU-DCPAHINC) is an ASC design incinerator located at new DCPAH facility on Bennett Rd. Unit is gas fired with a 1,200 lb/hr capacity at 1,800 F and 1 second retention time in secondary chamber.

3.b Process Flow Diagram

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

3.c Raw and Finished Materials

The raw material used by the process is natural gas which is used to incinerate pathological waste.

The DCPAH Incinerator is an ASC design incinerator that is gas fired with a 1,200 lb/hr capacity at 1,800 F and 1 second retention time in secondary chamber. The Farm Lane Incinerator is gas fired with a 1,000 lb/hr capacity.

3.d Process Instrumentation

Process data collected during the emissions test program includes inventory of waste by categorization, weight, and percentage for each charge throughout duration of test; the feed rate of waste during the course of the test in pounds; and the actual incinerator afterburner temperature.

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

Measurement of exhaust gas velocity, molecular weight, and moisture content were conducted using the following reference test methods codified at 40 CFR 60, Appendix A:

- Method 1 - *"Sample and Velocity Traverses for Stationary Sources"* was used to determine the velocity traverse points
- Method 2 - *"Determination of Stack Gas Velocity and Volumetric Flowrate"* was used to determine exhaust gas velocity
- Method 3A - *"Determination of Oxygen and Carbon Dioxide Concentration in Emissions from Stationary Sources"* will be used to determine exhaust gas molecular weight
- Method 4 - *"Determination of Moisture Content in Stack Gases"* was used to determine exhaust gas moisture content
- Method 5 - "Determination of Particulate Matter Emissions from Stationary Sources" was used to determine particulate matter concentrations and emission rates

Stack gas velocity traverses were conducted in accordance with the procedures outlined in Methods 1 and 2. Figures 1 and 2 present the test port and traverse/sampling point locations used at each site. 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. Because the pitot tube dimensions outlined in Sections 2-6 through 2-8 were within the specified limits, the baseline pitot tube coefficient of 0.84 (dimensionless) was assigned for this testing.

The O_2 and CO_2 content of the gas stream was measured using a Servomex 4100 O_2/CO_2 gas analyzer. 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 analyzer. Data was recorded on a PC equipped with data acquisition software. Recorded O_2 and CO_2 concentrations were averaged and reported for the duration of each test (as drift corrected per Method 7E). A drawing of the sampling train used for the testing program is presented as Figure 3. Sampling was performed in conjunction with the Method 5 sampling. A stratification test was performed on each source to determine the number of sampling points.

In accordance with Method 3A, a 3-point (zero, mid, and high) bias check and calibration check was performed on the analyzer prior to initiating the test program. Following each test run, a 2-point (zero and high) calibration drift check was performed. The O_2/CO_2 analyzer was operated at the 0-25% range.

Method 5 was used to measure particulate concentrations and calculate particulate emission rates from the exhaust stacks. BTEC's Nutech® Model 2010 modular isokinetic stack sampling system consisted of (1) a stainless-steel button-hook nozzle, (2) a heated borosilicate glass probe, (3) a heated filter box, (4) a set of four Greensburg-Smith (GS) impingers with the first modified and second standard GS impingers each containing 100 milliliters (mL) of deionized water, a third dry modified GS impinger and a fourth modified GS impinger containing approximately 800 grams of silica gel desiccant, (5) a length of sample line, and (6) a Nutech® control case equipped with a pump, dry gas meter, and calibrated orifice.

After completion of the final leak test for each test run, the filters were recovered, and the nozzles, probes, and the front halves of the filter holder assemblies were brushed and triple rinsed with acetone. The acetone rinses were collected in a pre-cleaned sample container. BTEC labeled the containers with the test number, test location, and test date, and marked the level of liquid on the outside of each container. Blank samples of the filter and acetone were collected. BTEC personnel transported all samples to BTEC's laboratory in Royal Oak, Michigan for analysis.

Exhaust gas moisture content was evaluated using Method 4. Exhaust gas was extracted as part of the PM sampling train 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 is then determined gravimetrically.

The acetone rinses were transferred to clean pre-weighed beakers. The beakers were weighed following room-temperature evaporation, and then desiccated to a constant weight. Filters were dried in a desiccator to a constant weight.

