BTEC Inc.

Volatile Organic Compound Destruction Efficiency and Benzo(a)Pyrene Emissions Test Report

Prepared for:

HarbisonWalker

1301 East 8th Street
White Cloud, Michigan

Project No. 16-4971.00
July 21, 2017

BT Environmental Consulting, Inc.
4949 Fernlee Avenue
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BTEC Inc.

EXECUTIVE SUMMARY

BT Environmental Consulting, Inc. (BTEC) was retained by Harbison Walker International (HWI) to evaluate the volatile organic compound (VOC) destruction efficiency (DE) of a single catalytic thermal oxidizer (CTO). The emissions test program also included the measurement of benzo(a)pyrene emission rates from the CTO. The emissions test program was conducted on June 1, 2017.

Michigan Department of Environmental Quality Air Quality Division Permit To Install No. 24-10A requires that the CTO maintain a VOC destruction efficiency of at least 90%, VOC emission rate less than 0.87 lb/hr, and benzo(a)pyrene emission rates less than 0.00011 lb/hr. The results of the emissions test program are summarized by Tables I and II.

Table I
CTO DE Emissions Test Result Summary
Sampling Date: June 1, 2017

Run	Time	Inlet VOC Emission Rate (lbs/hr)*	Outlet VOC Emission Rate (lbs/hr)*	Outlet VOC Emission Limit (lbs/hr)	VOC Destruction Efficiency (%)	Minimum Destruction Efficiency (%)
1	8:20-9:19	1.57	0.00		100.0	
2	10:50-11:49	2.19	0.01		99.3	
3	13:28-14:27	3.88	0.00		99.9	
	Averages:	2.55	0.01	0.87	99.7	90

* Inlet and Outlet VOC emission rates are corrected for methane

Table II
CTO Benzo(a)Pyrene Emissions Test Result Summary
Sampling Date: June 1, 2017

Run	Time	Benzo(a)Pyrene Emission Rate (lbs/hr)*	Benzo(a)Pyrene Emission Limit (lbs/hr)
1	8:45-10:43	<0.00003	
2	11:31-12:35	<0.00003	
3	13:04-14:09	<0.00003	
	Averages:	<0.00003	0.00011

* Lab results were ND. Calculations have been based off the RDL (reportable detection limit) of 1 µg.

BTEC Inc.

1. Introduction

BT Environmental Consulting, Inc. (BTEC) was retained by Harbison Walker International (HWI) to evaluate the volatile organic compound (VOC) emission rates and destruction efficiency (DE) of a single catalytic thermal oxidizer (CTO). The emissions test program also included the measurement of benzo(a)pyrene emission rates from the CTO. The purpose of this document is to summarize the results of the compliance emissions test program.

1.a Identification, Location, and Dates of Test

The CTO unit is operated at the Harbison Walker International (HWI) facility located at 1301 East 8th Street in White Cloud, Michigan. Emissions testing of the CTO was conducted on June 1, 2017.

1.b Purpose of Testing

To determine compliance with Michigan Department of Environmental Quality Air Quality Division (AQD) Permit No. 24-10A.

1.c Source Description

The HWI facility in White Cloud manufactures refractory. After the bricks are made they go into one of three natural gas ovens for curing. The ovens are referred to as Oven 1, Oven 2 and the Dryer and are permitted as EUBrickOvens. VOC emissions are collected from the ovens and routed through a catalytic thermal oxidizer and then exhausted to atmosphere. The oxidizer operates at a minimum inlet temperate of 700 degrees Fahrenheit.

1.d Test Program Contact

The contact for information regarding the test program as well as the test report is:

Mr. Bruce Morgan
Harbison Walker International
1301 East 8th Street
White Cloud, MI 49349

1.e Test Personnel

Names and affiliations for personnel who were present during the test program are summarized by Table 1.

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Table 1
Test Personnel

Name	Affiliation
Bruce Morgan	Harbison Walker
Jerry Buffenbarger	Harbison Walker
Todd Wessel	BTEC
Shane Rabideau	BTEC
Mason Sakshaug	BTEC
Rob Dickman	MDEQ
Adam Shaffer	MDEQ

2. Summary of Results

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

2.a Operating Data

Operating data is available in Appendix E.

