BTEC Inc.

VOC DE and CE Emissions Test Report

Prepared for:

Carroll Products, Inc.

Carroll Products, Inc.
44056 Phoenix Drive
Sterling Heights, Michigan 48314

Project No. 16-4967.00
April 3, 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 Carroll Products, Inc. (Carroll Products) to conduct a volatile organic compound (VOC) Destruction Efficiency (DE) test program on one recuperative thermal oxidizer (RTO). BTEC also conducted a Capture Efficiency (CE) test by measuring VOC emission rates at the RTO inlet sampling location as well as at one uncontrolled (room air) exhaust sampling location. The emissions test program was conducted on February 28, 2017.

Measurement of the RTO DE consisted of triplicate 60-minute test runs and measurement of the RTO CE consisted of triplicate 180-minute test runs. The emissions test program was required by MDEQ Air Quality Division Permit To Install (PTI) Number 78-01A. The results of the emission test program are summarized by Table I.

Table I
Overall Destruction Efficiency Test Results Summary
Test Date: February 28, 2017

RTO DE			
Pollutant	**Destruction Efficiency (%)**	**Average Emission Rate (pph)**	**Emission Limit**
VOC	98.9	0.30	95% DE

Table II
Overall Capture Efficiency Test Results Summary
Test Date: February 28, 2017

RTO CE			
Pollutant	**Capture Efficiency (%)**	**Average Emission Rate (pph)**	**Emission Limit**
VOC	76.4	6.6	70% CE

1. Introduction

BT Environmental Consulting, Inc. (BTEC) was retained by Carroll Products, Inc. (Carroll Products) to conduct a volatile organic compound (VOC) Destruction Efficiency (DE) test program on one recuperative thermal oxidizer (RTO). BTEC also conducted a Capture Efficiency (CE) test by measuring VOC emission rates at the RTO inlet sampling location as well as at one uncontrolled (room air) exhaust sampling location. The emissions test program was conducted on February 28, 2017.

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

1.a Identification, Location, and Dates of Test

Sampling and analysis for the emission test program was conducted on February 28, 2017 at the Carroll Products facility located in Sterling Heights, Michigan. The test program included evaluation of VOC DE and CE.

1.b Purpose of Testing

AQD issued Permit To Install No. 78-01A to Carroll Products. The permits limit emissions from the oxidizers as summarized by Table 1.

Table 1
VOC DE and CE Emission Limitations
Carroll Products, Inc.

Pollutant	Emission Limit
VOC	95% DE and 70% CE

1.c Source Description

The flexographic printing line is equipped to apply up to eight coatings on the web substrate as it feeds through the machine. Each of these coatings are fed to the printing press from small rectangular ink reservoirs. The reservoirs are refilled on an as needed basis from 5-gallon buckets received from the ink vendor. The ink in the reservoir is occasionally thinned by adding solvent by an automated solvent addition system which adds solvent in response to liquid viscosity measurements.

1.d Test Program Contacts

The contact for the source and test report is:

Mr. Joseph Wolf
President
Carroll Products, Inc.
44056 Phoenix Drive
Sterling Heights, Michigan 48314

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. Randal Tysar Senior Environmental Engineer	BTEC 4949 Fernlee Royal Oak, MI 48073	(248) 548-8070
Mr. Steve Smith Project Manager	BTEC 4949 Fernlee Royal Oak, MI 48073	(248) 548-8070
Mr. Paul Molenda 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. Iranna Konanahalli Environmental Engineer	MDEQ Air Quality Division	(586) 753-4731
Mr. Tom Maza Environmental Quality Analyst	MDEQ Air Quality Division	(313) 456-4709

2. Summary of Results

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

2.a Operating Data

The RTO Temperature was around 1,600 degrees F. Process data is included in Appendix D.

2.b Applicable Permit

The applicable permit for this emissions test program is Permit To Install (PTI) No. 78-01A.

2.c Results

The DE result was 98.9% and the CE was 76.4%.

