

VOC Destruction Efficiency Emissions Test Report

Test Date: May 29, 2019

Prepared for:

Ford Motor Company

Flat Rock, Michigan

Flat Rock Assembly Plant
1 International Drive
Flat Rock, MI 48134

Project No. 049AS-562337
July 11, 2019

Montrose Air Quality Services.
4949 Fernlee Avenue
Royal Oak, Michigan 48073
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MONTROSE

EXECUTIVE SUMMARY

Montrose Air Quality Services (MAQS) was retained by Ford Motor Company (Ford) to evaluate volatile organic compound (VOC) destruction efficiency (DE) and outlet concentration (in parts per million (ppm) as propane) on three (3) regenerative catalytic oxidizers (RCOs) and a single thermal oxidizer (RTO) at the Flat Rock Assembly Plant (FRAP) located in Flat Rock, Michigan. Sampling and analysis for this emission test program was conducted on May 29, 2019.

Testing consisted of three 60-minute test runs for VOC at each source. The emissions test program is required by Michigan Department of Environment, Great Lakes, and Energy (EGLE) Air Quality Division Permit No. MI-ROP-N0929-2018. The permit states, "... satisfactory operation of the three regenerative catalytic oxidizers and the one regenerative thermal oxidizer includes maintaining a minimum VOC destruction efficiency of 95 percent or an average control system outlet VOC concentration of less than or equal to 5 ppm as propane."

The results of the emission test program are summarized by Table 2. Detailed emissions test results are summarized by Table 3.

Table I
Control System Outlet Summary

Test Parameter	Results
Destruction Efficiency	92%
THC Concentration ¹ (-methane)(ppmv, wet, corrected as per USEPA 7E)	5

¹ Flow-Weighted average across all three test runs

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1. Introduction

Montrose Air Quality Services (MAQS) was retained by Ford Motor Company (Ford) to evaluate volatile organic compound (VOC) destruction efficiency (DE) and outlet concentration (in parts per million (ppm) as propane) on three (3) regenerative catalytic oxidizers (RCOs) and a single thermal oxidizer (RTO) at the Flat Rock Assembly Plant (FRAP) located in Flat Rock, Michigan. Sampling and analysis for this emission test program was conducted on May 29, 2019.

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" (March 2018). The following is a summary of the emissions test program and results in the format outlined by the AQD document.

1.a Identification, Location, and Dates of Test

Sampling and analysis for the emission test program was conducted on May 29, 2019 at the FRAP facility located in Flat Rock, Michigan.

1.b Purpose of Testing

The emissions test program is required by Michigan Department of Environmental Quality Air Quality Division Permit No. MI-ROP-N0929-2018.

1.c Source Description

The FRAP coating operations are controlled by three (3) RCOs (identified as RCO A, RCO B, and RCO C) and one (1) regenerative thermal oxidizer (RTO) as pollution control equipment. All three (3) RCO units share a common inlet duct. The RTO exhaust combines with RCO C exhaust before it is exhausted through the RCO C stack.

1.d Test Program Contact

The contact for the source and test program is:

Mr. Jamie Hayward
Plant Environmental Control Engineer
Flat Rock Assembly Plant
1 International Dr.
Flat Rock, Michigan 48134
(313) 805-9166

1.e Testing Personnel

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

**Table 1
Test Personnel**

Name and Title	Affiliation	Telephone
Mr. Jamie Hayward Plant Environmental Control Engineer	Flat Rock Assembly Plant 1 International Dr. Flat Rock, MI 48134	(313) 805-9166
Ms. Susan Hicks Senior Environmental Engineer	Ford Motor Company Fairlane Plaza North, Suite 800 290 Town Center Drive Dearborn, MI 48126	(313) 594-3185
Mr. Barry Boulianne District Manager	MAQS 4949 Fernlee Avenue Royal Oak, MI 48073	(248) 548-8070
Mr. Steve Smith Client Project Manager		
Mr. Matt Young Client Project Manager		
Mr. Mike Nummer Environmental Technician		
Mr. Ben Durham Environmental Technician		
Mr. Jacob Young Environmental Technician		
Mr. Paul Diven Field Project Manager		
Mr. Todd Wessel Client Project Manager		
Mr. John Lamb Air Quality Division	EGLE	
Mr. Mark Dziadosz Air Quality Division	EGLE	
Ms. Regina Angellotti Air Quality Division	EGLE	

2. Summary of Results

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

2.a Operating Data

Operational data collected during the testing includes the number of vehicles produced during each test run and operating temperatures for each RCO and the RTO at varying points during each test run. See Appendix D for this information.