The impinger trains were carefully disassembled. The liquid volume of each impinger was measured in a graduated cylinder. The silica gel was reweighed, and any increases were recorded on the field data sheets.

4.b Recovery and Analytical Procedures

See section 4.a.

4.c Sampling Ports

A diagram of the stack showing sampling ports in relation to upstream and downstream disturbances is included as Figure 1-2.

4.d Traverse Points

A diagram of the stack indicating traverse point locations and stack dimensions is included as Figures 1-2.

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 and 5.

Table 3
Incinerators Overall Emission Summary
Test Date: January 31 - February 1, 2017

Source	Pollutant	Emission Rate	Emission Limit
Farm Lane (EU-FLNRINC)	PM	0.19 lb/1000lb (wet)[1]	0.20 lb/1000lb (wet)[1]
DCPAH (EU-DCPAHINC)	PM	0.03 gr/dscf[2]	0.10 gr/dscf[2]
		0.75 lb/hr	1.71 lb/hr

1: Corrected to 50% excess air.
2: Corrected to 7% O_2.

5.b Discussion of Results

The average particulate emission rate for the Farm Lane incinerator was 0.19 lb/1000lb @50% excess air which is less than the limit of 0.20 lb/1000lb @50% excess air.

The average particulate emission rate for the DCPAH incinerator was 0.75 lb/hr and 0.03 gr/dscf @7% O_2 which is less than the limit of 1.71 lb/hr and 0.10 gr/dscf @7% O_2.

5.c Sampling Procedure Variations

During Runs 2 and 3 on the Farm Lane incinerator, the particulate matter filter had to be changed due to high vacuum problems. A sampling train leak check was performed before and after the filter was changed.

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.

Table 4
EU-FLNRINC Particulate Matter Emission Rates

Company	**MSU**			
Source Designation	**FLNR**			
Test Date	**1/31/2017**	**1/31/2017**	**1/31/2017**	
Meter/Nozzle Information	P-1	P-2	P-3	Average
Meter Temperature Tm (F)	69.9	79.9	80.5	76.8
Meter Pressure - Pm (in. Hg)	28.9	28.9	28.9	28.9
Measured Sample Volume (Vm)	60.9	59.2	59.3	59.8
Sample Volume (Vm-Std ft3)	59.1	56.4	56.4	57.3
Sample Volume (Vm-Std m3)	1.67	1.60	1.60	1.62
Condensate Volume (Vw-std)	4.291	3.159	3.206	3.552
Gas Density (Ps(std) lbs/ft3) (wet)	0.0733	0.0738	0.0736	0.0736
Gas Density (Ps(std) lbs/ft3) (dry)	0.0752	0.0754	0.0751	0.0752
Total weight of sampled gas (m g lbs) (wet)	4.64	4.39	4.39	4.47
Total weight of sampled gas (m g lbs) (dry)	4.44	4.25	4.24	4.31
Nozzle Size - An (sq. ft.)	0.002234	0.002234	0.002234	0.002234
Isokinetic Variation - I	101.5	98.6	99.1	99.7
Stack Data				
Average Stack Temperature - Ts (F)	764.3	758.7	767.1	763.3
Molecular Weight Stack Gas- dry (Md)	29.1	29.2	29.1	29.1
Molecular Weight Stack Gas-wet (Ms)	28.3	28.6	28.5	28.5
Stack Gas Specific Gravity (Gs)	0.979	0.986	0.983	0.983
Percent Moisture (Bws)	6.77	5.31	5.38	5.82
Water Vapor Volume (fraction)	0.0677	0.0531	0.0538	0.0582
Pressure - Ps ("Hg)	28.7	28.7	28.7	28.7
Average Stack Velocity -Vs (ft/sec)	17.6	16.9	17.0	17.2
Area of Stack (ft2)	11.5	11.5	11.5	11.5
Oxygen (%)	16.5	16.8	18.0	17.1
Carbon Dioxide (%)	2.8	3.1	2.1	2.6
Carbon Monoxide (%)	0.0	0.0	0.0	0.0
Nitrogen (%)	80.8	80.2	79.8	80.2
% Excess Air	340.3	385.4	594.9	440.2
Exhaust Gas Flowrate				
Flowrate ft^3(Actual)	12,188	11,729	11,766	11,894
Flowrate ft^3 (Standard Wet)	5,037	4,869	4,851	4,919
Flowrate ft^3 (Standard Dry)	4,696	4,611	4,591	4,633
Flowrate m^3 (standard dry)	133	131	130	131
Total Particulate Weights (mg)				
Nozzle/Probe/Filter	29.0	149.0	147.8	108.6
Total Particulate Concentration				
lb/1000 lb (wet)	0.01	0.07	0.07	0.05
lb/1000 lb (wet) corrected to 50% Excess Air	0.04	0.22	0.30	0.19
lb/1000 lb (dry)	0.014	0.077	0.077	0.056
mg/dscm (dry)	17.3	93.4	92.5	67.7
gr/dscf	0.0076	0.0408	0.0404	0.0296
Total Particulate Emission Rate				
lb/ hr	0.31	1.62	1.60	1.17