3. Source Description

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

3.a Process Description

The flexographic printing line is equipped to apply up to eight coatings on the web substrate as it feeds through the machine. Each of these coatings are fed to the printing press from small rectangular ink reservoirs. The reservoirs are refilled on an as needed basis from 5-gallon buckets received from the ink vendor. The ink in the reservoir is occasionally thinned by adding solvent by an automated solvent addition system which adds solvent in response to liquid viscosity measurements. The width of the substrate is a maximum of 49" but is typically 25-30".

3.b Process Flow Diagram

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

3.c Raw and Finished Materials

The raw material used by the process is VOC.

3.d Process Capacity

The width of the substrate is a maximum of 49" but is typically 25-30".

3.e Process Instrumentation

Process instrumentation includes substrate product rate, coating material usage rates, and RTO operating temperature. Process data recorded during the emissions test program is included in Appendix D.

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"
- Method 2 -"Determination of Stack Gas Velocity and Volumetric Flow rate"
- 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 Concentration 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 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 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 3. The O_2/CO_2 content of the gas stream was measured using an O_2 /CO_2 Fyrite gas analyzer.

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

Volatile Organic Compounds (USEPA Method 25A)

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 Labview® II data acquisition software. BTEC used a VIG Model 20 THC hydrocarbon analyzer to determine the VOC concentrations at the inlet, and a JUM 109A Methane/Non-Methane THC hydrocarbon analyzer to determine the VOC concentrations at the outlet.

The VIG hydrocarbon analyzer channels a fraction of the gas sample through a capillary tube that directs the sample to the flame ionization detector (FID), where the hydrocarbons present in the sample are ionized into carbon. The carbon concentration is then determined by the detector in parts per million (ppm). This concentration is transmitted 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 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.

In accordance with Method 25A, a 3-point (zero, 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.

4.b Recovery and Analytical Procedures

This test program did not include laboratory samples, consequently, sample recovery and analysis is not applicable to this test program.

4.c Sampling Ports

A diagram of the stack showing sampling ports in relation to upstream and downstream disturbances is included as Figures 3-5.

4.d Traverse Points

A diagram of the stack indicating traverse point locations and stack dimensions is included as Figures 3-5.

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
Overall Destruction Efficiency Test Results Summary
Test Date: February 28, 2017

RTO DE			
Pollutant	**Destruction Efficiency (%)**	**Average Emission Rate (pph)**	**Emission Limit**
VOC	98.9	0.30	95% DE

Table 4
Overall Capture Efficiency Test Results Summary
Test Date: February 28, 2017

Uncontrolled CE			
Pollutant	**Capture Efficiency (%)**	**Average Emission Rate (pph)**	**Emission Limit**
VOC	76.4	6.6	70% CE

5.b Discussion of Results

As summarized by Tables 3 and 4, RTO DE and CE results were within specified limits.

5.c Sampling Procedure Variations

No sampling procedure variations were used during the emissions test program.

5.d Process or Control Device Upsets

There were no process upsets during this test.

5.e Control Device Maintenance

Only routine control device maintenance was conducted prior to the emissions test program.

5.f Re-Test

The emissions test program was not a re-test.

5.g Audit Sample Analyses

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

5.h Calibration Sheets

Relevant equipment calibration documents are provided in Appendix B.

5.i Sample Calculations

Sample calculations are provided in Appendix C.

5.j Field Data Sheets

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

5.k Laboratory Data

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

Table 5
RTO Destruction Efficiency Summary
Carroll Products
Sterling Heights, Michigan

Parameter	Run 1	Run 2	Run 3	Average
Sampling Date	2/28/2017	2/28/2017	2/28/2017	
Sampling Time	7:34-8:34	8:40-9:40	10:58-11:58	
Inlet Flowrate (scfm)	5,574	4,973	3,017	4,521
Outlet Flowrate (scfm)	4,824	4,688	3,018	4,176
Inlet VOC Concentration (ppmv propane)	858.4	866.3	553.5	759.4
Inlet VOC Concentration (ppmv, corrected as per USEPA 7E)	859.9	867.7	544.9	757.5
Inlet VOC Mass Flowrate (lb/hr)	32.8	29.5	11.2	24.5
Outlet VOC Concentration (ppmv propane)	12.8	12.2	9.4	11.4
Outlet VOC Concentration (ppmv, corrected as per USEPA 7E)	11.2	9.0	5.8	8.7
Outlet VOC Mass Emission Rate (lb/hr)	0.4	0.3	0.1	0.3
VOC Destruction Efficiency (%)	**98.9**	**99.0**	**98.9**	**98.9**