2.b Applicable Permit

The CTO at the HWI facility is regulated by Michigan Department of Environmental Quality Air Quality Division (AQD) Permit No. 24-10A.

2.c Results

The results of the emissions test program are summarized by Tables 2 and 3. Detailed results are available as Tables 4 and 5.

2.d Emission Regulation Comparison

Permit No. 24-10A requires a minimum VOC destruction efficiency of 90%, VOC emission limit 0.87 lb/hr, and Benzo(a)Pyrene emission limit of 0.00011 lb/hr. All emission rates are less than the corresponding emission limits.

3. Source Description

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

3.a Process Description

The HWI facility in White Cloud manufactures refractory. After the bricks are made they go into one of three natural gas ovens for curing. The ovens are referred to as Oven 1, Oven 2 and the Dryer and are permitted as EUBrickOvens. VOC emissions are collected

from the ovens and routed through a catalytic thermal oxidizer and then exhausted to atmosphere. The oxidizer operates at a minimum inlet temperate of 700 degrees Fahrenheit.

3.b Process Flow Diagram

The CTO controls VOC emissions from the corresponding equipment by oxidizing organics present in the exhaust gas at elevated temperatures. Due to the simplicity of the CTO unit, a process flow diagram is not necessary.

3.c Raw and Finished Materials

Production data for the five presses are summarized in Appendix E.

3.d Process Instrumentation

Process instrumentation relevant to the emissions test program included inlet and outlet catalysis temperature.

4. Sampling and Analytical Procedures

Sections 4.a through 4.d provide a summary of the sampling and analytical procedures used during the emissions test program.

4.a Sampling Train and Field Procedures

Measurement of exhaust gas velocity, molecular weight, and moisture content was conducted using the following reference 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 3 - *"Determination of Molecular Weight of Dry Stack Gas"(Fyrite)*
- Method 4 - *"Determination of Moisture Content in Stack Gases"*
- Method 25A - *"Determination of Total Gaseous Organic Concentrations using a Flame Ionization Analyzer"*

Stack gas velocity traverses were conducted in accordance with the procedures outlined in Methods 1 and 2. An S-type pitot tube with a thermocouple assembly, calibrated in accordance with Method 2, Section 4.1.1, was used to measure the 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) was assigned.

A cyclonic flow check was 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. The null angle was determined to be less than 20 degrees at each sampling point.

Molecular weight was determined according to USEPA Method 3, "Gas Analysis for the Determination of Dry Molecular Weight." The equipment used for this evaluation consisted of a one-way squeeze bulb with connecting tubing and a set of Fyrite® combustion gas analyzers. Carbon dioxide and oxygen content were analyzed using the Fyrite® procedure.

Exhaust gas moisture content was evaluated using Method 4. Exhaust gas was extracted and passed through the Method 0010 sampling train. Exhaust gas moisture content was then determined gravimetrically.

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 IOtech® 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. The response factor determined during testing was 2.3.

4.b Recovery and Analytical Procedures

See section 4.a.

4.c Sampling Ports

Sampling ports and traverse points for the exhaust flowrate sampling location are illustrated by Figure 1.

4.d Traverse Points

Sampling ports and traverse points for the exhaust flowrate sampling location are illustrated by Figure 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 Tables 2-3. Detailed results are included on Tables 4-5.

Table 2
CTO DE Emissions Test Result Summary
Sampling Date: June 1, 2017

Run	Time	Inlet VOC Emission Rate (lbs/hr)*	Outlet VOC Emission Rate (lbs/hr)*	Outlet VOC Emission Limit (lbs/hr)	VOC Destruction Efficiency (%)	Minimum Destruction Efficiency (%)
1	8:20-9:19	1.57	0.00		100.0	
2	10:50-11:49	2.19	0.01		99.3	
3	13:28-14:27	3.88	0.00		99.9	
	Averages:	2.55	0.01	0.87	99.7	90

* Inlet and Outlet VOC emission rates are corrected for methane

Table 3
CTO Benzo(a)Pyrene Emissions Test Result Summary
Sampling Date: June 1, 2017

Run	Time	Benzo(a)Pyrene Emission Rate (lbs/hr)*	Benzo(a)Pyrene Emission Limit (lbs/hr)
1	8:45-10:43	0.00003	
2	11:31-12:35	0.00003	
3	13:04-14:09	0.00003	
	Averages:	0.00003	0.00011

* Lab results were ND. Calculations have been based off the RDL (reportable detection limit) of 1 µg.

