BTEC Inc.

City of Warren Sewage Sludge Incinerator PM, HCl, Metals, D/F, NOx, CO, and SO_2 Emissions Test Report

Prepared for:

Tetra Tech, Inc.

710 Avis Drive
Ann Arbor, Michigan 48108

Project No. 17-5057.00
August 18, 2017

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BTEC Inc.

EXECUTIVE SUMMARY

BT Environmental Consulting, Inc. (BTEC) was retained by Tetra Tech Inc. (Tetra Tech) to conduct a performance test in conformance with Michigan Rule 972 "Emissions Standards For Existing Sewage Sludge Incineration Units" and 40 CFR Part 60 Subpart MMMM. The test program consisted of sampling and analysis of stack exhaust gas concentrations and emission rates for filterable particulate matter (PM), multiple metals (Cd, Pb, and Hg), dioxins and furans (D/F), hydrogen chloride (HCl), carbon monoxide (CO), sulfur dioxide (SO_2), oxides of nitrogen (NOx), and visible opacity from the Incinerator exhaust stack located at the City of Warren Wastewater Treatment Plant (WWTP). The emissions test program was conducted on July 13-14, 2017.

Testing consisted of triplicate 84-minute test runs for PM, HCl, CO, SO2, and NOx , triplicate 120-minute test runs for metals and D/F, and triplicate 60-minute test runs for opacity. The emissions test program was required by MDEQ Air Quality Division Renewable Operating Permit (ROP) No. MI-ROP-B1792-2016. The results of the emission test program are summarized by Table I.

Table I
Incinerator Overall Emission Summary
Test Date: July 13-14, 2017

Pollutant		Emission Limit[1]	Emission Rate[1]
PM		80 mg/dscm	9.0 mg/dscm
NOx		220 ppmv	205 ppmv
SO2		26 ppmv	0.17 ppmv
CO		3,800 ppmv	2,377 ppmv
Dioxins and Furans		5.0 ng/dscm total or	2.6 ng/dscm total
		0.28 ng/dscm TEQ	0.04 ng/dscm TEQ
Metals	Cadmium	0.095 mg/dscm	0.006 mg/dscm
	Lead	0.3 mg/dscm	0.048 mg/dscm
	Mercury	0.28 mg/dscm	0.040 mg/dscm
HCl		1.2 ppmv	0.8 ppmv

1: All emission limits and emission rates are corrected to 7% oxygen.

1. Introduction

BT Environmental Consulting, Inc. (BTEC) was retained by Tetra Tech Inc. (Tetra Tech) to conduct a performance test in conformance with Michigan Rule 972 "Emissions Standards For Existing Sewage Sludge Incineration Units" and 40 CFR Part 60 Subpart MMMM. The test program consisted of sampling and analysis of stack exhaust gas concentrations and emission rates for filterable particulate matter (PM), multiple metals (Cd, Pb, and Hg), dioxins and furans (D/F), hydrogen chloride (HCl), carbon monoxide (CO), sulfur dioxide (SO_2), oxides of nitrogen (NOx), and visible opacity from the Incinerator exhaust stack located at the City of Warren Wastewater Treatment Plant (WWTP). The emissions test program was conducted on July 13-14, 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 July 13-14, 2017 at the WWWTP in Warren, Michigan. The test program included evaluation of NOx, CO, SO2, D/F, metals, PM, HCl, and opacity from the incinerator exhaust.

1.b Purpose of Testing

AQD issued Renewable Operating Permit No. MI-ROP-B1792-2016 to WWWTP. This permit limits emissions from the incinerator as summarized by Table 1.

Table 1
Existing Multiple Hearth Sewage Sludge Emission Limitations

Pollutant	Part 62 Subpart LLL Limit
PM	80 mg/dscm
NOx	220 ppmV
SO_2	26 ppmV
CO	3,800 ppmV
Dioxin and Furans	5.0 ng/dscm total or 0.28 ng/dscm TEQ
Metals	Cadmium 0.095 mg/dscm
	Lead 0.3 mg/dscm
	Mercury 0.28 mg/dscm
HCl	1.2 ppmV

All limits are corrected to 7% oxygen

1.c Source Description

The City of Warren owns and operates a multiple hearth sewage sludge incinerator located in Warren, Michigan. The incinerator combusts natural gas and sewage sludge, a product of secondary and tertiary waste water treatment processes, also known as biosolids. The incinerator exhaust gases are passed through a wet scrubber prior to discharge to atmosphere.

1.d Test Program Contacts

The contact for the source and test report is:

Mr. Todd Schaedig, P.E.
Facility Engineer
City of Warren Wastewater Treatment Plant
32360 Warkrop Ave.
Warren, MI 48093
586-264-2530 ext 8203

Ms. Valerie Guenther P.E.
Project Manager
Tetra Tech Inc.
710 Avis Drive, Suite 100
Ann Arbor, Michigan 48108
734-765-3984 (c) 734-213-4043 (w)

Mr. Barry P. Boulianne
Senior Project Manager
BT Environmental Consulting, Inc.
4949 Fernlee Avenue
Royal Oak, MI 48073
313-449-2361

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
Ms. Valerie Guenther Project Manager	Tetra Tech Inc. 710 Avis Drive, Suite 100 Ann Arbor, Michigan 48108	(734) 765-3984
Mr. Matthew Young Project Manager	BTEC 4949 Fernlee Royal Oak, MI 48073	(248) 744-9133
Mr. Brandon Chase Senior Environmental Engineer	BTEC 4949 Fernlee Royal Oak, MI 48073	(248) 548-8070
Mr. Mason Sakshaug Environmental Technician	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. Josh Boulianne 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. Mark Dziadosz Environmental Quality Analyst	MDEQ Air Quality Division	(586) 753-3745
Mr. Sebastian Kallumkal Senior Environmental Engineer	MDEQ Air Quality Division	(586) 753-3738

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 monitored during the emissions test program included sludge feed rate in wet tons per hour, pH at the venturi stage drain, water flow in gpm and differential pressure in inches of water column across the VenturiPak unit and combustion chamber temperature of hearths 4, 5, 6 & 7 in degrees Fahrenheit. Based on one year of operational experience with the new pollution controls in place Warren believes that the best representation of the combustion temperature in the incinerator is the average of hearths 4, 5, 6 and 7. This average better represents the minimum temperature that should be maintained in the incinerator during the varying sludge cake loading conditions that might be encountered

during normal plant operations. The actual data that was recorded is compiled and averaged per the rule in Appendix F.

2.b Applicable Permit

The applicable permit for this emissions test program is Renewable Operating Permit (ROP) No. MI-ROP-B1792-2016.

2.c Results

The overall results of the emission test program are summarized by Table 3 (see Section 5.a). Detailed emission summaries can be found in Tables 4-7.

3. Source Description

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

3.a Process Description

The City of Warren owns and operates a multiple hearth sewage sludge incinerator located in Warren, Michigan. The incinerator combusts natural gas and sewage sludge, a product of secondary and tertiary waste water treatment processes, also known as biosolids. The incinerator exhaust gases are passed through a wet scrubber prior to discharge to atmosphere.