Inlet VOC Correction			
Co	8.95	18.28	14.87
Cma	746	746	746
Cm	745.83	747.34	752.23

Outlet VOC Correction			
Co	1.85	3.61	4.02
Cma	49.8	49.8	49.8
Cm	50.30	50.66	49.61

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

Table 6
Capture Efficiency Summary
Carroll Products
Sterling Heights, Michigan

Parameter	Run 1	Run 2	Run 3	Average
Sampling Date	2/28/2017	2/28/2017	2/28/2017	
Sampling Time	7:34-10:34	10:58-13:58	14:08-17:08	
Inlet Flowrate (scfm)	5,574	3,017	4,518	4,369
Room Air (scfm)	7,955	8,140	8,033	8,043
Inlet VOC Concentration (ppmv propane)	893.7	587.2	855.5	778.8
Inlet VOC Concentration (ppmv, corrected as per USEPA 7E)	895.7	579.1	845.9	773.6
Inlet VOC Mass Flowrate (lb/hr)	34.2	12.0	26.2	24.1
Outlet VOC Concentration (ppmv propane)	113.7	110.5	122.6	115.6
Outlet VOC Concentration (ppmv, corrected as per USEPA 7E)	115.0	112.9	126.1	118.0
Outlet VOC Mass Emission Rate (lb/hr)	6.3	6.3	6.9	6.5
VOC Capture Efficiency (%)	**84.5**	**65.5**	**79.1**	**76.4**

Inlet VOC Correction			
Co	8.95	14.87	9.54
Cma	746	746	746
Cm	745.83	752.23	755.59

Room Air VOC Correction			
Co	0.50	0.78	0.81
Cma	99.5	99.5	99.5
Cm	98.46	97.49	96.93

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

BTEC Inc.

