BTEC Inc.

Topcoat and Electrocoat VOC DE Emissions Test Summary Report

Prepared for:

General Motors Company

N6950

General Motors Lansing Delta Township
8175 Millett Hwy
Lansing, MI 48917

Project No. 13-4441.00
November 22, 2013

BT Environmental Consulting, Inc.
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BTEC Inc.

Executive Summary

BT Environmental Consulting, Inc. (BTEC) was retained by General Motors LLC (GM) to conduct a compliance emissions test program to evaluate the volatile organic compound (VOC) destruction efficiency (DE) of the Topcoat System Regenerative Thermal Oxidizer (RTO) and the Electrocoat RTO at the GM Lansing Delta Township Assembly facility in Lansing, Michigan. The emissions test program was conducted on October 8-9th 2013.

The test program consisted of triplicate 60-minute test runs at the Topcoat and Electrocoat RTO inlet and outlet sampling locations and was performed utilizing United States Environmental Protection Agency (USEPA) Test Methods 1, 2, 3, 4, and 25A. The average Topcoat System RTO DE measured during the emissions test program was 96.9%. The average Electrocoat System RTO DE measured during the emissions test program was 96.1%.

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1. Introduction

BT Environmental Consulting, Inc. (BTEC) was retained by General Motors LLC (GM) to conduct a compliance emissions test program to evaluate the volatile organic compound (VOC) destruction efficiency (DE) of the Topcoat System Regenerative Thermal Oxidizer (RTO) and the Electrocoat RTO at the GM Lansing Delta Township Assembly facility in Lansing, Michigan. The emissions test program was conducted on October 8-9th 2013.

The test program consisted of triplicate 60-minute test runs at the Topcoat and Electrocoat RTO inlet and outlet sampling locations and was performed utilizing United States Environmental Protection Agency (USEPA) Test Methods 1, 2, 3, 4, and 25A.

The Air Quality Division (AQD) of Michigan's Department of Environmental Quality has published a guidance document entitled "Format for Submittal of Source Emission Test Plans and Reports" (February 2008). 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

The source tested is located at the GM Lansing Delta Township facility (8175 Millett Hwy, Lansing, Michigan). VOC DE testing of the Topcoat RTO was performed on October 8th, 2013. VOC DE testing of the Electrocoat RTO was performed on October 9th, 2013.

1.b Purpose of Testing

The purpose of the testing is to demonstrate compliance with Michigan Renewable Operating Permit MI-ROP-N6950-2009A.

1.c Source Description

The emission units tested included the Topcoat and Electrocoat VOC abatement systems included in Renewable Operating Permit (ROP) No. MI-ROP-N6950-2009A. These emission units are part of an automobile surface coating process line. The emissions test program included evaluation of the following:

(1) The VOC destruction efficiency (DE) of the electrocoat system regenerative thermal oxidizer (RTO);
(2) The VOC DE of the topcoat system RTO.

1.d Test Program Contact

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

Ms. Kim Essenmacher
Staff Environmental Engineer
General Motors LLC
WFG – FES
GM Warren Technical Center, M/C: 480-206-1E0
30020 Mound Road - Bldg 1-11, Warren, MI 48090
(248) 255-7780

1.e Test Personnel

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

Table 1
Test Personnel

Name	Affiliation
Kim Essenmacher	GM-WFG
Karen Carlson	GM-LDT
Matthew Young	BTEC
Paul Draper	BTEC
Ken Felder	BTEC

2. Summary of Results

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

2.a Operating Data

Process and control equipment operating data relevant to the emissions test program is provided in Appendix A.

2.b Applicable Permit

The emission units tested included the Topcoat and Electrocoat VOC abatement systems included in Renewable Operating Permit (ROP) No. MI-ROP-N6950-2009A.

2.c Results

The results of the emissions test program are summarized by Tables 2 and 3.

2.d Emission Regulation Comparison

The purpose of the emissions test program is to verify VOC DE values for both RTO units. The values are then used in calculating VOC emission rates from each emission unit. Consequently, the results of the emissions test program do not have a corresponding emission limitation. The test results will be used to calculate daily emissions according to U.S. EPA document EPA-450/3-88-018, "Protocol for Determining the Daily Volatile Organic Compound Emission Rate of Automobile and Light-Duty Truck Topcoat Operations." for the affected emission groups.