2.b Applicable Permit

The applicable permit for this emissions test program is Permit No. MI-ROP-N0929-2018.

2.c Results

The overall results of the emission test program are summarized by Table 2 (see Section 5.a).

3. Source Description

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

3.a Process Description

FRAP is an automotive assembly plant located in Flat Rock, Michigan. Vehicle body panels are stamped and assembled on-site from sheet metal components. The bodies are cleaned, treated, and prepared for painting in the phosphate system. Drawing compounds, mill oils, and dirt are removed from the vehicle bodies utilizing both high pressure spray and immersion cleaning/rinsing techniques. Vehicle bodies then are dip coated in electro deposition corrosion primer paint for protection. The electro primer (e-coat) is heat-cured to the vehicle body in a high-temperature bake oven. After completing the e-coat operation, vehicle bodies are conveyed to the sealer area for application of various sealants to body seams and joints. Vehicle bodies are then conveyed to an oven to cure the sealers.

After the sealer oven, the vehicles are routed to one of the two identical 3-Wet paint systems. In the 3-Wet paint booth, the vehicle is painted with primer, a color basecoat and a protective clearcoat layer using automatic bells on robot spray applicators. The vehicle then passes through an oven to cure the 3-Wet applications. The 3-Wet booths allow for paint application of one layer after the other without an intermediate drying stage.

The vehicle paint process includes the e-coat priming, guidecoat surface priming, base/clearcoat and vehicle sealing operations. The majority of the process emissions associated with these coating activities are oxidized at elevated temperatures by the RCO and RTO emission control equipment that is part of this test program.

3.b Process Flow Sheet or Diagram

Each RCO and the RTO controls VOC emissions from the corresponding equipment by oxidizing organics present in the exhaust gas at elevated temperatures.

3.c Raw and Finished Materials

The raw materials include various automotive coatings that are used in the following emission units: EGECOAT, EGGUIDECOAT/EGTOPCOAT, and EGCOAT. They

include body sealing agents, electro deposition primer, surface primers, topcoat (basecoat and clearcoat) coatings.

3.d Process Capacity

FRAP operates under a process limitation of 4.8 lb/job.

3.e Process Instrumentation

The only process operating parameters relevant to the emissions test program are RCO and RTO operating temperatures.

4. Sampling and Analytical Procedures

Sections 4.a through 4.d provide a summary of the sampling and analytical procedures used to verify the DE and outlet concentration of each RCO.

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”*

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 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.

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 average of the absolute values of the flow angles was less than 20 degrees at each sampling location.

Molecular weight determinations were evaluated 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 as part of the moisture sampling and passed through (i) two impingers, each with 100 ml deionized water, (ii) an empty impinger, and (iii) an impinger filled with silica gel. Exhaust gas moisture content is then determined gravimetrically. Moisture evaluations consisted of a single 30-minute sample run at the RTO Inlet. Outlet, and each RCO Exhaust stack. Wet bulb/dry bulb was used at the RCO Inlet.

Measurement of exhaust gas VOC and methane concentrations was conducted using the following reference test methods codified at 40 CFR 60, Appendix A:

- Method 25A- *“Determination of Total Gaseous Organic Concentration Using a Flame Ionization Analyzer”*

VOC concentrations were measured using the procedures found in 40 CFR 60, Appendix A, Method 25A, *“Determination of Total Gaseous Organic Concentration Using a Flame Ionization Analyzer.”*

The RCO 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.

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.

The RCO inlet, and RTO inlet and outlet locations were measured using a VIG Model 20 THC analyzer. The VIG THC 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).

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.

A drawing of the Method 25A sampling train used for the testing program is presented as Figure 5. 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

A diagram of the stacks showing sampling ports in relation to upstream and downstream disturbances are included as Figures 1-4.

4.d Traverse Points

A diagram of the stacks showing sampling ports in relation to upstream and downstream disturbances are included as Figures 1-4.

5. Test Results and Discussion

Sections 5.a through 5.j provide a summary of the test results.

5.a Results Tabulation

The results of the emission test program are summarized by Table 2. Detailed emissions test results are summarized by Table 3.