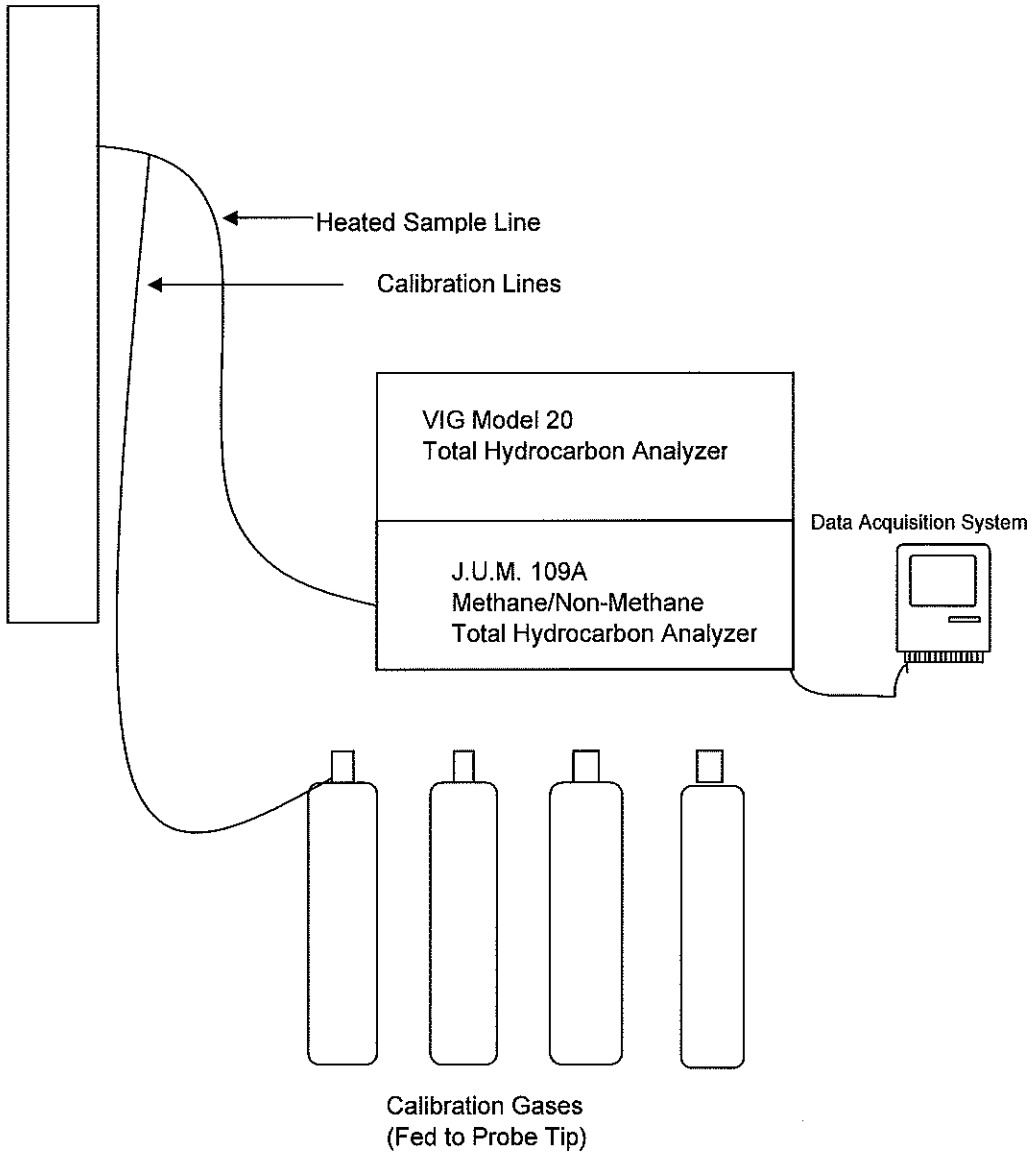


Figure No. 1

Site: **Sampling Date:** **USEPA Method 25A** **February 28, 2017** **Carroll Products, Inc.** **Sterling Heights, Michigan**	**BT Environmental Consulting, Inc.** **4949 Fernlee Avenue** **Royal Oak, Michigan 48073**

BTEC Inc.