3.b Process Flow Diagram

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

3.c Raw and Finished Materials

The process combusts dewatered biosolids which is fed to the incinerator at a maximum rate of 6.75 wet tons per hour, which is equivalent to an 85% feed rate of 5.74 wet tons per hour.

3.d Process Capacity

The process combusts dewatered biosolids which is fed to the incinerator at a maximum rate of 6.75 wet tons per hour, which is equivalent to an 85% feed rate of 5.74 wet tons per hour.

3.e Process Instrumentation

Process data monitored during the emissions test program included sludge feed rate in wet tons per hour, pH at the venturi stage drain, water flow in gpm and differential pressure in inches of water column across the VenturiPak unit and combustion chamber temperature of

hearths 4, 5, 6, & 7 in degrees Fahrenheit. The actual data that was recorded is compiled and averaged per the rule in Appendix 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

Sampling and analytical methodologies for the emissions test program were separated into six categories as follows:

(1) Measurement of exhaust gas velocity, molecular weight, and moisture content;
(2) Measurement of exhaust gas filterable PM and HCl concentration using USEPA Method 5/26A
(3) Measurement of exhaust gas metals concentration using USEPA Method 29
(4) Measurement of exhaust gas D/F concentration using USEPA Method 23
(5) Measurement of exhaust gas O_2, CO_2, NOx, SO_2 and CO concentration using USEPA Method 3A/6C/7E/10
(6) Measurement of exhaust gas visible emissions using USEPA Method 9

Sampling and analytical methodologies by category are summarized below.

Exhaust Gas Velocity, Molecular Weight, and Moisture Content

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, Section 4.1.1, were used to measure exhaust gas velocity pressures (using a manometer) and temperatures during testing. The S-type pitot tube dimensions outlined in Sections 2-6 through 2-8 were within specified limits, therefore, a baseline pitot tube coefficient of 0.84 (dimensionless) was assigned. A diagram of the sample points is provided in Figure 1.

Cyclonic flow checks were performed at each 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.

The Molecular Weight of the gas stream was evaluated according to procedures outlined in Title 40, Part 60, Appendix A, Method 3A. The O_2 /CO_2 content of the gas stream was measured using an O_2/CO_2 analyzer.

Exhaust gas was extracted as part of the sampling train. Exhaust gas moisture content was then determined gravimetrically.

PM and HCl (USEPA Method 5/26A)

40 CFR 60, Appendix A, Method 5, *"Determination of Particulate Emissions from Stationary"* and 40 CFR 60, Appendix A, Method 26A, *"Determination of Hydrogen Halide and Halogen Emissions from Stationary Sources"* was used to measure PM and HCl concentrations and emission (see Figure 2 for a schematic of the sampling train).

BTEC's Nutech® Model 2010 modular isokinetic stack sampling systems consisted of (1) a glass nozzle, (2) a steel probe with glass liner, (3) a set of four Greenburg-Smith (GS) impingers with the first and third modified and second standard GS impingers, the first two containing 100 ml 0.1N H2SO4, the third empty, and a fourth modified GS impinger containing approximately 300 g of silica gel desiccant, (5) a length of sample line, and (6) a CleanAir® control case equipped with a pump, dry gas meter, and calibrated orifice.

A sampling train leak test was conducted before and after each test run. After completion of the final leak test for each test run, the filter was recovered, and the probe, nozzle and the front half of the filter holder assembly were brushed and triple rinsed with acetone. The acetone rinses were collected in a pre-cleaned sample container. The impinger catch solution was then transferred to pre-cleaned sample containers. The impingers were then triple rinsed with deionized water (DI H2O), and the rinses added to the H2SO4 sample containers. The back-half of the filter holder was rinsed and added to the H2SO4 sample container. The containers were labeled with the test number, test location, test date, and the level of liquid was marked on the outside of each container.

Metals (USEPA Method 29)

40 CFR 60, Appendix A, Method 29, "Determination of Metals Emissions From Stationary Sources" was used to measure metals concentrations and calculate appropriate emission rates (see Figure 3 for a schematic of the sampling train).

BTEC's Nutech® Model 2010 modular isokinetic stack sampling system consisted of (1) a Teflon coated stainless steel nozzle, (2) a glass probe, (3) six Greenburg-Smith (GS) impingers with the first two filled with 100 ml of a 5% HNO3 / 10% H2O2 solution, an empty impinger, then two with 100 ml of a 4% KMnO4 / 10% H2SO4 solution, and a modified impinger filled with approximately 300 grams of silica gel. (4) a length of sample line, and (5) a Nutech® control case equipped with a pump, dry gas meter, and calibrated orifice.

Upon completion of the final leak test for each test run, the filter was recovered, and the nozzle and the front half of the filter holder assembly were brushed and triple rinsed with 100 ml of 0.1N HNO3. The rinses were collected in a pre-cleaned sample container and prepared for transport.

The back half of the filter housing and first three impingers were triple rinsed with 100 ml of 0.1N HNO3. The fourth impinger (empty) was rinsed with 100 ml of 0.1N HNO3. The fifth and sixth impingers were triple rinsed with 100 ml of KMNO4, followed by a triple rinse with 100 ml of H20 and placed in their respective sample containers. The impingers were then triple rinsed with 25 ml of 8N HCl and placed in sample container with 200 ml H20.

Dioxins and Furans (USEPA Method 23)

40 CFR 60, Appendix A, Method 23, "Determination of Polychlorinated Dibenzo-p-dioxins and Polychlorinated Dibenzofurans from Municipal Waste Combustors" was used to evaluate CDD/CDF concentrations (see Figure 4 for a schematic of the sampling train).

The Method 23 sampling train consisted of (1) a borosilicate glass or quartz nozzle, (2) a steel probe w/ glass liner, (3) a heated quartz 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 impinger was empty, and the fourth impinger contained approximately 300 g of silica gel desiccant.

Upon completion of the final leak test for each test run, the filter was recovered, and the nozzle and the front half of the filter holder assembly were brushed and triple rinsed with Acetone and $MeCl_2$. The rinses were collected in a pre-cleaned sample container.

The back half of the filter housing was rinsed with acetone and MeCl2. The Condenser was soaked in MeCl2 for 5 minutes with three separate portions and recovered into the pre-cleaned sample container. A repeat of this rinse method using toluene was performed and added to the sample container.

O_2, CO_2, NOx, SO_2 and CO (USEPA Method 3A/6C/7E/10)

The NOx content of the gas stream was measured using a Thermo Model 42i NOx gas analyzer. The CO content of the gas stream was measured using a TECO 48 CO gas analyzer. The SO2 content was measured using a Western Research SO_2 gas analyzer. The O2/CO2 content was measured using a Servomex 4000 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 gas analyzers. Data was recorded on a PC equipped with data acquisition software. Recorded NOx 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 5.

In accordance with Method 7E, a 4-point (zero, low, 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 NOx analyzer was operated at the 0-500 ppm range. The CO analyzer was operated at the 0-5000 ppm range. The SO_2 analyzer was operated in the 0-100 ppm range.

Visible Emissions (USEPA Method 9)

40 CFR 60, Appendix A, Method 9, *"Visual Determination of the Opacity of Emissions from Stationary Sources"* was used to measure opacity on incinerator exhaust. Triplicate test runs of 60 minutes were conducted.