**Table 2
Control System Outlet**

Test Parameter	Results
Destruction Efficiency	92%
THC Concentration ¹ (-methane)(ppmv, wet, corrected as per USEPA 7E)	5

¹Flow-Weighted average across all three test runs

5.b Sampling Procedure Variations

There were no sampling procedure variations.

5.c Process or Control Device Upsets

No upset conditions occurred during testing.

5.d Control Device Maintenance

Prior to this test event, Ford had not completed any major maintenance.

5.e Re-test

This emissions test program was not a re-test.

5.f Audit Sample Analyses

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

5.g Calibration Sheets

Relevant equipment calibration documents are provided as Appendix B.

5.h Sample Calculations

Sample calculations are provided in Appendix C.

5.i Field Data Sheets

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

5.j Laboratory Data

There are no laboratory results for this test program.

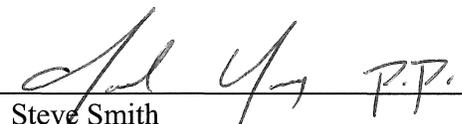
MEASUREMENT UNCERTAINTY STATEMENT

Both qualitative and quantitative factors contribute to field measurement uncertainty and should be taken into consideration when interpreting the results contained within this report. Whenever possible, Montrose Air Quality Services, LLC, (MAQS) personnel reduce the impact of these uncertainty factors through the use of approved and validated test methods. In addition, MAQS personnel perform routine instrument and equipment calibrations and ensure that the calibration standards, instruments, and equipment used during test events meet, at a minimum, test method specifications as well as the specifications of our Quality Manual and ASTM D 7036-04. The limitations of the various methods, instruments, equipment, and materials utilized during this test have been reasonably considered, but the ultimate impact of the cumulative uncertainty of this project is not fully identified within the results of this report.

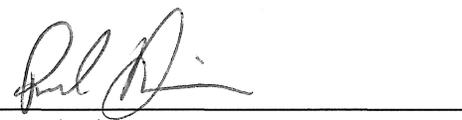
Limitations

All testing performed was done in conformance to the ASTM D7036-04 standard. The information and opinions rendered in this report are exclusively for use by Ford Motor Company. MAQS will not distribute or publish this report without Ford Motor Company's consent except as required by law or court order. MAQS accepts responsibility for the competent performance of its duties in executing the assignment and preparing reports in accordance with the normal standards of the profession, but disclaims any responsibility for consequential damages.

This report was prepared by:


Steve Smith
Client Project Manager

This report was reviewed by:


Paul Diven
Field Project Manager

Tables

Table 3
RTO & RCO VOC Destruction Efficiency and Outlet Concentration Summary
2 Inlet / 4 Outlet
Ford FRAP
Flatrock, MI
May 29, 2019