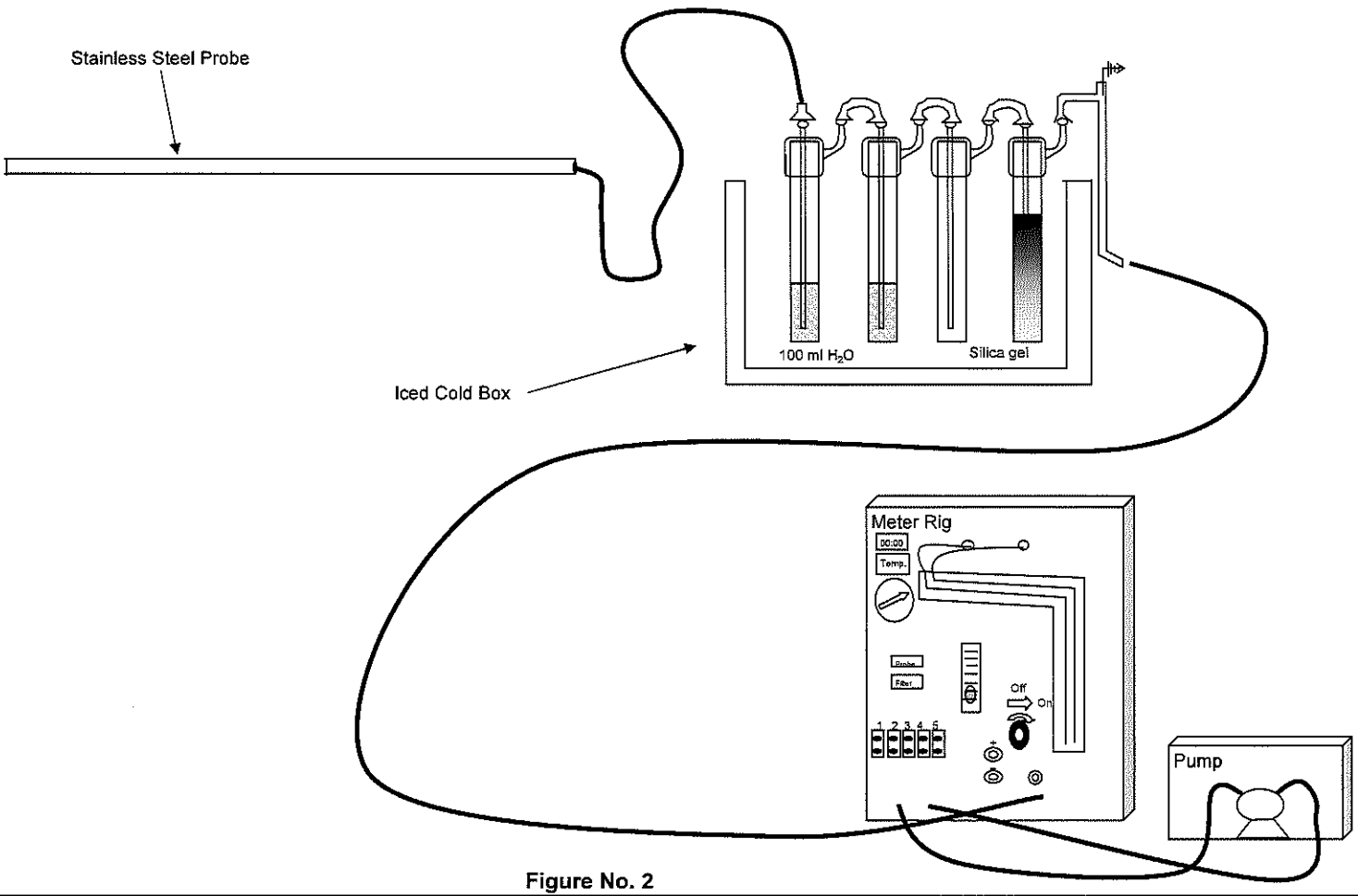


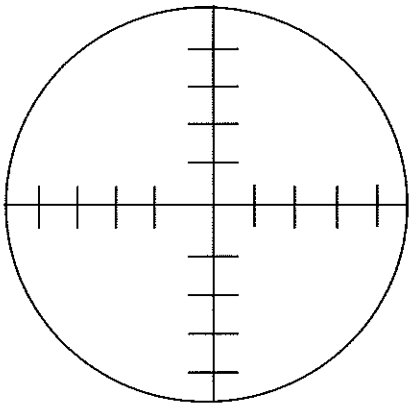
Figure No. 2

Site:	Sampling Date:	
USEPA Method 4 Carroll Products, Inc. Sterling Heights, Michigan	February 28, 2017	BT Environmental Consulting, Inc. 4949 Fernlee Avenue Royal Oak, Michigan 48073

BTEC Inc.

diameter = 26"

Points	Distance "
1	0.8
2	2.7
3	5.0
4	8.4
5	17.6
6	21.0
7	23.3
8	25.2



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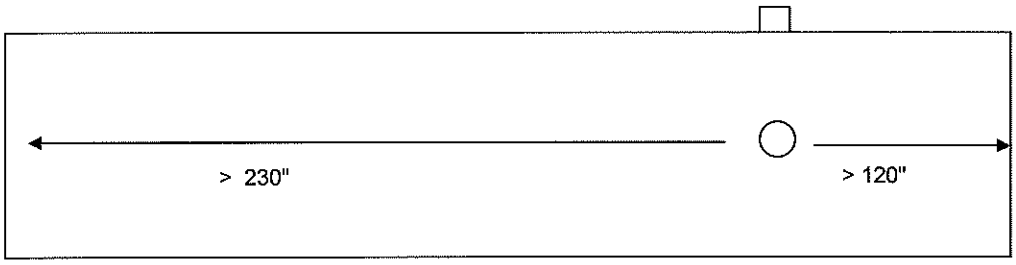
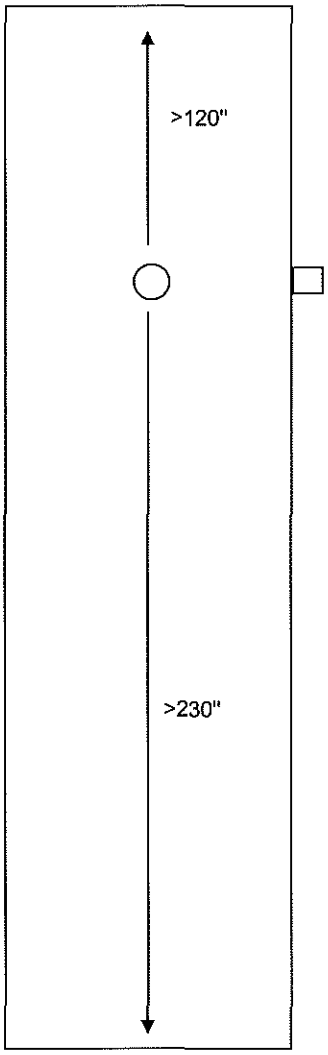