3. Source Description

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

3.a Process Description

The topcoat process consists of two identical booths, each containing a basecoat application zone, a heated flash zone, a clearcoat application zone and an observation zone. Each identical booth is followed by an oven. VOC emissions are controlled by a Rotary Carbon Concentrator and Regenerative Thermal Oxidizer.

The electrocoat process consists of a dip tank followed by a curing oven. VOC emissions are controlled by an Electrocoat Regenerative Thermal Oxidizer.

3.b Process Flow Diagram

A Process Flow Diagram is included as Figure 1.

3.c Raw and Finished Materials

The raw materials used in the coating process line include various automotive surface coatings.

3.d Process Capacity

The coating line has a current target production rate of 70 to 74 jobs per hour.

3.e Process Instrumentation

Process instrumentation relevant to the emissions test program includes monitoring the combustion chamber temperature of the RTO units.

4. Sampling and Analytical Procedures

Sections 4.a through 4.d provide a summary of the sampling and analytical procedures used to verify RTO DE.

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 40 CFR 60, Appendix A:

- Method 1 - *"Sample and Velcoity 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"*

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 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 locations. 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 average null angle was determined to be less than 20 degrees at each of the applicable sampling location.

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 (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 volumetrically (liquid impingers) and gravimetrically (silica gel impinger). A schematic drawing of the Method 4 sampling train is provided as Figure 2.

VOC concentrations were measured at each location using the procedures found in 40 CFR 60, Appendix A, Method 25A, "Determination of Total Gaseous Organic Concentration Using a Flame Ionization Analyzer." Triplicate 60-minute test runs were conducted on each source.

VOC concentrations were measured using a VIG Industries Model 20 THC gas analyzer. The RTO outlet VOC concentrations were measured using a JUM 109A Methane/Non-Methane Analyzer. For each sampling location, 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 Laptop PC equipped with data acquisition software.

VOC concentrations at the Topcoat RTO inlet sampling location were determined to be stratified. Consistent with the specification of Method 7E, Section 8.1.2, the inlet sampling location was traversed at twelve points (six points per port) maintaining the probe position at each point for a total of five minutes.

The VIG THC hydrocarbon analyzer directs the sample to the flame ionization detector (FID), where the hydrocarbons present in the sample will be ionized into carbon. The carbon concentration is then determined by the detector in parts per million (ppm). This concentration is sent to the data acquisition system (DAS) at 4-second intervals in the form of an analog signal, specifically voltage, to produce data that can be averaged over the duration of the testing program. This data is then used to determine the average ppm for total hydrocarbons (THC) using the equivalent units of propane (calibration gas).

The J.U.M. Model 109A utilizes two flame ionization detectors (FID) to determine the average concentration (ppm) for THC (as propane) and the average concentration for methane. Upon entry, the gas stream is split by the analyzer. 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 a data acquisition system (DAS), where 4-second interval data points are recorded to produce an average based on the overall duration of the test. This average is then used to determine the average concentration for THC reported as the calibration gas, propane, in equivalent units.

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 ppm, as propane, is divided by the methane analyzer's response to the methane calibration gas, in ppm as methane.

For the 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.

A drawing of the Method 25A sampling train used for the testing program is presented as Figure 3. Protocol 1 gas certification sheets for the calibration gases used for this testing program are presented in Appendix B.

4.b Recovery and Analytical Procedures

Because all measurements were conducted using on-line analyzers, no samples were recovered during the test program.

4.c Sampling Ports

The THC sampling probes for the outlet of the Topcoat RTO was placed at a single fixed position for the first run, then traversed at twelve points during the second and third runs. The THC concentrations at the RTO inlet were traversed at twelve points. The Electrocoat Inlet and Outlet were placed at a single fixed position for the 60-minute duration of each test run.

4.d Traverse Points

Traverse points for exhaust flowrate sampling locations are illustrated by Figures 4-7.

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 and 3.

5.b Discussion of Results

The Topcoat RTO had a DE of 96.9 %. The Electrocoat RTO had a DE of 96.1%

5.c Sampling Procedure Variations

The emissions test program did not include sampling procedure variations.

5.d Process or Control Device Upsets

No process or control device upsets occurred during the emissions test program.

5.e Control Device Maintenance

Combustion Valve Maintenance and Optimization was performed on the CC RTO over 2013 Memorial Day weekend and on the ELPO RTO over 2013 Labor Day weekend.

5.f Audit Sample Analyses

No samples were collected as part of the test program.

5.g Calibration Sheets

Certificates of analysis for the calibration gases used during testing are provided in Appendix B.