Testing was conducted at the request of Sebastian Kallumkal of the MDEQ, although there is no permitted limit for visible emissions. The highest individual opacity reading observed for the incinerator was 10%. Hand written opacity sheets as well as observer certification are included in Appendix A.

4.b Recovery and Analytical Procedures

Descriptions of the recovery procedures are provided in section 4.a for each sampling method.

4.c Sampling Ports

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

4.d Traverse Points

A diagram of the stack indicating traverse point locations and stack dimensions is included as 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 overall results of the emissions test program are summarized by Table 3. Detailed results for the emissions test program are summarized by Tables 4 through 7.

Table 3
Incinerator Overall Emission Summary
Test Date: July 13-14, 2017

Pollutant		Emission Limit[1]	Emission Rate[1]
PM		80 mg/dscm	9.0 mg/dscm
NOx		220 ppmv	205 ppmv
SO2		26 ppmv	0.17 ppmv
CO		3,800 ppmv	2,377 ppmv
Dioxins and Furans		5.0 ng/dscm total or 0.28 ng/dscm TEQ	2.6 ng/dscm total 0.04 ng/dscm TEQ
Metals	Cadmium	0.095 mg/dscm	0.006 mg/dscm
	Lead	0.3 mg/dscm	0.048 mg/dscm
	Mercury	0.28 mg/dscm	0.040 mg/dscm
HCl		1.2 ppmv	0.8 ppmv

1: All emission limits and emission rates are corrected to 7% oxygen.

5.b Discussion of Results

All emissions are below their corresponding limits.

5.c Sampling Procedure Variations

None.

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

An audit sample for cadmium, lead, and mercury was sent to Maxxam for analysis.

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

Laboratory analytical results are presented in Appendix E. Raw CEM data is provided electronically in Appendix D.

Table 4
Incinerator Particulate Matter and HCl Emission Rates

Company	**Tetra Tech (WWTP)**			
Source Designation	**Incinerator**			
Test Date	**7/14/2017**	**7/14/2017**	**7/14/2017**	
Test Run Time	8:50-10:21	10:47-12:14	12:50-14:16	
Meter/Nozzle Information	P-1	P-2	P-3	Average
Meter Temperature Tm (F)	76.5	80.4	83.8	80.2
Meter Pressure - Pm (in. Hg)	29.5	29.5	29.6	29.5
Measured Sample Volume (Vm)	69.5	68.2	76.2	71.3
Sample Volume (Vm-Std ft3)	68.1	66.3	73.7	69.3
Sample Volume (Vm-Std m3)	1.93	1.88	2.09	1.96
Condensate Volume (Vw-std)	2.546	2.442	3.088	2.692
Gas Density (Ps(std) lbs/ft3) (wet)	0.0753	0.0757	0.0755	0.0755
Gas Density (Ps(std) lbs/ft3) (dry)	0.0763	0.0767	0.0767	0.0766
Total weight of sampled gas (m g lbs) (wet)	5.32	5.20	5.80	5.44
Total weight of sampled gas (m g lbs) (dry)	5.20	5.08	5.65	5.31
Nozzle Size - An (sq. ft.)	0.001294	0.001294	0.001294	0.001294
Isokinetic Variation - I	99.8	100.0	100.7	100.1
Stack Data				
Average Stack Temperature - Ts (F)	94.2	95.7	97.5	95.8
Molecular Weight Stack Gas- dry (Md)	29.5	29.7	29.7	29.6
Molecular Weight Stack Gas-wet (Ms)	29.1	29.3	29.2	29.2
Stack Gas Specific Gravity (Gs)	1.006	1.011	1.009	1.008
Percent Moisture (Bws)	3.61	3.56	4.02	3.73
Water Vapor Volume (fraction)	0.0361	0.0356	0.0402	0.0373
Pressure - Ps ("Hg)	29.4	29.4	29.4	29.4
Average Stack Velocity -Vs (ft/sec)	11.6	11.3	12.6	11.8
Area of Stack (ft2)	12.4	12.4	12.4	12.4
Oxygen (%)	10.51	8.45	8.66	9.21
Exhaust Gas Flowrate				
Flowrate ft^3(Actual)	8,661	8,425	9,381	8,822
Flowrate ft^3 (Standard Wet)	8,099	7,857	8,721	8,226
Flowrate ft^3 (Standard Dry)	7,807	7,578	8,370	7,918
Flowrate m^3 (standard dry)	221	215	237	224
Total Particulate Weights (mg)				
Nozzle/Probe/Filter	14.1	15.7	14.6	14.8
Total Particulate Concentration				
lb/1000 lb (wet)	0.006	0.007	0.006	0.006
lb/1000 lb (dry)	0.006	0.007	0.006	0.006
mg/dscm (dry)	7.3	8.4	7.0	7.6
mg/dscm (dry) @7%O2	9.8	9.3	7.9	9.0
gr/dscf	0.0032	0.0037	0.0031	0.0033
Total Particulate Emission Rate				
lb/ hr	0.21	0.24	0.22	0.22
Total HCl Weight (ug)				
Sample Catch	2200.00	1700.00	2300.00	2066.67
Blank correction	0.00	0.00	0.00	0.00
Total	2200.00	1700.00	2300.00	2066.67
Total HCl Concentration				
lb/1000 lb (wet)	0.001	0.001	0.001	0.001
lb/1000 lb (dry)	0.001	0.001	0.001	0.001
mg/dscm (dry)	1.1	0.9	1.1	1.0
PPMV (dry)	0.8	0.6	0.7	0.7
PPMV (dry) @7%O2	1.0	0.7	0.8	0.8
Total HCl Emission Rate				
lb/ hr	0.03	0.03	0.03	0.03