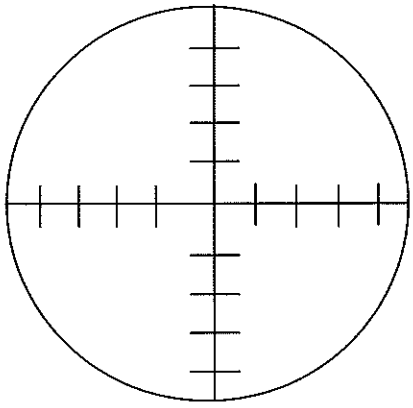
Figure No. 3

Site: **RTO Inlet** **Carroll Products** **Sterling Heights, Michigan**	**Sampling Date:** **February 28, 2017**	**BT Environmental Consulting, Inc.** **4949 Fernlee** **Royal Oak, Michigan**

BTEC Inc.

diameter = 26"





Not to Scale

Points	Distance "
1	0.83
2	2.73
3	5.04
4	8.40
5	17.60
6	20.96
7	23.27
8	25.17

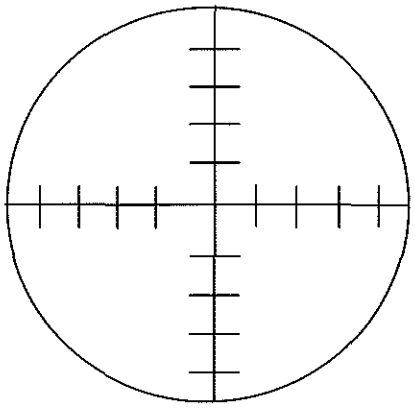
Figure No. 4

Site: **RTO Outlet** **Carroll Products** **Sterling Heights, Michigan**	**Sampling Date:** **February 28, 2017**	**BT Environmental Consulting, Inc.** **4949 Fernlee** **Royal Oak, Michigan**

BTEC Inc.

diameter = 36"

Points	Distance "
1	1.2
2	3.8
3	7.0
4	11.6
5	24.4
6	29.0
7	32.2
8	34.8



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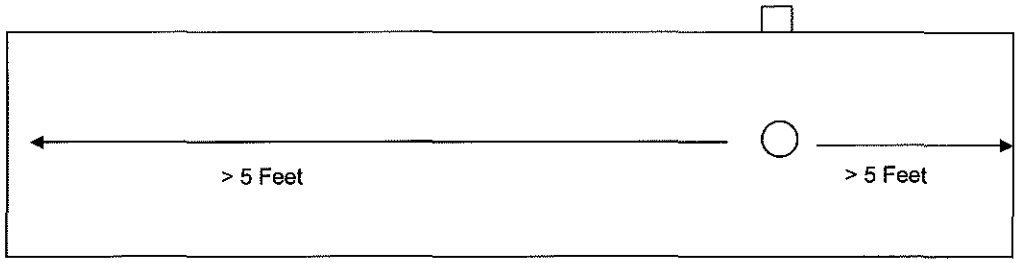

Figure No. 5

Site: **Uncontrolled** **Carroll Products** **Sterling Heights, Michigan**	**Sampling Date:** **February 28, 2017**	**BT Environmental Consulting, Inc.** **4949 Fernlee** **Royal Oak, Michigan**