5.h Sample Calculations

Sample calculations are provided as Appendix C.

5.i Field Data Sheets

Field data sheets are provided in Appendix D.

5.j Laboratory Data

No laboratory analysis was included in this test program.

Process Data Request per MDEQ Letter from Nathan Hude dated September 23, 2013

1. **FG-Topcoat RTO**
   a. Chamber temperatures at 15 minute increments

      Temperature Chart is provided in Appendix A.

   b. Chamber temperature recordings demonstrating a three hour rolling average if chamber temperatures go below 1400 degrees.

      Not applicable: chamber temperature did not fall below 1400 degrees during test.

   c. Bed Switch Timing

      150 seconds

   d. A separate count of the number of vehicles coated during each run on the EU-Topcoat1 and EU-Topcoat2

Run #	Topcoat 1 vehicle count	Topcoat 2 vehicle count
1	24	28
2	33	31
3	32	19

   e. A written explanation if production is haulted on EU-Topcoat1 or EU-Topcoat2 during any point in the testing

      Not applicable – no production haults during testing

2. EU-Electrocoat RTO

a. Chamber temperatures at 15 minute increments

Temperature Chart is provided in Appendix A.

b. Chamber temperature recordings demonstrating a three hour rolling average if chamber temperatures go below 1400 degree.

Not applicable: chamber temperature did not fall below 1400 degrees during test.

c. Bed Switch Timing

150 seconds

d. Number of parts coated during run

Run #	ELPO vehicles
1	55
2	40
3	45

e. Total number of lines / booths controlled by RTO

ELPO dip tank / oven is controlled by RTO

f. Total number of lines / booths operating during the test

ELPO dip tank / oven were operating during the test

g. Differential pressure readings representing positive flow into the Electrocoat dip tank

As discussed with Nathan Hude, Air Quality Division Technical Programs Unit, the ELPO dip tank does not have differential pressure sensors. Inward flow was demonstrated using smoke tubes and witnessed by Mr. Hude on the day of the ELPO RTO DE test.

Tables

Table 2
Topcoat Line RTO Destruction Efficiency Summary
General Motors - Lansing Delta Township Assembly Plant
Lansing, Michigan

Parameter	Run 1	Run 2	Run 3	Average
Sampling Date	10/8/2013	10/8/2013	10/8/2013	
Sampling Time	8:16-9:18	10:07-11:09	12:55-13:59	
Inlet Flowrate (scfm)	31339	31236	32061	31,545
Outlet Flowrate (scfm)	43240	41822	41885	42,316
Inlet VOC Concentration (ppmv propane)	428.95	419.64	421.15	423.2
Inlet VOC Concentration (ppmv, corrected as per USEPA 7E)	*428.7*	*420.8*	*421.9*	423.8
Inlet VOC Mass Flowrate (standard lb/hr)	*91.9*	*89.9*	*92.6*	91.5
Outlet VOC Concentration (ppmv propane)	8.41	10.28	9.93	9.5
Outlet VOC Concentration (ppmv, corrected as per USEPA 7E)	*8.5*	*10.4*	*10.2*	9.7
Outlet CH4 Concentration (ppmv methane)	0.16	0.05	0.34	0.2
Outlet CH4 Concentration (ppmv, corrected as per USEPA 7E)	*-0.1*	*-0.1*	*0.3*	0.0
Outlet VOC Concentration (- methane)	*8.5*	*10.4*	*10.1*	9.7
Outlet VOC Mass Emission Rate (standard lb/hr)	*2.5*	*3.0*	*2.9*	2.8
VOC Destruction Efficiency (%)	**97.3**	**96.7**	**96.9**	**96.9**

Inlet VOC Correction			
Co	1.31	4.90	2.13
Cma	448.00	448.00	448.00
Cm	448.22	446.46	447.04

Outlet VOC Correction			
Co	0.12	0.14	0.13
Cma	19.90	19.90	19.90
Cm	19.63	19.46	19.31

Outlet CH4 Correction			
Co	0.22	0.18	0.09
Cma	19.80	19.80	19.80
Cm	20.13	19.65	19.55

Note: Runs 1 and 2 drift corrected results for methane are negative. Values are presented but omitted from 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
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
Propane Analyzer Response Factor to Methane Gas = 2.26

Table 3
ELPO Destruction Efficiency Summary
General Motors - Lansing Delta
Lansing, Michigan