Table 5
Incinerator Metals Emission Rates

Company	**Tetra Tech (WWTP)**			
Source Designation	**Incinerator**			
Test Date	**7/13/2017**	**7/13/2017**	**7/13/2017**	
Test Run Time	8:47-11:04	12:16-14:30	15:15-17:24	
Meter/Nozzle Information	P-1	P-2	P-3	Average
Meter Temperature Tm (F)	72.4	75.6	77.4	75.2
Meter Pressure - Pm (in. Hg)	29.4	29.4	29.4	29.4
Measured Sample Volume (Vm)	94.2	105.0	103.4	100.9
Sample Volume (Vm-Std ft3)	91.7	101.7	99.9	97.8
Sample Volume (Vm-Std m3)	2.60	2.88	2.83	2.77
Condensate Volume (Vw-std)	3.400	3.678	3.593	3.557
Gas Density (Ps(std) lbs/ft3) (wet)	0.0759	0.0758	0.0758	0.0758
Gas Density (Ps(std) lbs/ft3) (dry)	0.0770	0.0769	0.0769	0.0769
Total weight of sampled gas (m g lbs) (wet)	7.22	7.99	7.84	7.68
Total weight of sampled gas (m g lbs) (dry)	7.06	7.82	7.67	7.52
Nozzle Size - An (sq. ft.)	0.001294	0.001294	0.001294	0.001294
Isokinetic Variation - I	100.1	100.5	100.4	100.3
Stack Data				
Average Stack Temperature - Ts (F)	87.7	89.3	89.9	89.0
Molecular Weight Stack Gas- dry (Md)	29.8	29.8	29.7	29.8
Molecular Weight Stack Gas-wet (Ms)	29.4	29.3	29.3	29.3
Stack Gas Specific Gravity (Gs)	1.014	1.013	1.013	1.013
Percent Moisture (Bws)	3.57	3.49	3.47	3.51
Water Vapor Volume (fraction)	0.0357	0.0349	0.0347	0.0351
Pressure - Ps ("Hg)	29.3	29.3	29.3	29.3
Average Stack Velocity -Vs (ft/sec)	10.8	12.0	11.8	11.5
Area of Stack (ft2)	12.4	12.4	12.4	12.4
Oxygen (%)	8.77	9.27	8.84	8.96
Exhaust Gas Flowrate				
Flowrate ft^3(Actual)	8,067	8,931	8,786	8,595
Flowrate ft^3 (Standard Wet)	7,611	8,400	8,255	8,088
Flowrate ft^3 (Standard Dry)	7,338	8,106	7,968	7,804
Flowrate m^3 (standard dry)	208	230	226	221
Total Metals Weights (ug)				
Cadmium	15.9	14.9	13.7	14.8
Lead	110.4	121.4	113.4	115.1
Mercury	92.9	93.1	95.7	93.9
Cadmium Concentration				
lb/1000 lb (wet)	4.86E-06	4.11E-06	3.85E-06	4.27E-06
lb/1000 lb (dry)	4.97E-06	4.20E-06	3.94E-06	4.37E-06
mg/dscm (dry)	6.12E-03	5.17E-03	4.85E-03	5.38E-03
mg/dscm (dry) @7%O2	7.02E-03	6.18E-03	5.58E-03	6.26E-03
gr/dscf	2.68E-06	2.26E-06	2.12E-06	2.35E-06
Cadmium Emission Rate				
lb/ hr	1.69E-04	1.58E-04	1.45E-04	1.57E-04
Lead Concentrations				
lb/1000 lb (wet)	3.37E-05	3.35E-05	3.19E-05	3.30E-05
lb/1000 lb (dry)	3.45E-05	3.42E-05	3.26E-05	3.38E-05
mg/dscm (dry)	4.25E-02	4.22E-02	4.01E-02	4.16E-02
mg/dscm (dry) @7%O2	4.87E-02	5.04E-02	4.62E-02	4.85E-02
gr/dscf	1.86E-05	1.84E-05	1.75E-05	1.82E-05
Lead Emission Rate				
lb/ hr	1.17E-03	1.29E-03	1.20E-03	1.22E-03
Mercury Concentrations				
lb/1000 lb (wet)	2.84E-05	2.57E-05	2.69E-05	2.70E-05
lb/1000 lb (dry)	2.90E-05	2.63E-05	2.75E-05	2.76E-05
mg/dscm (dry)	3.58E-02	3.23E-02	3.39E-02	3.40E-02
mg/dscm (dry) @7%O2	4.10E-02	3.87E-02	3.90E-02	3.96E-02
Mercury Emission Rate				
lb/ hr	9.87E-04	9.86E-04	1.01E-03	9.96E-04

Table 6A
Incinerator Dioxins and Furans Emission Rates

Company	**Tetra Tech WWTP**			
Source Designation	**Incinerator**			
Test Date	**7/13/2017**	**7/13/2017**	**7/13/2017**	
Meter/Nozzle Information	P-1	P-2	P-3	Average
Meter Temperature Tm (F)	79.7	83.3	85.8	82.9
Meter Pressure - Pm (in. Hg)	29.5	29.5	29.5	29.5
Measured Sample Volume (Vm)	103.9	103.6	108.4	105.3
Sample Volume (Vm-Std ft3)	100.9	99.9	104.1	101.6
Sample Volume (Vm-Std m3)	2.86	2.83	2.95	2.88
Condensate Volume (Vw-std)	3.461	3.428	3.569	3.486
Gas Density (Ps(std) lbs/ft3) (wet)	0.0760	0.0759	0.0758	0.0759
Gas Density (Ps(std) lbs/ft3) (dry)	0.0770	0.0769	0.0769	0.0769
Total weight of sampled gas (m g lbs) (wet)	7.93	7.84	8.16	7.98
Total weight of sampled gas (m g lbs) (dry)	7.77	7.68	8.00	7.82
Nozzle Size - An (sq. ft.)	0.001342	0.001342	0.001342	0.001342
Isokinetic Variation - I	99.4	99.9	100.0	99.8
Stack Data				
Average Stack Temperature - Ts (F)	91.9	94.0	94.2	93.3
Molecular Weight Stack Gas- dry (Md)	29.8	29.8	29.7	29.8
Molecular Weight Stack Gas-wet (Ms)	29.4	29.4	29.3	29.4
Stack Gas Specific Gravity (Gs)	1.015	1.014	1.013	1.014
Percent Moisture (Bws)	3.32	3.32	3.32	3.32
Water Vapor Volume (fraction)	0.0332	0.0332	0.0332	0.0332
Pressure - Ps ("Hg)	29.3	29.3	29.3	29.3
Average Stack Velocity -Vs (ft/sec)	11.6	11.5	12.0	11.7
Area of Stack (ft2)	12.4	12.4	12.4	12.4
Exhaust Gas Flowrate				
Flowrate ft^3(Actual)	8,657	8,563	8,916	8,712
Flowrate ft^3 (Standard Wet)	8,105	7,987	8,312	8,134
Flowrate ft^3 (Standard Dry)	7,836	7,722	8,036	7,865
Flowrate m^3 (standard dry)	222	219	228	223

Table 6B
Incinerator Dioxins and Furans Emission Rates
Tetra Tech (WWWTP)
Warren, Michigan
BTEC Project No. 16-4839.00
Sampling Date: July 13, 2017