5.b Discussion of Results

All emission rates are below corresponding emission limits.

5.c Sampling Procedure Variations

There were no sampling variations used during the emission compliance test program.

5.d Process or Control Device Upsets

A temperature probe was removed from the ductwork and when the oven monitoring system detected that the temperature dropped below the set point, the ovens automatically shut down. The Method 0010 sampling train, Run 1, was paused during the shutdown. Run 1 for the VOC sampling had already been complete, and VOC Run 2 had not yet started, so the VOC sampling was unaffected by the oven shut down. The Method 0010 sampling train, Run 1, was resumed when the ovens were restarted. Approximate times were: shut down around 9:23 AM and start up around 10:15. Both Rob Dickman and Adam Shaffer of the MDEQ were aware of the ovens shutting down and agreed to continue with the testing.

5.e Control Device Maintenance

Routine maintenance of the CTO has been conducted as recommended by the manufacturer.

5.f Audit Sample Analyses

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

5.g Calibration Sheets

Calibration data relevant to the emissions test program is provided in Appendix B.

In accordance with Method 25A, a 4-point (zero, low, mid, and high) calibration check was performed on the THC analyzer. Calibration drift checks were performed at the completion of each run.

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. The results of the Method 205 verification test are provided in Appendix C.

A drawing of the Method 25A sampling train used for the testing program is presented as Figure 2.

SW-846 Test Method 0010 was used to measure benzo(a)pyrene emission rates. The Method 0010 sampling train consisted of (1) a borosilicate glass nozzle, (2) a heated steel probe w/ borosilicate glass liner, (3) a heated glass fiber filter assembly, (4) a glass recirculating ice water condenser system, (5) a XAD-2 sorbent trap, (6) an empty pot bellied impinger, (7) a set of four GS impingers, (8) a length of sample line, and (9) a Nutech® control case equipped with a pump, dry gas meter, and calibrated orifice. Prior to each test, the first and second impingers were filled with 100 ml of HPLC water, the third was empty, and the fourth impinger contained approximately 300 g of silica gel desiccant. A schematic drawing of the Method 0010 sample train is provided as Figure 3.

After completion of the final leak test for each test run, the impinger train was carefully disassembled. The liquid volume of each impinger was measured gravimetrically and any mass increase was noted on field sheets. The adsorbent module was removed from the sampling train, tightly capped at both ends, labeled, covered with Teflon tape and then aluminum foil, and stored in an iced cooler for later transport to the laboratory. The filter was recovered and placed in its original Petri dish. The nozzle, probe, filter housing, and condenser were brushed and triple rinsed with a methanol / methylene chloride ($MeCl_2$) (1:1 v/v methanol/methylene chloride) which was collected in a pre-cleaned sample container. The nozzle, probe, filter housing, and condenser were then triple rinsed with methanol/methylene chloride which was collected in a separate 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 HPLC water, methanol/methylene chloride, adsorbent module, and filter were collected. Samples were couriered by Maxxam Analytical's (Maxxam) personnel to Maxxam's laboratory for analysis.

5.h Sample Calculations

Sample calculations are provided in Appendix C.

5.i Field Data Sheets

Copies of the relevant field data sheets and field notes are provided in Appendix A.

5.j Laboratory Data

Laboratory analytical results are provided in Appendix E.