Parameter	Run 1	Run 2	Run 3	Average
Sampling Date	10/9/2013	10/9/2013	10/9/2013	
Sampling Time	10:37-11:47	12:00-13:00	13:45-14:45	
Inlet Flowrate (scfm)	18,873	18,889	17,820	18,527
Outlet Flowrate (scfm)	21,606	21,081	20,149	20,945
Inlet VOC Concentration (ppmv propane)	165.92	128.00	150.72	148.2
Inlet 1 VOC Concentration (ppmv, corrected as per USEPA 7E)	*161.6*	*124.1*	*157.3*	147.7
Inlet VOC Mass Flowrate (standard lb/hr)	*20.9*	*16.0*	*19.2*	18.7
Outlet VOC Concentration (ppmv propane)	6.99	4.47	5.45	5.6
Outlet VOC Concentration (ppmv, corrected as per USEPA 7E)	*7.0*	*4.5*	*5.6*	5.7
Outlet CH4 Concentration (ppmv methane)	1.61	1.44	1.42	1.5
Outlet CH4 Concentration (ppmv, corrected as per USEPA 7E)	*1.4*	*1.3*	*1.3*	1.3
Outlet VOC Concentration (- methane)	*6.4*	*3.9*	*5.0*	5.1
Outlet VOC Mass Emission Rate (standard lb/hr)	*0.9*	*0.6*	*0.7*	0.7
VOC Destruction Efficiency (%)	**95.5**	**96.5**	**96.4**	**96.1**

Inlet VOC Correction			
Co	4.30	7.66	4.90
Cma	299.00	299.00	299.00
Cm	303.28	297.57	282.11

Outlet VOC Correction			
Co	0.12	0.14	0.17
Cma	19.90	19.90	19.90
Cm	19.63	19.46	18.94

Outlet CH4 Correction			
Co	0.22	0.18	0.12
Cma	19.80	19.80	19.80
Cm	20.13	19.65	19.60

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
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

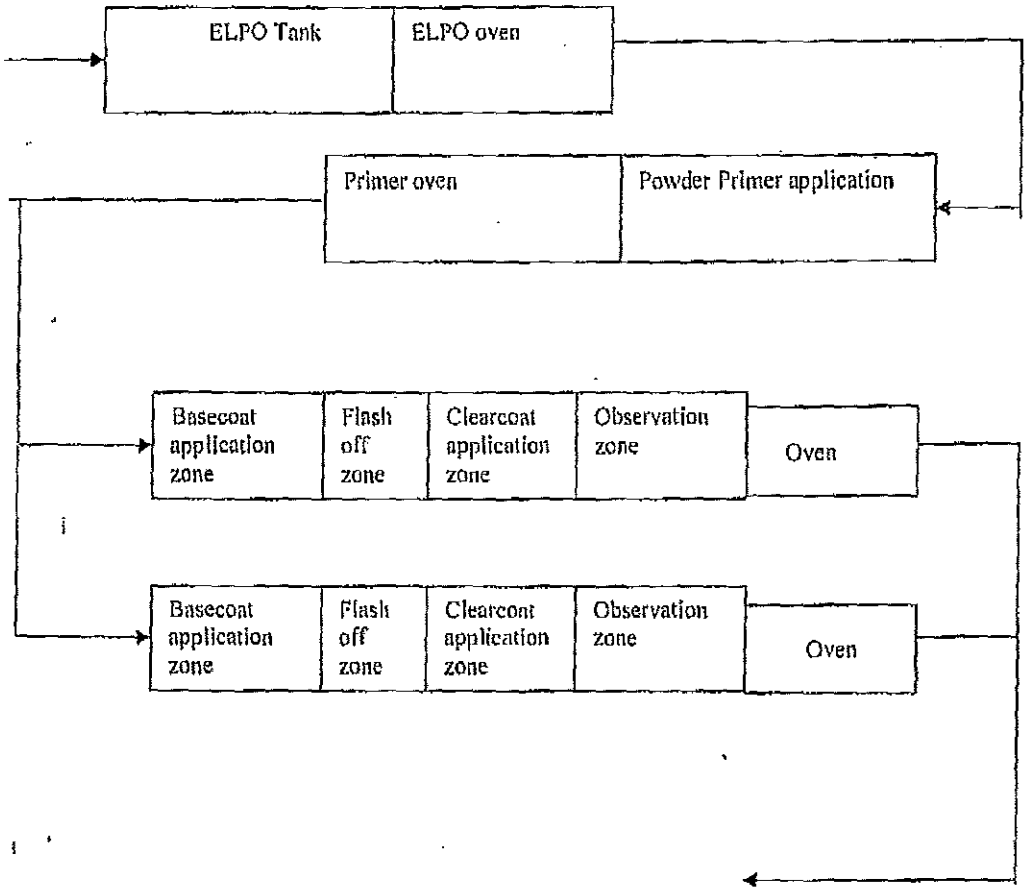
Equations

lb/hr = ppmv * MW/24.14 * 1/35.31 * 1/453,600 * scfm* 60
Propane Analyzer Response Factor to Methane Gas = 2.20