Parameter	Compound Toxic Equivalency	Run 1	Run 2	Run 3	Average
Test Run Date		7/13/2017	7/13/2017	7/13/2017	
Test Run Time		8:47-11:04	12:16-14:30	15:15-17:24	
Sample Volume (dscf)		100.9	99.9	104.1	101.6
O_2 Concentration (%)		8.77	9.27	8.84	8.96
Laboratory Result (pg)					
2378-TCDD		28.8	24.2	32.1	28.4
12378-PeCDD		0.0	0.0	0.0	0.0
123478-HxCDD		0.0	0.0	0.0	0.0
123678-HxCDD		2.6	2.5	2.5	2.5
123789-HxCDD		3.4	0.0	2.6	2.0
1234678-HpCDD		14.0	11.6	11.5	12.4
OCDD		20.4	27.5	24.5	24.1
Total Tetra CDD		475	331.0	370.0	392.0
Total Penta CDD		31	29.6	27.8	29.3
Total Hexa CDD		36.0	29.6	17.0	27.5
Total Hepta CDD		29.3	22.8	24.7	25.6
Total Dioxins:		591.3	440.5	464.0	498.6
2378-TCDF		499.0	407.0	463.0	456.3
12378-PeCDF		45.2	34.7	37.9	39.3
23478-PeCDF		83.9	57.4	60.6	67.3
123478-HxCDF		31.8	20.3	22.9	25.0
123678-HxCDF		12.5	8.5	10.2	10.4
234678-HxCDF		17.7	11.8	13.9	14.5
123789-HxCDF		0.0	0.0	0.0	0.0
1234678-HpCDF		27.2	25.3	31.7	28.1
1234789-HpCDF		3.4	0.0	2.9	2.1
OCDF		13.8	16.1	19.0	16.3
Total Tetra CDD		4440	3260.0	6820.0	4840.0
Total Penta CDD		1070	871.0	954.0	965.0
Total Hexa CDD		139	96.1	117.0	117.4
Total Hepta CDD		43.9	35.4	48.5	42.6
Total Furans:		5692.9	4262.5	7939.5	5965.0
Concentrations (ng/dscm) - corrected to 7%O_2, No TEQ applied					
DIOXINS					
2378-TCDD	NA	1.2E-02	1.0E-02	1.3E-02	1.1E-02
12378-PeCDD	NA	0.0E+00	0.0E+00	0.0E+00	0.0E+00
123478-HxCDD	NA	0.0E+00	0.0E+00	0.0E+00	0.0E+00
123678-HxCDD	NA	1.0E-03	1.1E-03	9.8E-04	1.0E-03
123789-HxCDD	NA	1.4E-03	0.0E+00	1.0E-03	7.9E-04
1234678-HpCDD	NA	5.6E-03	4.9E-03	4.5E-03	5.0E-03
OCDD	NA	8.2E-03	1.2E-02	9.6E-03	9.8E-03
Total Tetra CDD	NA	1.9E-01	1.4E-01	1.4E-01	1.6E-01
Total Penta CDD	NA	1.2E-02	1.2E-02	1.1E-02	1.2E-02
Total Hexa CDD	NA	1.4E-02	1.2E-02	6.6E-03	1.1E-02
Total Hepta CDD	NA	1.2E-02	9.6E-03	9.7E-03	1.0E-02
Total Dioxins:		2.4E-01	1.9E-01	1.8E-01	2.0E-01
FURANS					
2378-TCDF	NA	2.0E-01	1.7E-01	1.8E-01	1.8E-01
12378-PeCDF	NA	1.8E-02	1.5E-02	1.5E-02	1.6E-02
23478-PeCDF	NA	3.4E-02	2.4E-02	2.4E-02	2.7E-02
123478-HxCDF	NA	1.3E-02	8.6E-03	9.0E-03	1.0E-02
123678-HxCDF	NA	5.0E-03	3.6E-03	4.0E-03	4.2E-03
234678-HxCDF	NA	7.1E-03	5.0E-03	5.4E-03	5.8E-03
123789-HxCDF	NA	0.0E+00	0.0E+00	0.0E+00	0.0E+00
1234678-HpCDF	NA	1.1E-02	1.1E-02	1.2E-02	1.1E-02
1234789-HpCDF	NA	1.4E-03	0.0E+00	1.1E-03	8.3E-04
OCDF	NA	5.5E-03	6.8E-03	7.4E-03	6.6E-03
Total Tetra CDD	NA	1.8E+00	1.4E+00	2.7E+00	1.9E+00
Total Penta CDD	NA	4.3E-01	3.7E-01	3.7E-01	3.9E-01
Total Hexa CDD	NA	5.6E-02	4.1E-02	4.6E-02	4.7E-02
Total Hepta CDD	NA	1.8E-02	1.5E-02	1.9E-02	1.7E-02
Total Furans:		2.3E+00	1.8E+00	3.1E+00	2.4E+00
Dioxins and Furans Totals:		2.5E+00	2.0E+00	3.3E+00	2.6E+00
Concentrations (ng/dscm) - Corrected to 7%O_2					
DIOXINS					
2378-TCDD	1	1.2E-02	1.0E-02	1.3E-02	1.1E-02
12378-PeCDD	1	0.0E+00	0.0E+00	0.0E+00	0.0E+00
123478-HxCDD	0.1	0.0E+00	0.0E+00	0.0E+00	0.0E+00
123678-HxCDD	0.1	1.0E-04	1.1E-04	9.8E-05	1.0E-04
123789-HxCDD	0.1	1.4E-04	0.0E+00	1.0E-04	7.9E-05
1234678-HpCDD	0.01	5.6E-05	4.9E-05	4.5E-05	5.0E-05
OCDD	0.0003	2.5E-06	3.5E-06	2.9E-06	2.9E-06
Dioxins Totals:		1.2E-02	1.0E-02	1.3E-02	1.2E-02
FURANS					
2378-TCDF	0.1	2.0E-02	1.7E-02	1.8E-02	1.8E-02
12378-PeCDF	0.03	5.4E-04	4.4E-04	4.4E-04	4.8E-04
23478-PeCDF	0.3	1.0E-02	7.3E-03	7.1E-03	8.2E-03
123478-HxCDF	0.1	1.3E-03	8.6E-04	9.0E-04	1.0E-03
123678-HxCDF	0.1	5.0E-04	3.6E-04	4.0E-04	4.2E-04
234678-HxCDF	0.1	7.1E-04	5.0E-04	5.4E-04	5.8E-04
123789-HxCDF	0.1	0.0E+00	0.0E+00	0.0E+00	0.0E+00
1234678-HpCDF	0.01	1.1E-04	1.1E-04	1.2E-04	1.1E-04
1234789-HpCDF	0.01	1.4E-05	0.0E+00	1.1E-05	8.3E-06
OCDF	0.0003	1.7E-06	2.0E-06	2.2E-06	2.0E-06
Furans Totals:		3.3E-02	2.7E-02	2.8E-02	2.9E-02
Dioxins and Furans Totals:		4.5E-02	3.7E-02	4.0E-02	4.1E-02

Note: values in Bold are below RDL (reportable detection limit) and have been reported as zero as per USEPA Method 23

dscfm = dry standard cubic feet per minute (corrected to 528°R, 29.92 in H_g)
dscfm = dry standard cubic feet (corrected to 528°F, 29.92 in H_g)
35.31 = conversion from m^3 to ft^3
1000 = conversion from ng to pg
lb/hr = pounds per hour
O_2 = oxygen concentration, %
60 = conversion from hr to minutes

Equations
(ng/dscm @7% O_2) = (Lab Result/1000) * (13.9/(20.9-O2)) / (Sample Volume * (1/35.31))
(ng/dscm @7% O_2) = TEF * (Lab Result/1000) * (13.9/(20.9-O2)) / (Sample Volume * (1/35.31))

Table 7
Incinerator NOx, SO2, and CO Emission Rates
Tetra Tech WWTP
Warren, MI
BTEC Project No. 17-5057.00
Sampling Dates: 7-14-17