Table 5
EU-DCPAHINC Particulate Matter Emission Rates

Company	**MSU**			
Source Designation	**DCPAHINC**			
Test Date	**2/1/2017**	**2/1/2017**	**2/1/2017**	
Meter/Nozzle Information	P-1	P-2	P-3	Average
Meter Temperature Tm (F)	77.5	84.3	85.6	82.5
Meter Pressure - Pm (in. Hg)	29.2	29.2	29.2	29.2
Measured Sample Volume (Vm)	39.5	40.6	41.4	40.5
Sample Volume (Vm-Std ft3)	38.2	38.8	39.4	38.8
Sample Volume (Vm-Std m3)	1.08	1.10	1.12	1.10
Condensate Volume (Vw-std)	3.583	3.348	3.301	3.411
Gas Density (Ps(std) lbs/ft3) (wet)	0.0730	0.0732	0.0733	0.0731
Gas Density (Ps(std) lbs/ft3) (dry)	0.0754	0.0755	0.0755	0.0755
Total weight of sampled gas (m g lbs) (wet)	3.05	3.08	3.13	3.09
Total weight of sampled gas (m g lbs) (dry)	2.88	2.93	2.98	2.93
Nozzle Size - An (sq. ft.)	0.000576	0.000576	0.000576	0.000576
Isokinetic Variation - I	102.7	101.1	101.0	101.6
Stack Data				
Average Stack Temperature - Ts (F)	1060.4	1102.6	1174.7	1112.6
Molecular Weight Stack Gas- dry (Md)	29.2	29.2	29.2	29.2
Molecular Weight Stack Gas-wet (Ms)	28.2	28.3	28.4	28.3
Stack Gas Specific Gravity (Gs)	0.975	0.978	0.979	0.977
Percent Moisture (Bws)	8.58	7.95	7.72	8.08
Water Vapor Volume (fraction)	0.0858	0.0795	0.0772	0.0808
Pressure - Ps ("Hg)	29.0	29.0	29.0	29.0
Average Stack Velocity -Vs (ft/sec)	58.2	61.2	65.1	61.5
Area of Stack (ft2)	7.5	7.5	7.5	7.5
Oxygen (%)	14.72	15.48	14.19	14.80
Exhaust Gas Flowrate				
Flowrate ft^3(Actual)	26,080	27,423	29,144	27,549
Flowrate ft^3 (Standard Wet)	8,787	8,991	9,134	8,971
Flowrate ft^3 (Standard Dry)	8,034	8,276	8,428	8,246
Flowrate m^3 (standard dry)	227	234	239	234
Total Particulate Weights (mg)				
Nozzle/Probe/Filter	35.9	35.4	8.2	26.5
Total Particulate Concentration				
lb/1000 lb (wet)	0.026	0.025	0.006	0.019
lb/1000 lb (dry)	0.027	0.027	0.006	0.020
mg/dscm (dry)	33.2	32.2	7.3	24.3
gr/dscf	0.01	0.01	0.00	0.01
gr/dscf @ 7% Oxygen	0.03	0.04	0.01	0.03
Total Particulate Emission Rate				
lb/ hr	1.00	1.00	0.23	0.75