Figures

GENERAL MOTORS CORPORATION -LDTA

Figure 1 - Paint Shop Process Layout



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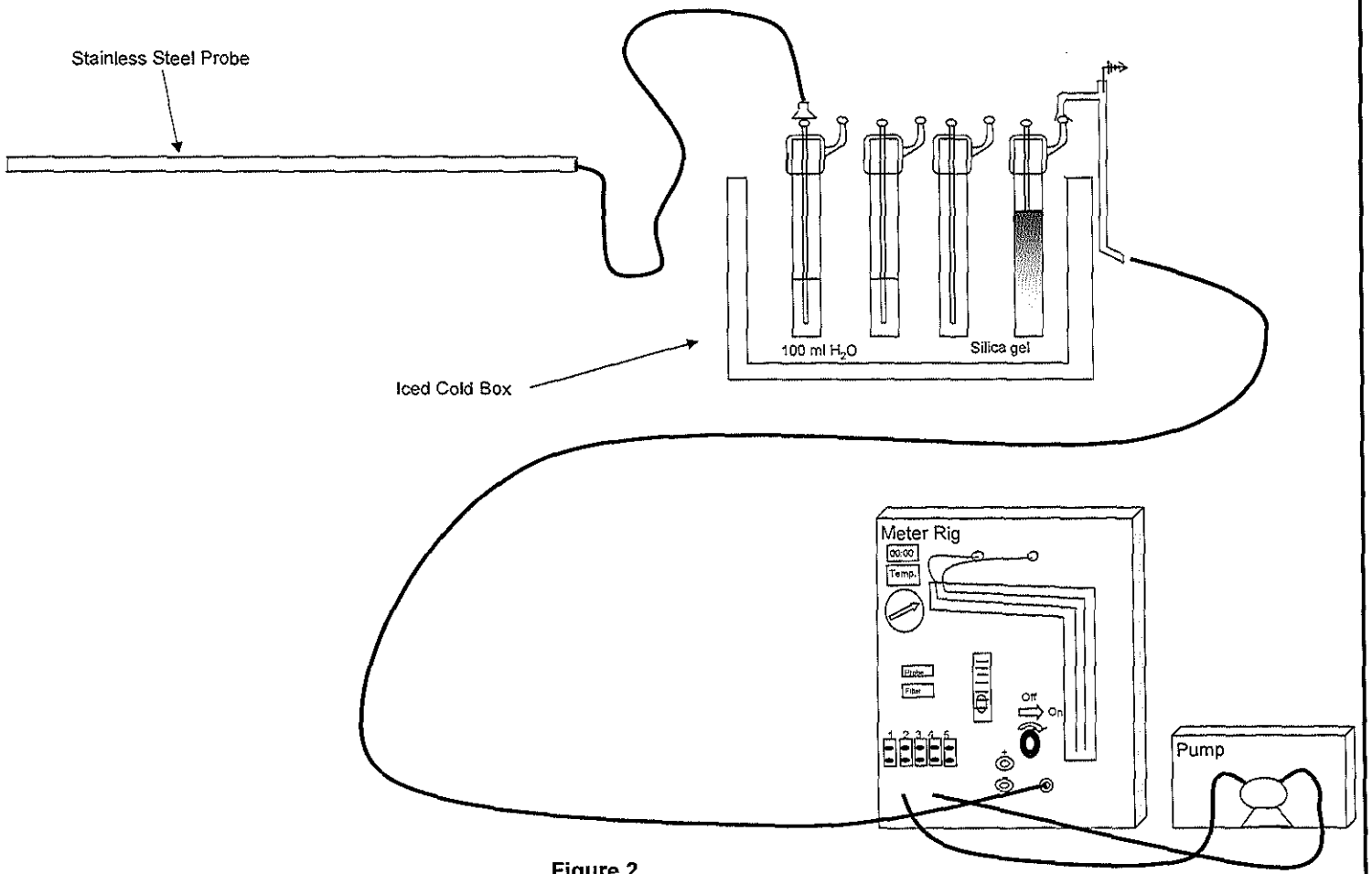

Figure 2

Site:	Sampling Date:	
USEPA Method 4 General Motors Lansing, Michigan	October 8-9, 2013	BT Environmental Consulting, Inc. 4949 Fernlee Avenue Royal Oak, Michigan

BTEC Inc.