Parameter	Run 1	Run 2	Run 3	Average
Sampling Time	8:02-9:02	9:45-10:45	12:10-13:10	
RTO Inlet Flowrate (scfm)	24,904	26,098	26,230	25,744
RCO Inlet Flowrate (scfm)	365,884	357,832	350,733	358,150
RCO A Flowrate (scfm)	124,133	124,403	125,847	124,794
RCO B Flowrate (scfm)	127,141	119,682	124,099	123,641
RCO C Flowrate (scfm)(includes the RTO exhaust flowrate)	148,682	155,527	159,158	154,456
RTO Outlet Flowrate (scfm)	29,800	29,410	30,300	29,836
RTO Inlet THC Concentration (ppmv propane)	126.07	133.34	94.95	118.12
RTO Inlet THC Concentration (ppmv, corrected as per USEPA 7E)	125.46	130.00	90.04	115.17
RTO Inlet THC Mass Flowrate (standard lb/hr)	21.38	23.22	16.16	20.25
RTO Outlet THC Concentration (ppmv propane)	5.31	6.62	6.05	5.99
RTO Outlet THC Concentration (ppmv, corrected as per USEPA 7E)	4.30	4.59	3.75	4.21
RTO Outlet THC Mass Emission Rate (standard lb/hr)	0.88	0.92	0.78	0.86
RCO Inlet THC Concentration (ppmv propane)	54.45	66.22	59.60	60.09
RCO Inlet VOC Concentration (ppmv, corrected as per USEPA 7E)	54.62	66.43	59.82	60.29
RCO Inlet THC Mass Flowrate (standard lb/hr)	136.78	162.68	143.59	147.68
RCO A Outlet THC Concentration (ppmv propane)	12.62	13.18	12.47	12.76
RCO A Outlet THC Concentration (ppmv, corrected as per USEPA 7E)	12.12	12.71	11.97	12.27
RCO A Outlet CH4 Concentration (ppmv methane)	14.50	12.65	13.67	13.61
RCO A Outlet CH4 Concentration (ppmv, corrected as per USEPA 7E)	14.00	12.25	13.14	13.13
RCO A Outlet THC Concentration (- methane) (ppmv, corrected as per USEPA 7E)	5.79	7.24	5.91	6.32
RCO A Outlet THC Mass Emission Rate (standard lb/hr)	4.92	6.17	5.09	5.39
RCO B Outlet THC Concentration (ppmv propane)	5.50	6.09	5.70	5.76
RCO B Outlet THC Concentration (ppmv, corrected as per USEPA 7E)	4.76	5.48	5.12	5.12
RCO B Outlet CH4 Concentration (ppmv methane)	3.17	2.82	2.67	2.89
RCO B Outlet CH4 Concentration (ppmv, corrected as per USEPA 7E)	2.45	2.22	2.21	2.29
RCO B Outlet THC Concentration (- methane) (ppmv, corrected as per USEPA 7E)	3.65	4.45	4.12	4.07
RCO B Outlet THC Mass Emission Rate (standard lb/hr)	3.17	3.64	3.50	3.44
RCO C Outlet THC Concentration (ppmv propane)	7.65	8.42	7.66	7.91
RCO C Outlet THC Concentration (ppmv, corrected as per USEPA 7E)	6.79	7.18	6.50	6.82
RCO C Outlet CH4 Concentration (ppmv methane)	4.86	4.15	4.34	4.45
RCO C Outlet CH4 Concentration (ppmv, corrected as per USEPA 7E)	4.61	3.97	4.23	4.27
RCO C Outlet THC Concentration (- methane) (ppmv, corrected as per USEPA 7E)	4.79	5.43	4.59	4.94
RCO C Outlet THC Mass Emission Rate (standard lb/hr)	4.88	5.78	5.00	5.22
RCO A, B, and C Flow-weighted THC Concentration (-methane) (ppmv, corrected as per USEPA 7E)	5	6	5	5
RCO A, B, and C and RTO Combined DE (%)	92	92	91	92

RTO Inlet VOC Correction			
Co	0.02	3.15	4.50
Cma	425	425	425
Cm	427.02	428.78	431.45

RCO A Outlet VOC Correction			
Co	0.77	0.95	0.96
Cma	50	50	50
Cm	49.64	49.06	49.07

RCO A Outlet CH4 Correction			
Co	0.65	0.68	0.73
Cma	50	50	50
Cm	50.13	49.57	49.99

RCO B Outlet VOC Correction			
Co	0.81	0.79	0.78
Cma	50	50	50
Cm	50.03	49.22	48.85

RCO B Outlet CH4 Correction			
Co	0.78	0.68	0.53
Cma	50	50	50
Cm	49.68	48.91	49.14

RCO C Outlet VOC Correction			
Co	0.98	1.47	1.42
Cma	50	50	50
Cm	50.10	49.88	49.45

RCO C Outlet CH4 Correction			
Co	0.32	0.26	0.21
Cma	50	50	50
Cm	49.60	49.23	49.08

RCO Inlet VOC Correction			
Co	0.14	0.27	0.33
Cma	50.37	50.37	50.37
Cm	50.22	50.28	50.24

RTO Outlet VOC Correction			
Co	1.01	2.07	2.33
Cma	50	50	50
Cm	51.12	51.66	51.93

scfm: standard cubic feet per minute
 ppmv: parts per million on a volume to volume basis
 lb/hr: pounds per hour
 THC: total hydrocarbons
 MW: molecular weight
 24.14: molar volume of air at standard conditions (70°F, 29.92" Hg)
 35.31: ft³ per m³
 453600: mg per lb

RCO A
 RCO B
 RCO C

RCO Response Factors			
RCO A	2.21	2.24	2.17
RCO B	2.19	2.16	2.19
RCO C	2.31	2.26	2.22