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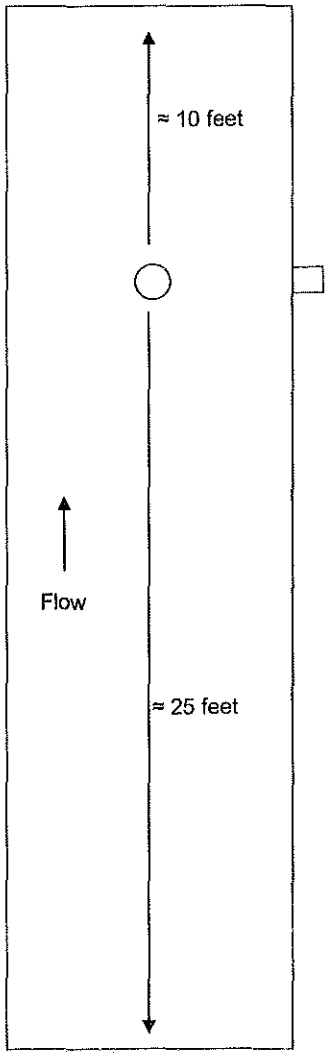
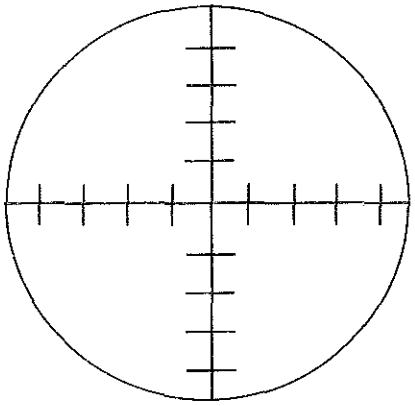
diameter = 46 inches





Not to Scale

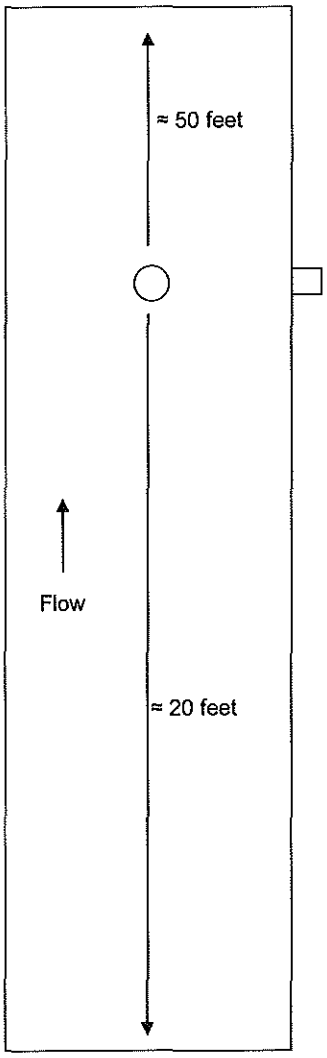
Points	Distance "
1	1.5
2	4.8
3	8.9
4	14.9
5	31.1
6	37.1
7	41.2
8	44.5

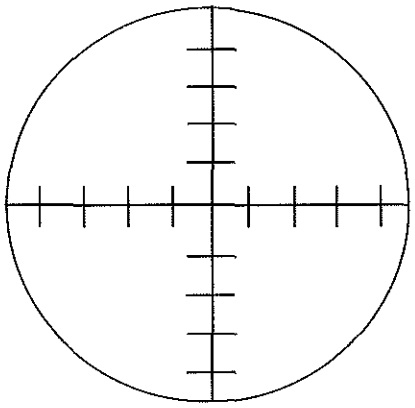
Figure No. 1

Site:	Sampling Date:	
EU-FLNRINC Exhaust MSU East Lansing, Michigan	January 31, 2017	BT Environmental Consulting, Inc. 4949 Fernlee Avenue Royal Oak, Michigan 48073

BTEC Inc.

diameter = 37 inches





Not to Scale

Points	Distance "
1	1.2
2	3.9
3	7.2
4	12.0
5	25.0
6	29.8
7	33.1
8	35.8

Figure No. 2

Site: **EU-DCPAHINC Exhaust** **MSU** **East Lansing, Michigan**	**Sampling Date:** **February 1, 2017**	**BT Environmental Consulting, Inc.** **4949 Fernlee Avenue** **Royal Oak, Michigan 48073**