Table 4
Catalytic Thermal Oxidizer VOC Destruction Efficiency
Harbison Walker
White Cloud, Michigan
BTEC Project No. 16-4971
Sampling Dates: June 1, 2017

Parameter	Run 1	Run 2	Run 3	Average
Sampling Date	6/1/2017	6/1/2017	6/1/2017	
Sampling Time	8:20-9:19	10:50-11:49	13:28-14:27	
Inlet Flowrate (scfm)	8,555	8,588	8,560	8,568
Outlet Flowrate (scfm)	8,555	8,588	8,560	8,568
Inlet VOC Concentration (ppmv propane)	36.23	46.35	72.53	51.70
Inlet VOC Concentration (ppmv, corrected as per USEPA 7E)	36.33	46.16	74.52	52.34
Inlet CH4 Concentration (ppmv methane)	21.60	19.95	18.59	20.05
Inlet CH4 Concentration (ppmv, corrected as per USEPA 7E)	21.15	19.72	18.64	19.84
Inlet VOC Concentration (- methane)	26.84	37.32	66.16	43.44
Inlet VOC Mass Emission Rate (lb/hr)	1.57	2.19	3.88	2.55
Outlet VOC Concentration (ppmv propane)	0.78	0.09	0.85	0.57
Outlet VOC Concentration (ppmv, corrected as per USEPA 7E)	1.03	0.94	0.94	0.97
Outlet CH4 Concentration (ppmv methane)	1.93	0.23	1.60	1.25
Outlet CH4 Concentration (ppmv, corrected as per USEPA 7E)	2.41	1.42	1.76	1.86
Outlet VOC Concentration (- methane)*	***0.00***	0.25	0.08	0.11
Outlet VOC Mass Emission Rate (lb/hr)	0.00	0.01	0.00	0.01
VOC Destruction Efficiency (%)	**100.0**	**99.3**	**99.9**	**99.7**

*Methane subtraction on Outlet Run 1 resulted in a negative number and has been replaced with zero for calculations

scfm: standard cubic feet per minute
ppmv: parts per million on a volume to volume basis
lb/hr: pounds per hour
VOC: volatile organic compound
MW = molecular weight (C_3H_8 = 44.10)
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