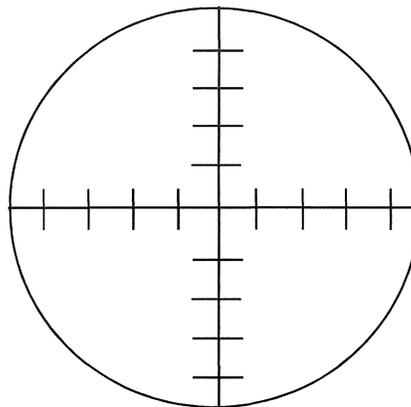
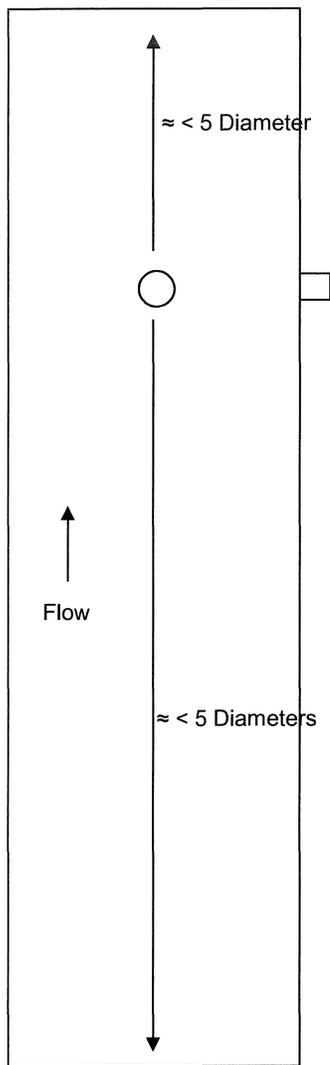
Equations

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

Flow-weighted concentration = (F_A*C_A + F_B*C_B + F_C*C_C - F_{RTO}*C_{RTO}) / (F_A + F_B + F_C - F_{RTO}), where F = flowrate (scfm) and C = THC concentration (-methane) (ppmv, corrected as per USEPA 7E)

RTO A, B and C Combined DE = [RCO Inlet pph - (RCO A outlet pph + RCOB outlet pph + (RCO C outlet pph - RTO outlet pph)]/RCO Inlet pph

diameter = 107 inches



Not to Scale

Points	Distance "
1	3.4
2	11.2
3	20.8
4	34.6
5	72.4
6	86.2
7	95.8
8	103.6

Figure No. 1

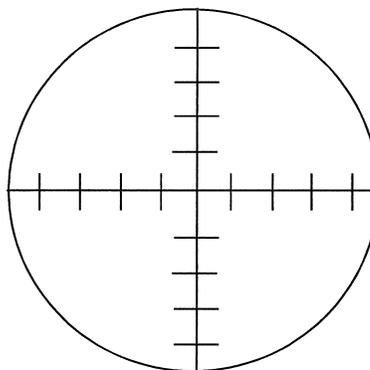
Site:
RCO A, B, C
Ford FRAP
Flat Rock, Michigan

Sampling Date:
May 29, 2019

Montrose Air Quality Services
4949 Fernlee Avenue
Royal Oak, Michigan 48073

diameter = 168 inches

Points	Distance "
1	5.4
2	17.6
3	32.6
4	54.3
5	113.7
6	135.4
7	150.4
8	162.6



Not to Scale

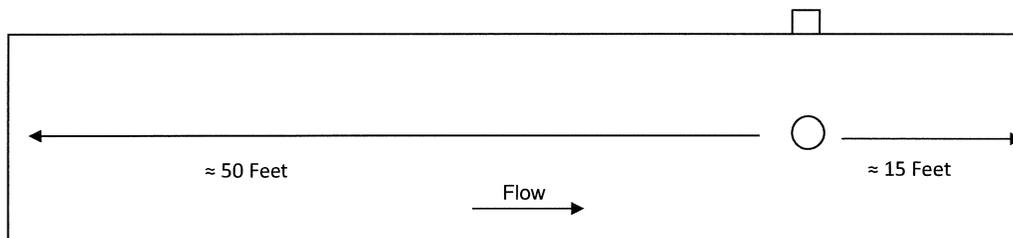


Figure No. 2

Site:
RCO Inlet
Ford FRAP
Flat Rock, Michigan

Sampling Date:
May 29, 2019

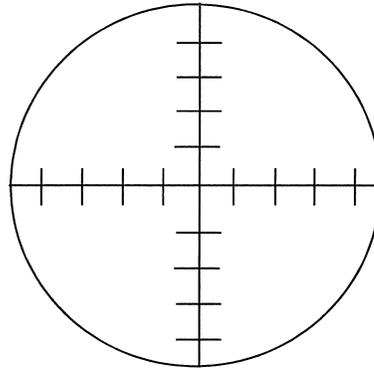
Montrose Air Quality Services
4949 Fernlee Avenue
Royal Oak, Michigan 48073