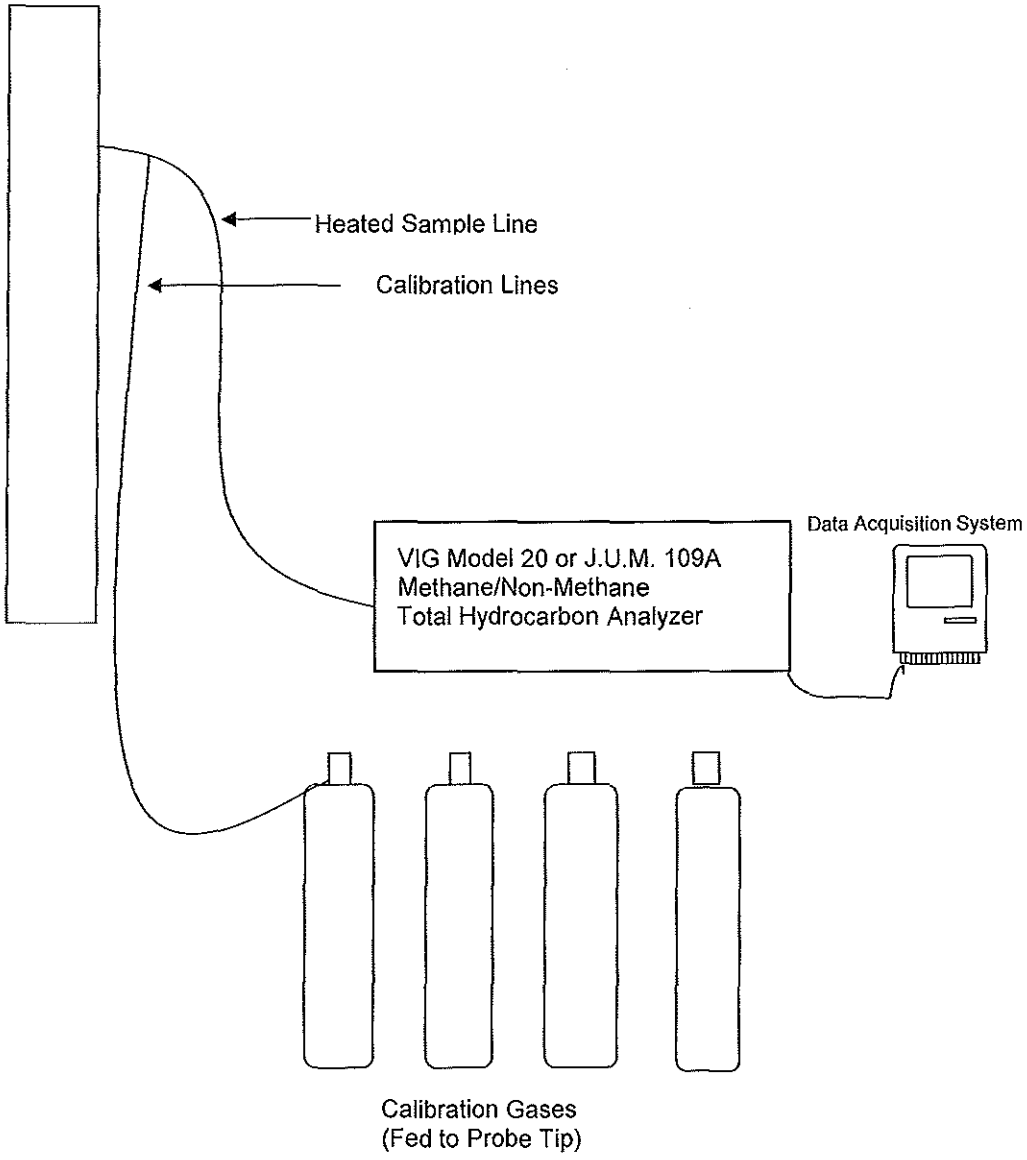

Figure 3

Site:	Sampling Date:	
USEPA Method 25A General Motors Lansing, Michigan	October 8-9, 2013	BT Environmental Consulting, Inc. 4949 Fernlee Avenue Royal Oak, Michigan