Equations

lb/hr = ppmv * MW/24.14 * 1/35.31 * 1/453,600 * scfm* 60

Inlet VOC Correction			
Co	-0.24	-0.08	0.60
Cma	30	30	30
Cm	29.88	30.10	29.56

Inlet CH4 Correction			
Co	0.38	1.01	0.66
Cma	30	30	30
Cm	30.49	29.83	29.52

Outlet VOC Correction			
Co	-0.25	-0.85	-0.09
Cma	30	30	30
Cm	29.70	28.97	29.92

Outlet CH4 Correction			
Co	-0.51	-1.25	-0.15
Cma	30	30	30
Cm	29.76	29.98	29.66

Inlet RF=	2.23
Outlet RF =	2.05

Table 5
Catalytic Thermal Oxidizer Benzo(a)Pyrene Emission Rates

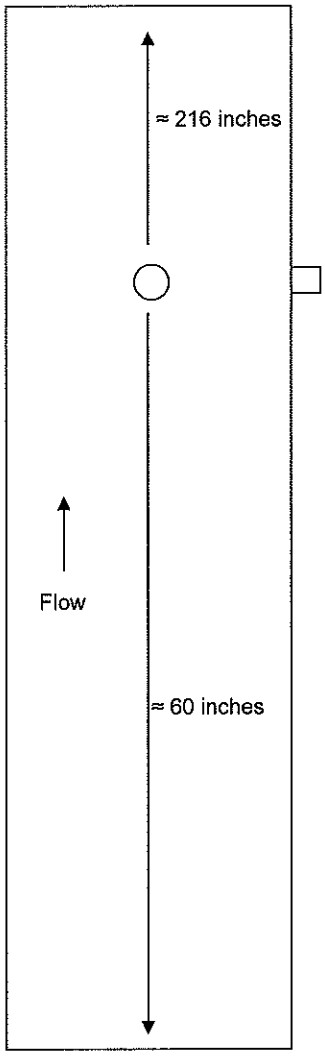
Company	**Harbison Walker**			
Source Designation	**Catalytic Thermal Oxidizer**			
Test Date	**6/1/2017**	**6/1/2017**	**1/2/1904**	
Meter/Nozzle Information	P-1	P-2	P-3	Average
Meter Temperature Tm (F)	73.8	89.8	92.6	85.4
Meter Pressure - Pm (in. Hg)	29.2	29.2	29.2	29.2
Measured Sample Volume (Vm)	35.3	36.6	36.5	36.1
Sample Volume (Vm-Std ft3)	34.3	34.6	34.3	34.4
Sample Volume (Vm-Std m3)	0.97	0.98	0.97	0.97
Condensate Volume (Vw-std)	1.183	1.330	1.127	1.213
Gas Density (Ps(std) lbs/ft3) (wet)	0.0736	0.0735	0.0736	0.0736
Gas Density (Ps(std) lbs/ft3) (dry)	0.0745	0.0745	0.0745	0.0745
Total weight of sampled gas (m g lbs) (wet)	2.61	2.64	2.61	2.62
Total weight of sampled gas (m g lbs) (dry)	2.56	2.58	2.56	2.56
Nozzle Size - An (sq. ft.)	0.000727	0.000727	0.000727	0.000727
Isokinetic Variation - I	100.5	101.3	100.2	100.7
Stack Data				
Average Stack Temperature - Ts (F)	411.0	416.9	406.3	411.4
Molecular Weight Stack Gas- dry (Md)	28.8	28.8	28.8	28.8
Molecular Weight Stack Gas-wet (Ms)	28.5	28.4	28.5	28.5
Stack Gas Specific Gravity (Gs)	0.983	0.982	0.984	0.983
Percent Moisture (Bws)	3.33	3.70	3.18	3.40
Water Vapor Volume (fraction)	0.0333	0.0370	0.0318	0.0340
Pressure - Ps ("Hg)	29.1	29.1	29.1	29.1
Average Stack Velocity -Vs (ft/sec)	22.9	23.1	22.8	22.9
Area of Stack (ft2)	10.6	10.6	10.6	10.6
Exhaust Gas Flowrate				
Flowrate ft^3(Actual)	14,493	14,648	14,423	14,521
Flowrate ft^3 (Standard Wet)	8,555	8,588	8,560	8,568
Flowrate ft^3 (Standard Dry)	8,270	8,270	8,287	8,276
Flowrate m^3 (standard dry)	234	234	235	234
Total Benzo(a)pyrene Weight (µg)				
Sample Catch	1	1	1	1
Total Benzo(a)pyrene Concentration				
lb/1000 lb (wet)	8.4E-07	8.3E-07	8.5E-07	8.4E-07
lb/1000 lb (dry)	8.6E-07	8.5E-07	8.6E-07	8.6E-07
mg/dscm (dry)	1.0E-03	1.0E-03	1.0E-03	1.0E-03
Total Benzo(a)pyrene Emission Rate				
lb/ hr	0.00003	0.00003	0.00003	0.00003

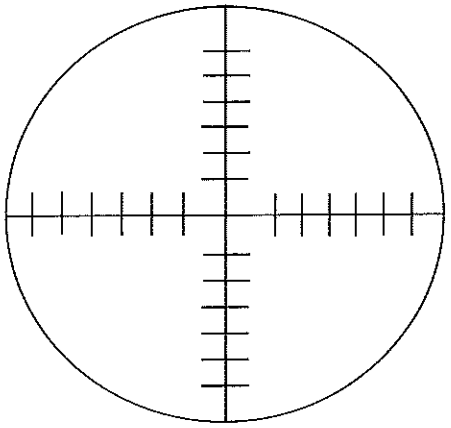
Lab results were ND. Calculations have been based off the RDL (reportable detection limit) of 1 µg.

Rev. 14.0
3-20-15 BC

BTEC Inc.

diameter = 44 inches





Not to Scale

Points	Distance "
1	0.9
2	2.9
3	5.2
4	7.8
5	11.0
6	15.7
7	28.3
8	33.0
9	36.2
10	38.8
11	41.1
12	43.1

Figure No. 1

Site: **CTO Exhaust** **HarbisonWalker** **White Cloud, Michigan**	**Sampling Date:** **June 1, 2017**

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

BTEC Inc.