Parameter	Run 1	Run 2	Run 3	Average
Test Run Date	7/14/2017	7/14/2017	7/14/2017	
Test Run Time	8:50-10:21	10:47-12:14	12:50-14:16	
Outlet Flowrate (dscfm)	7,807	7,578	8,370	**7,918**
Outlet Flowrate (scfm)	8,099	7,857	8,721	**8,226**
Oxygen Concentration (%)	10.57	8.50	8.69	**9.25**
Oxygen Concentration (%, drift corrected as per USEPA 7E)	10.51	8.45	8.66	**9.21**
Carbon Dioxide Concentration (%)	6.90	8.36	8.20	**7.82**
Carbon Dioxide Concentration (%, drift corrected as per USEPA 7E)	6.97	8.47	8.38	**7.94**
Outlet Oxides of Nitrogen Concentration (ppmv)	145.53	191.26	192.15	**176.31**
Outlet NOx Concentration (ppmv, corrected as per USEPA 7E)	143.28	187.01	188.00	**172.76**
NOx Emission Rate (lb/hr)	**8.11**	**10.35**	**11.48**	**9.98**
NOx Emission Rate (lb/hr) (corrected as per USEPA 7E)	**7.99**	**10.12**	**11.24**	**9.78**
Outlet NOx Concentration (ppmv, corrected to 7% O_2)	**191.68**	**208.79**	**213.50**	**204.66**
Outlet Carbon Monoxide Concentration (ppmv)	1546.29	2092.39	2112.68	**1917.12**
Outlet CO Concentration (ppmv, corrected as per USEPA 7E)	1617.14	2186.70	2225.73	**2009.86**
CO Emission Rate (lb/hr)	**52.47**	**68.92**	**76.87**	**66.09**
CO Emission Rate (lb/hr) (corrected as per USEPA 7E)	**54.87**	**72.03**	**80.98**	**69.29**
Outlet CO Concentration (ppmv, corrected to 7% O_2)	**2163.45**	**2441.38**	**2527.59**	**2377.47**
Outlet Sulfur Dioxide Concentration (ppmv)	2.59	3.10	3.09	**2.93**
Outlet SO_2 Concentration (ppmv, corrected as per USEPA 7E)	1.71	2.51	2.41	**2.21**
SO_2 Emission Rate (lb/hr)	**0.20**	**0.23**	**0.26**	**0.23**
SO_2 Emission Rate (lb/hr) (corrected as per USEPA 7E)	**0.13**	**0.19**	**0.20**	**0.17**
Outlet SO_2 Concentration (ppmv, corrected to 7 % O_2)	**2.29**	**2.80**	**2.74**	**2.61**

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, SO_2 = 64.05)
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 * ***dcfm*** * 60
$Conc_{@7\%O2}$ = Conc * (20.9 -7)/(20.9 - $\%O_2$)

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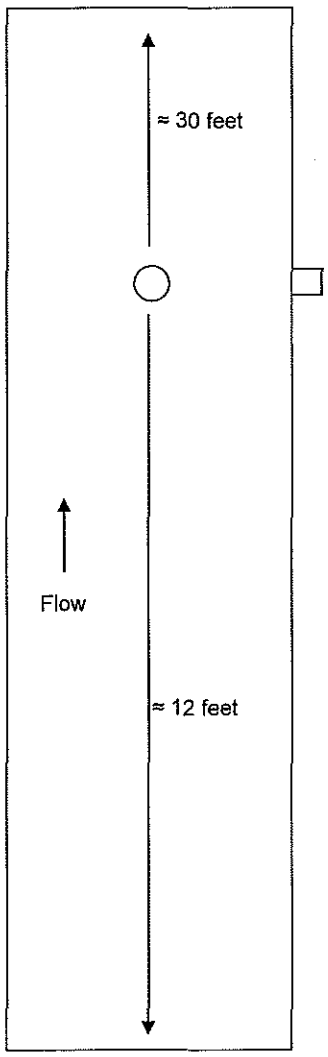
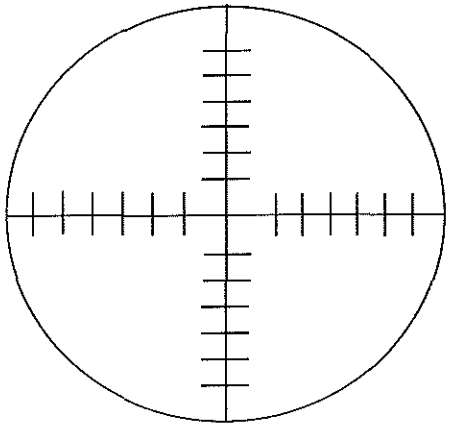
diameter = 47.75 inches





Not to Scale

Points	Distance "
1	1.0
2	3.2
3	5.6
4	8.5
5	11.9
6	17.0
7	30.8
8	35.8
9	39.3
10	42.1
11	44.6
12	46.7

Figure No. 1

Site: **Incinerator Exhaust** **WWTP** **Warren, Michigan**	**Sampling Date:** **July 13-14, 2017**	**BT Environmental Consulting, Inc.** **4949 Fernlee Avenue** **Royal Oak, Michigan 48073**

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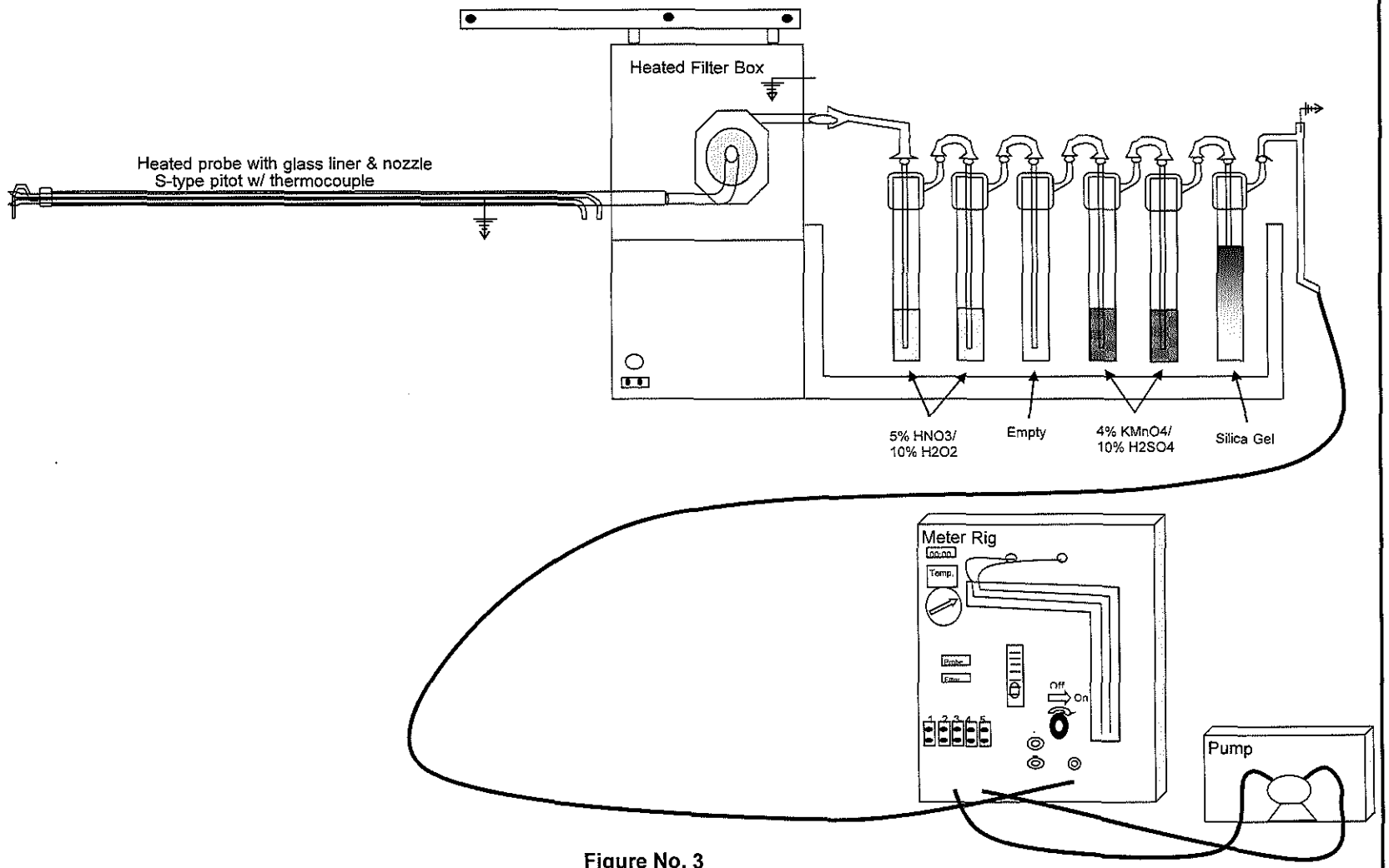