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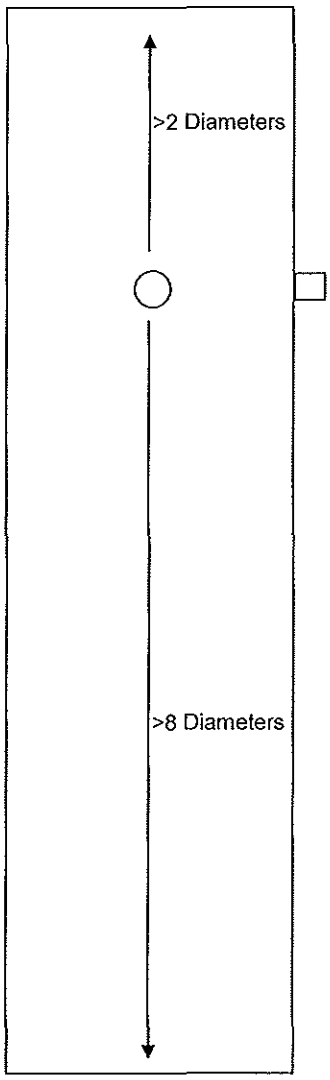
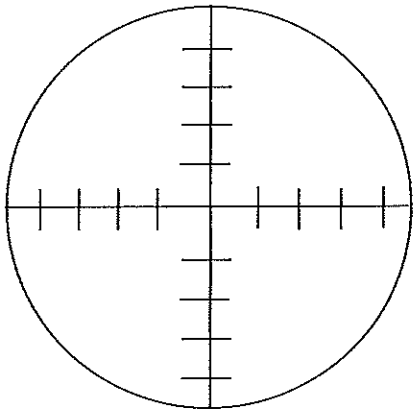
diameter = 55 inches





Not to Scale

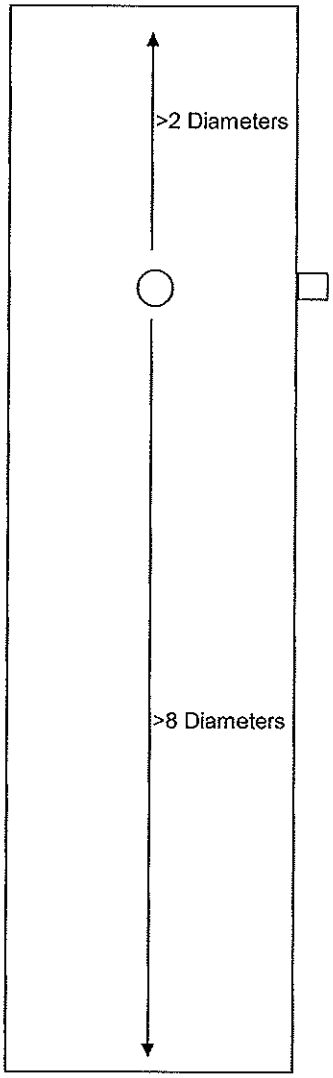
Points	Distance "
1	1.78
2	5.83
3	10.77
4	17.93
5	37.57
6	44.73
7	49.67
8	53.72

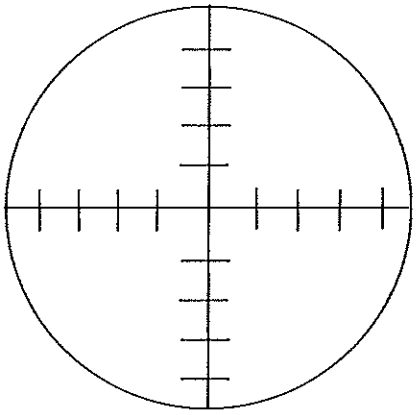
Figure 4

Site:	Sampling Date:	BT Environmental Consulting, Inc.
Topcoat RTO Inlet General Motors Lansing, Michigan	October 8-9, 2013	4949 Fernlee Avenue Royal Oak, Michigan

BTEC Inc.