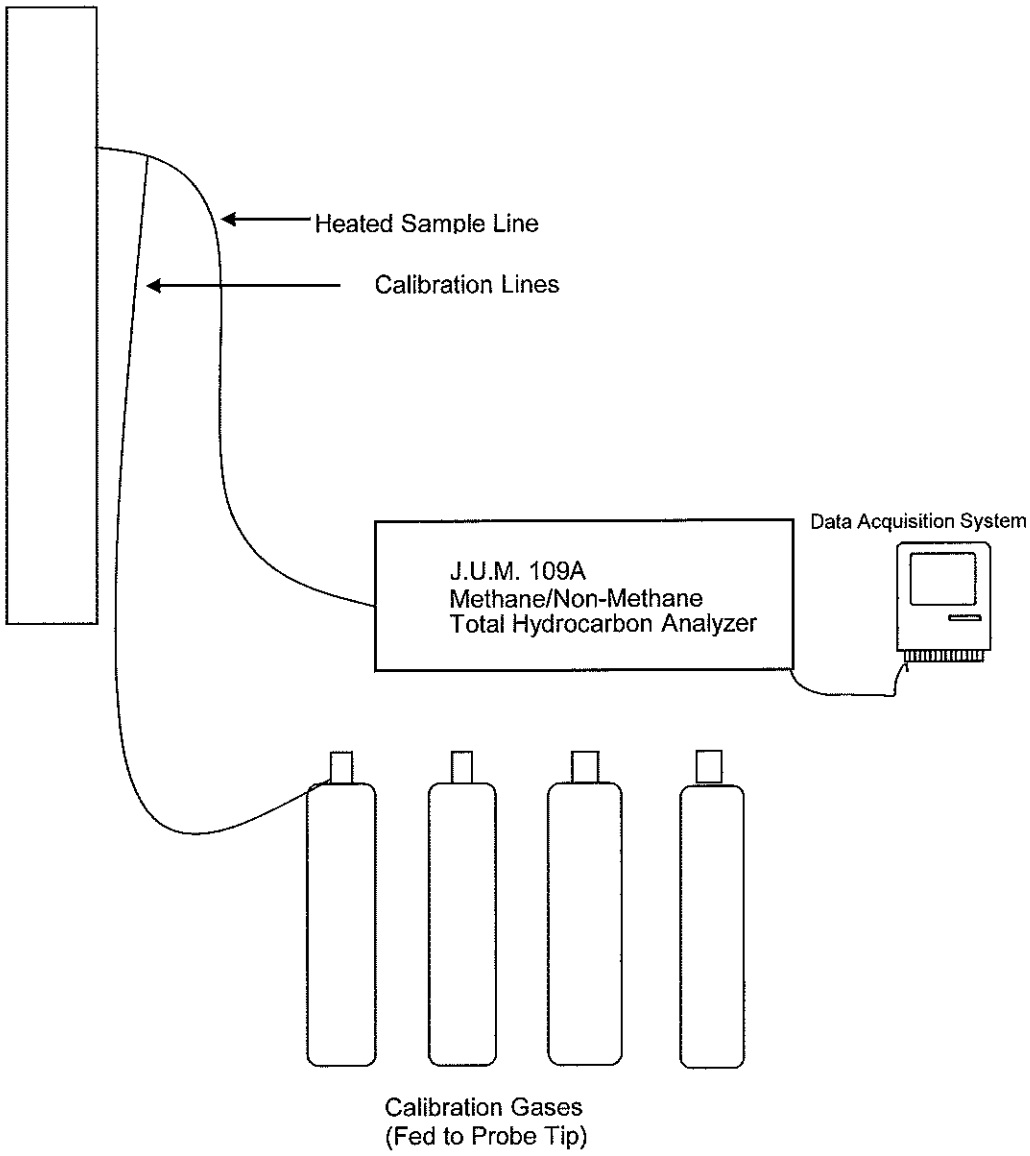


Figure No. 2

Site: **USEPA Method 25A** **HarbisonWalker** **White Cloud, Michigan**	**Sampling Date:** **June 1, 2017**

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

BTEC Inc.