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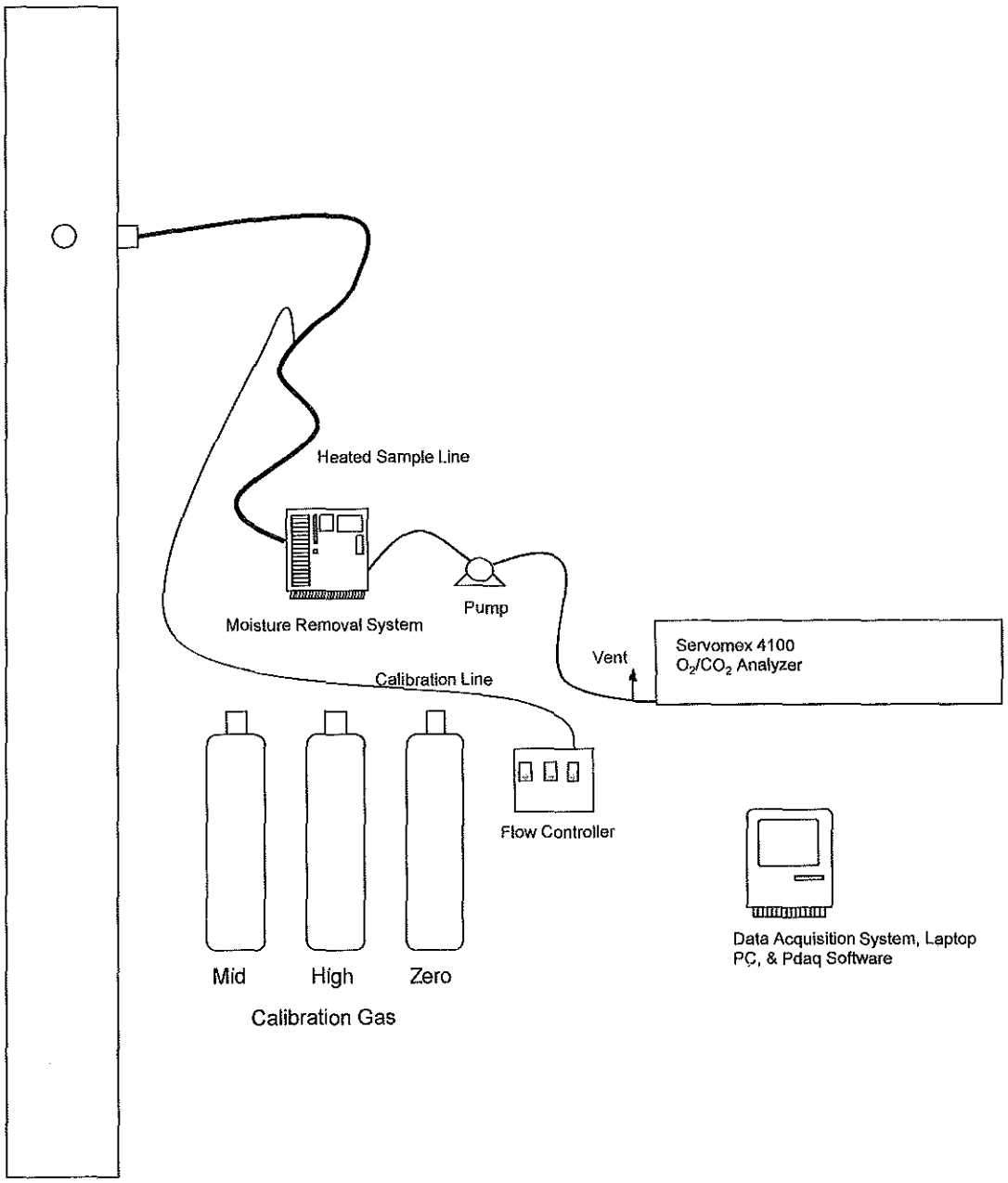

Figure No. 3

Site: **USEPA Method 3A** **MSU** **East Lansing, MI**	**Sampling Date:** **January 31 -** **February 1, 2017**	**BT Environmental Consulting Inc.** **4949 Fernlee Avenue** **Royal Oak, MI 48073**

BTEC Inc.