Figure No. 3

Site: **USEPA Method 29** **WWTP** **Warren, Michigan**	**Sampling Date:** **July 13, 2017**	**BT Environmental Consulting Inc.** **4949 Fernlee Avenue** **Royal Oak, MI 48073**

BTEC Inc.

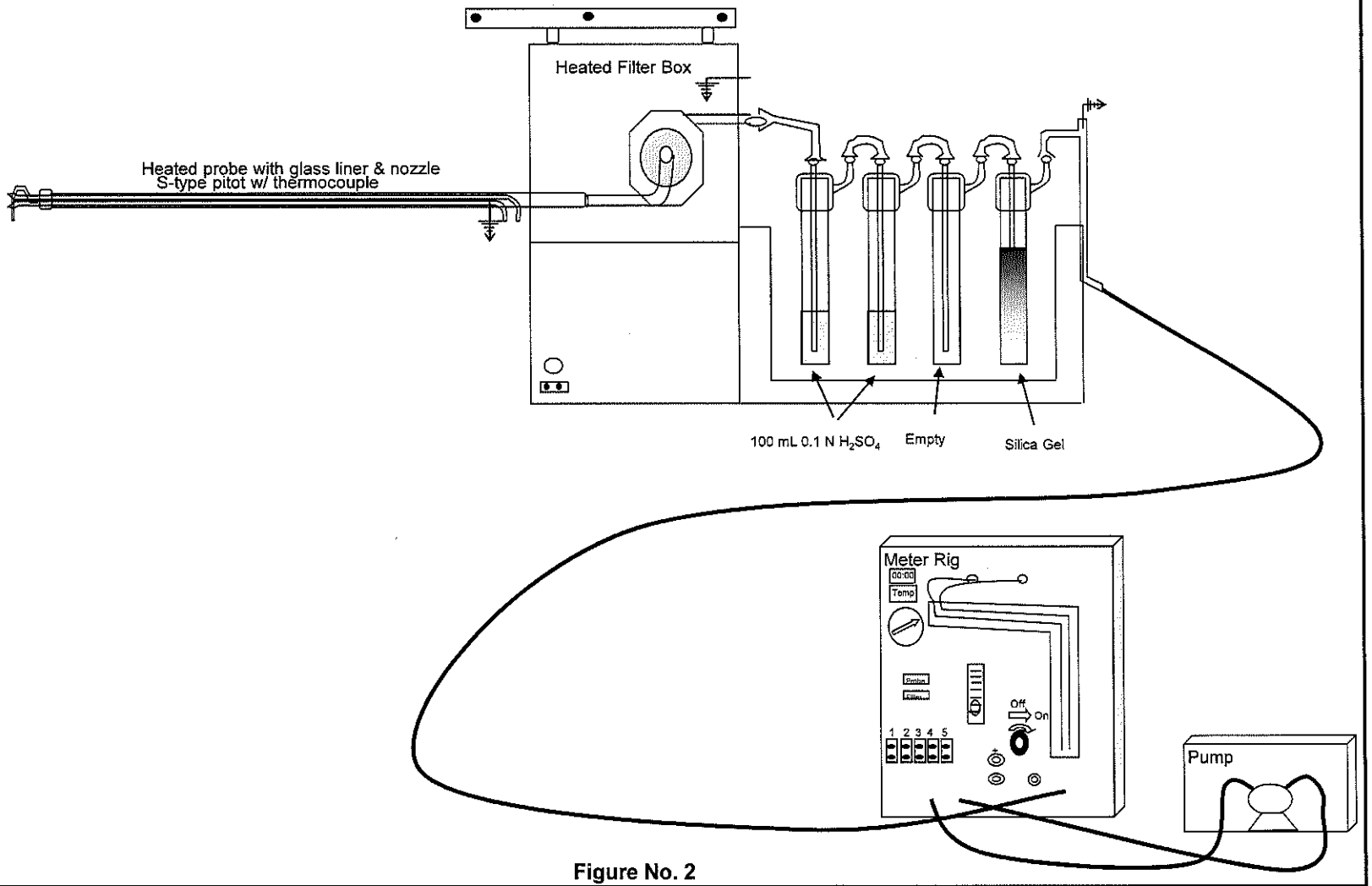

Figure No. 2

Site: **USEPA Method 5/26A** **WWTP** **Warren, Michigan**	**Sampling Date:** **July 14, 2017**	**BT Environmental Consulting, Inc.** **4949 Fernlee Avenue** **Royal Oak, Michigan 48073**

BTEC Inc.