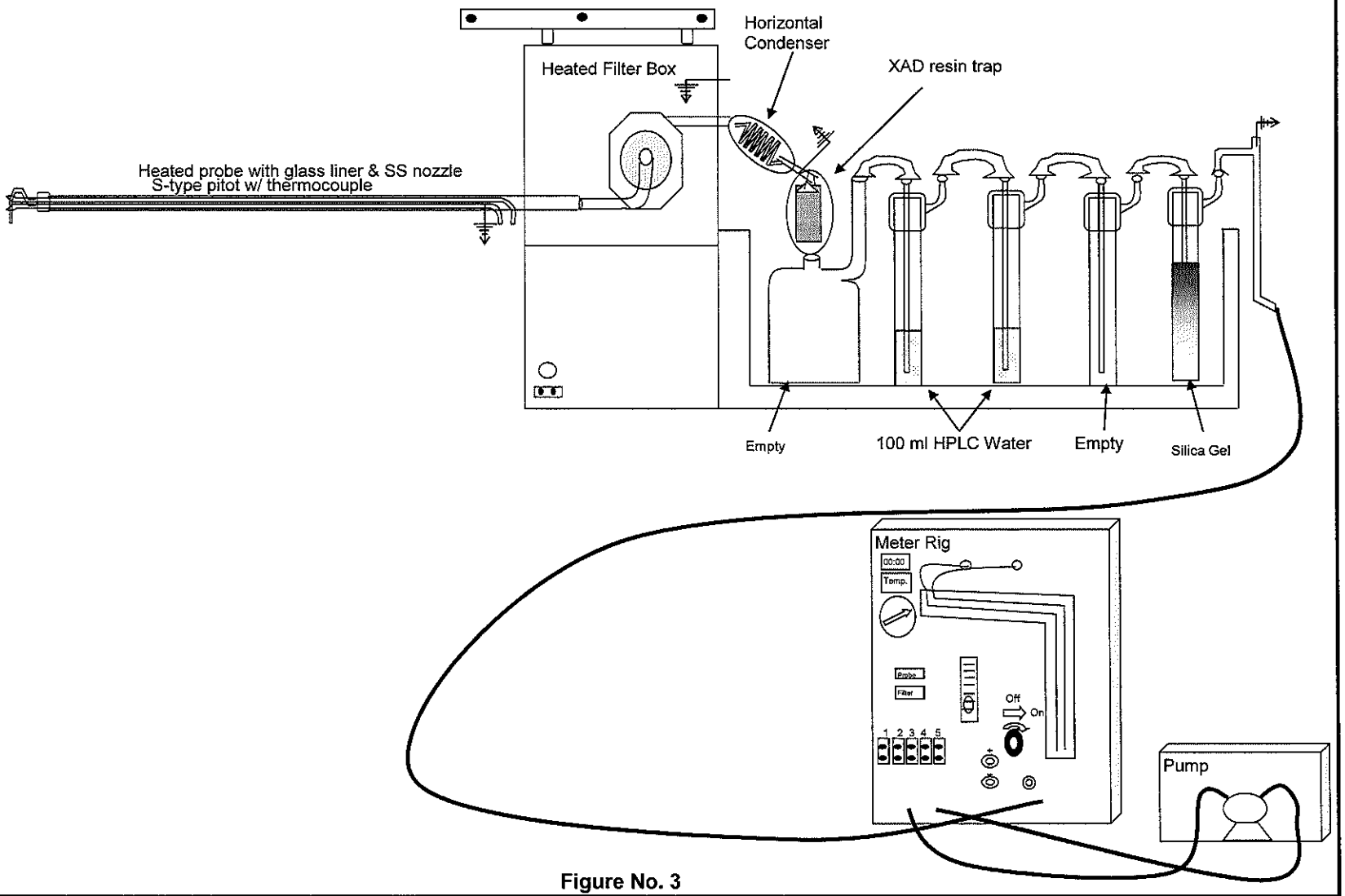


Figure No. 3

Site: **SW-846 Test Method 0010** **HarbisonWalker** **White Cloud, Michigan**	**Sampling Date:** **June 1, 2017**	**BT Environmental Consulting, Inc.** **4949 Fernlee Avenue** **Royal Oak, Michigan 48073**