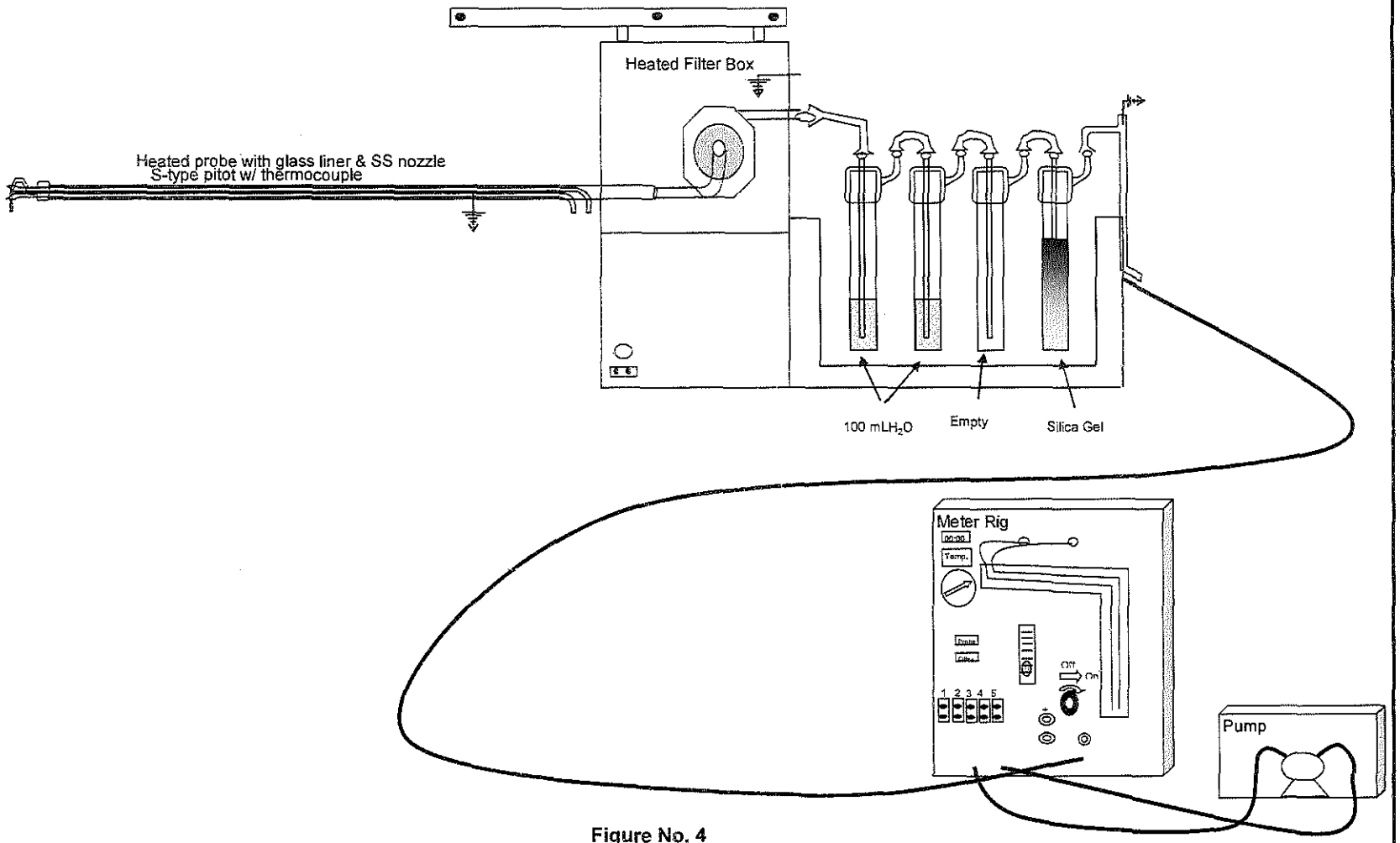

Figure No. 4

Site: USEPA Method 5 MSU East Lansing, Michigan	Sampling Date: January 31, 2017 February 1, 2017	BT Environmental Consulting, Inc. 4949 Fernlee Avenue Oak, Michigan 48073

Royal