diameter = 59.5





Not to Scale

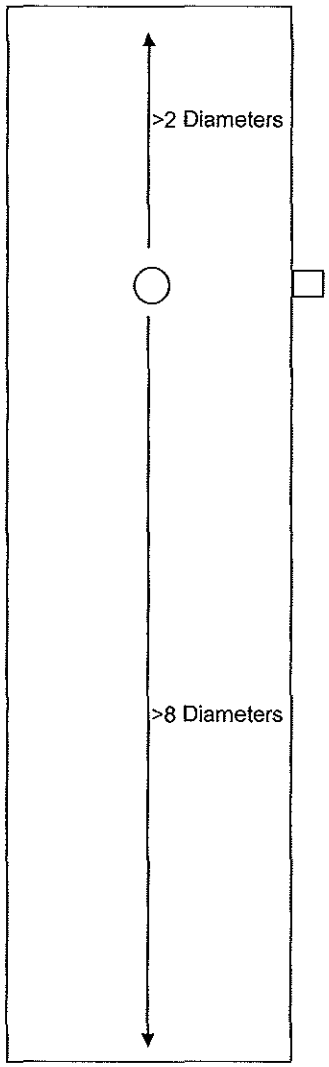
Points	Distance "
1	1.90
2	6.25
3	11.54
4	19.22
5	40.28
6	47.96
7	53.25
8	57.60

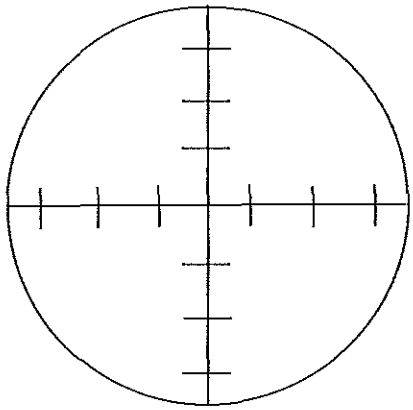
Figure 5

Site: **Top Coat RTO Outlet** **General Motors** **Lansing, Michigan**	**Sampling Date:** **October 8-9, 2013**	**BT Environmental Consulting, Inc.** **4949 Fernlee Avenue** **Royal Oak, Michigan**

BTEC Inc.

diameter = 48 inches





Not to Scale

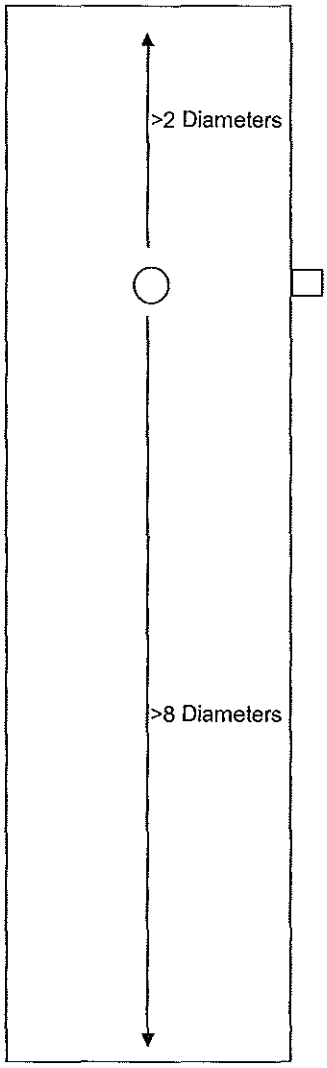
Points	Distance "
1	1.54
2	5.04
3	9.31
4	15.50
5	32.50
6	38.69
7	42.96
8	46.46

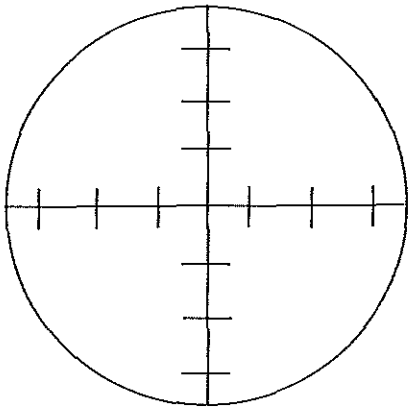
Figure 6

Site: **Electrocoat Inlet** **General Motors** **Lansing, Michigan**	**Sampling Date:** **October 8-9, 2013**	**BT Environmental Consulting, Inc.** **4949 Fernlee Avenue** **Royal Oak, Michigan**

BTEC Inc.

diameter = 47"





Not to Scale

Points	Distance "
1	1.50
2	4.94
3	9.12
4	15.18
5	31.82
6	37.88
7	42.07
8	45.50

Figure 7

Site: **Electrocoat Outlet** **General Motors** **Lansing, Michigan**	**Sampling Date:** **October 8-9, 2013**	**BT Environmental Consulting, Inc.** **4949 Fernlee Avenue** **Royal Oak, Michigan**