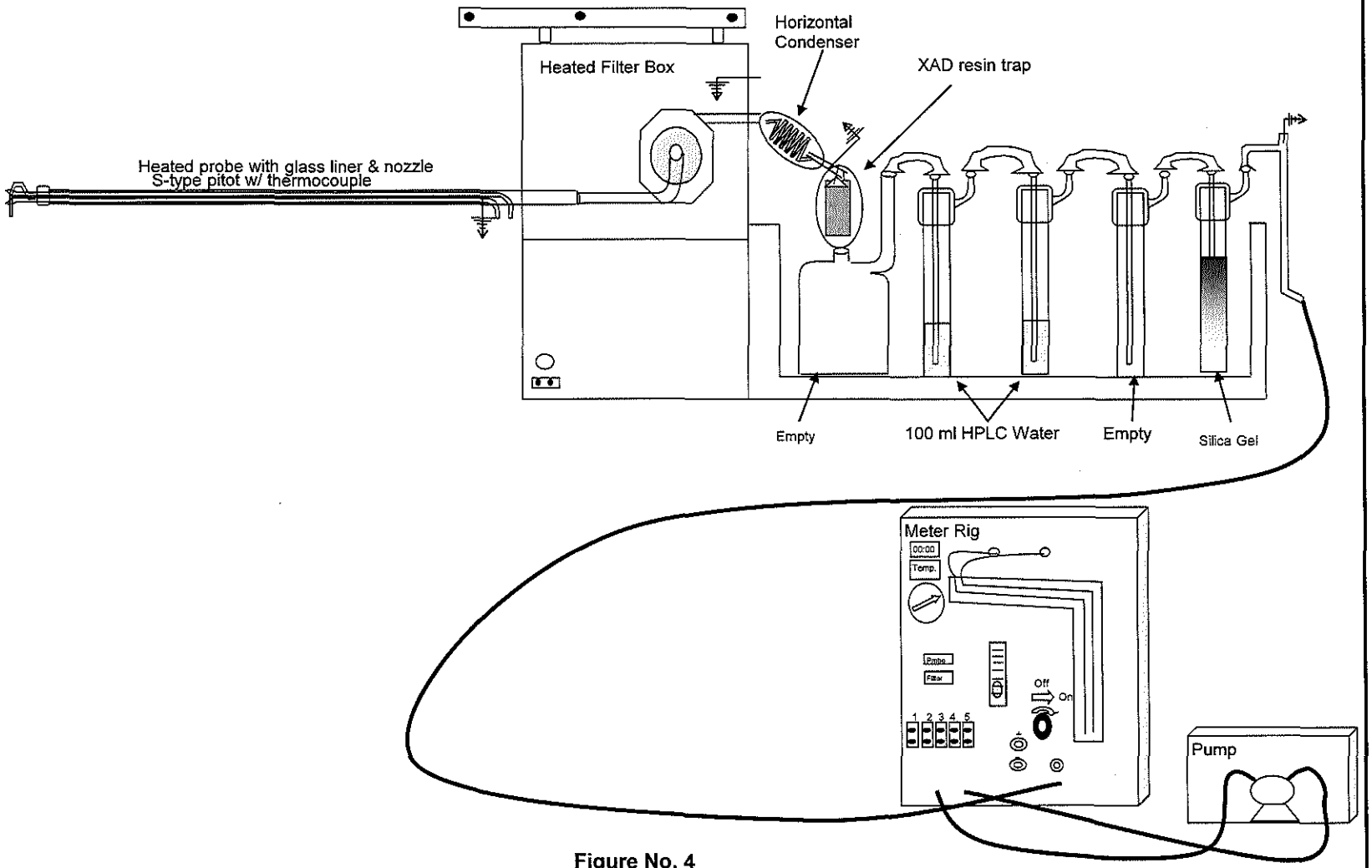

Figure No. 4

Site: **USEPA Method 23** **WWTP** **Warren, Michigan**	**Sampling Date:** **July 13, 2017**	**BT Environmental Consulting, Inc.** **4949 Fernlee Avenue** **Royal Oak, Michigan 48073**

BTEC Inc.

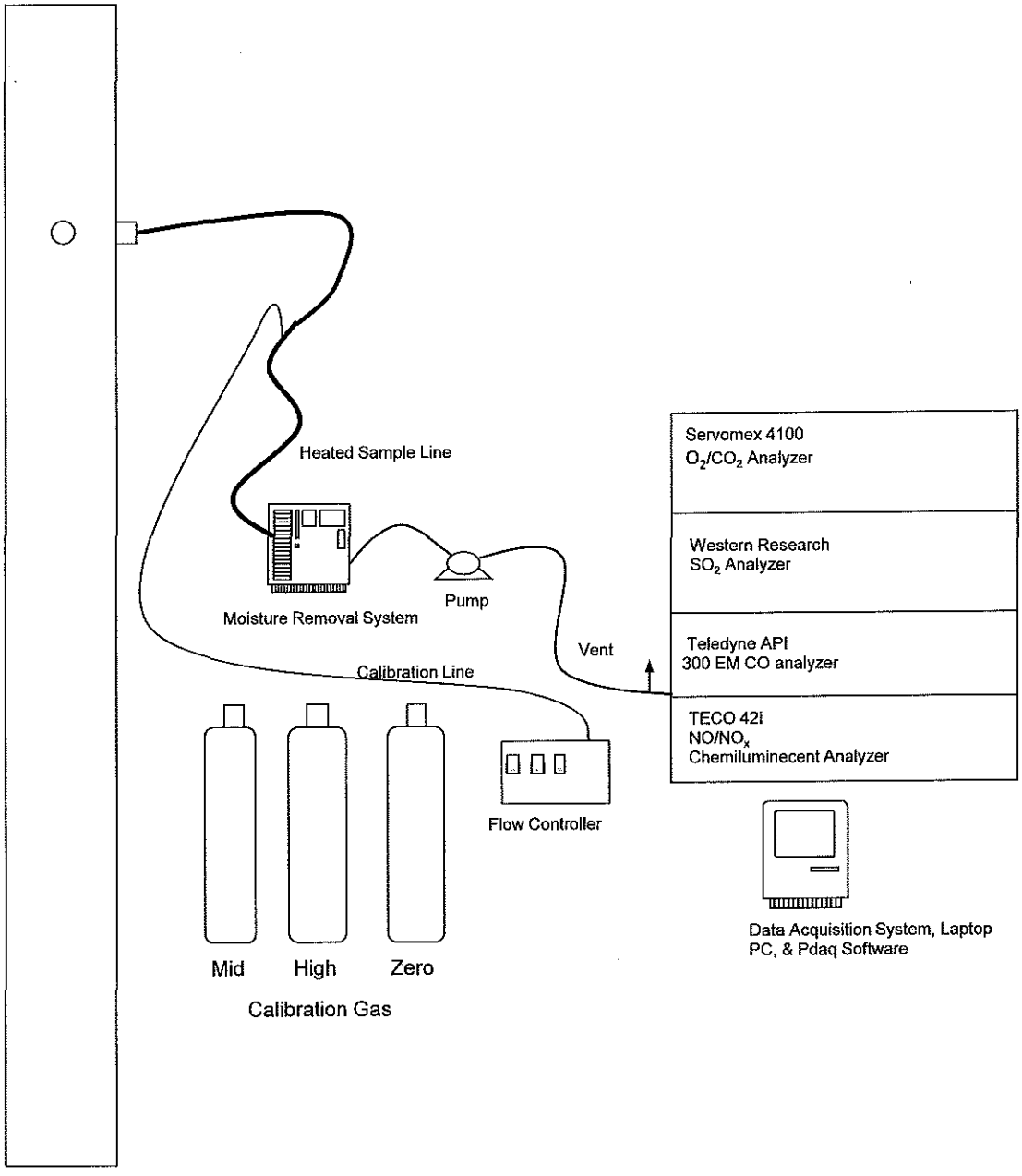

Figure No. 5

Site:	Sampling Date:	
USEPA Method 3A, 6C, 7E, and 10 WWTP Warren, Michigan	July 14, 2017	BT Environmental Consulting Inc. 4949 Fernlee Avenue Royal Oak, MI 48073