MONTROSE
AIR QUALITY SERVICES

diameter = 49.5 inches

Points	Distance "
1	1.6
2	5.2
3	9.6
4	16.0
5	33.5
6	39.9
7	44.3
8	47.9



Not to Scale

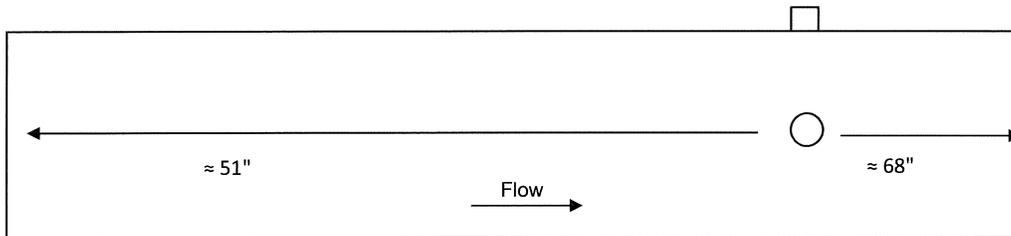


Figure No. 3

Site:
RTO Inlet
Ford FRAP
Flat Rock, Michigan

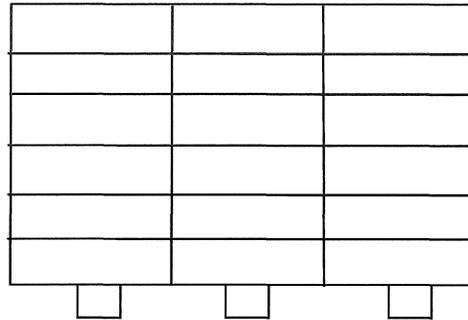
Sampling Date:
May 29, 2019

Montrose Air Quality Services
4949 Fernlee Avenue
Royal Oak, Michigan 48073



Stack Dimensions:

Depth: 42 inches
 Width: 46 inches



Not to Scale

Points	Distance "
1	3.5
2	10.5
3	17.5
4	24.5
5	31.5
6	38.5

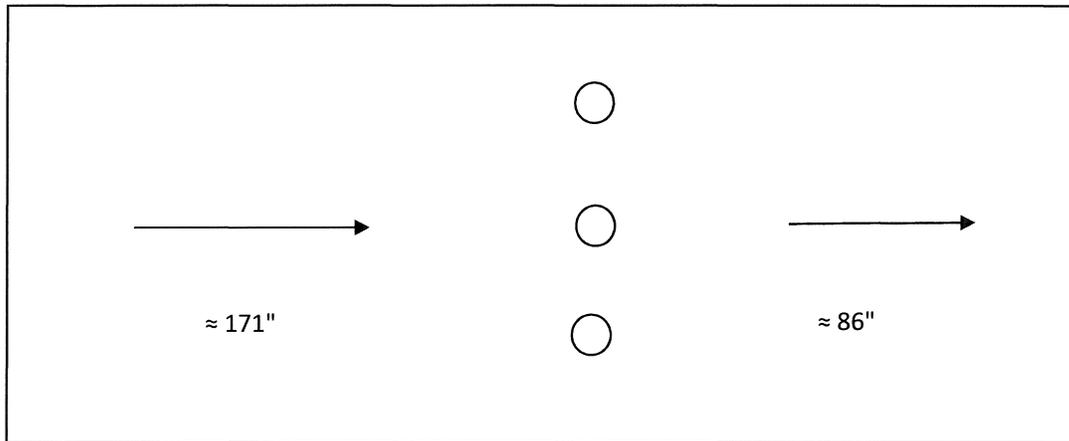


Figure No. 4

Site:
 RTO Outlet
 Ford FRAP
 Flat Rock, Michigan

Sampling Date:
 May 29, 2019

Montrose Air Quality Services
 4949 Fernlee Avenue
 Royal Oak, Michigan 48073

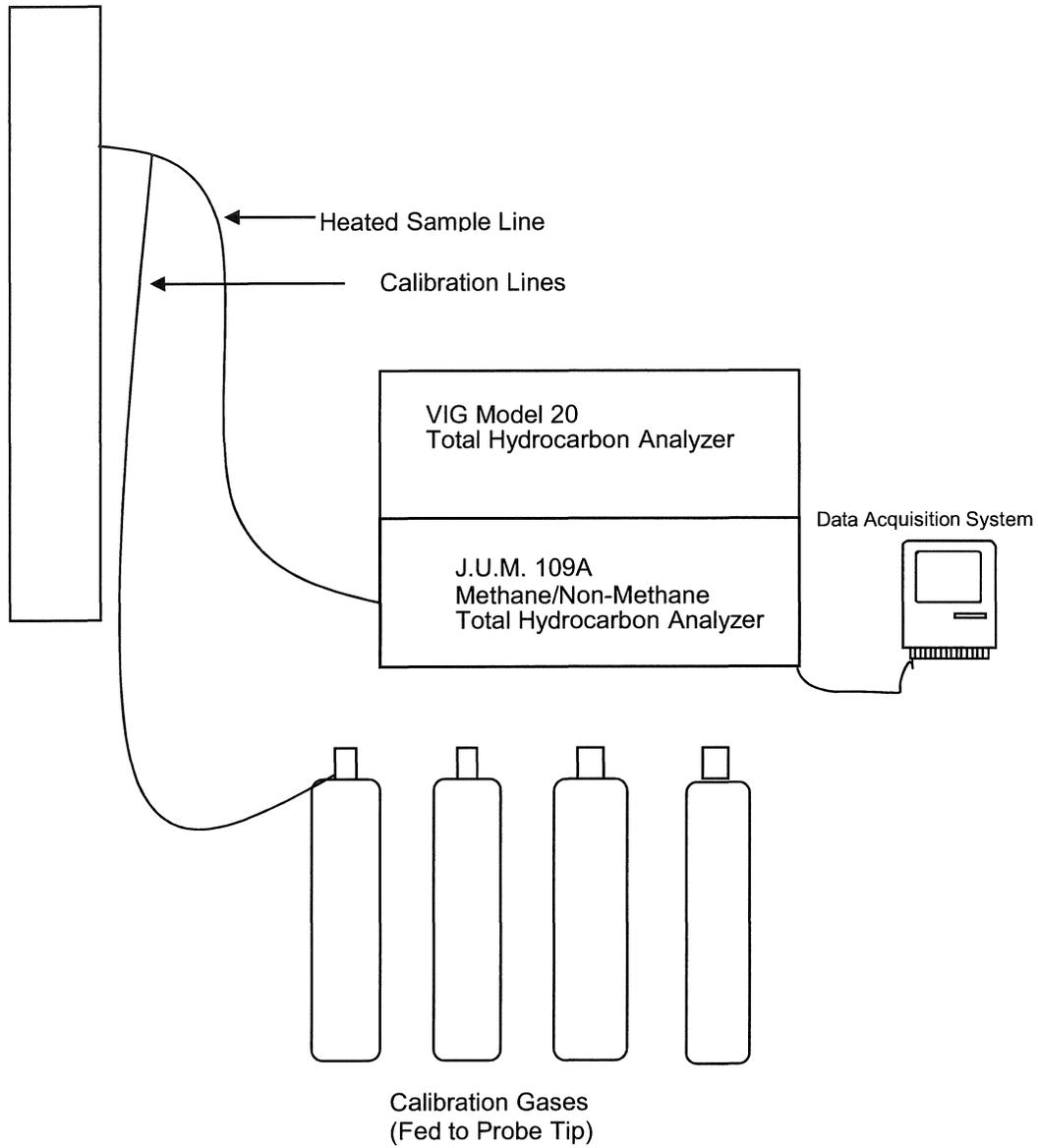


Figure No. 5

Site:
USEPA Method 25A
Ford FRAP
Flat Rock, Michigan

Sampling Date:
May 29, 2019

Montrose Air Quality Services
4949 Fernlee Avenue
Royal Oak, Michigan 48073

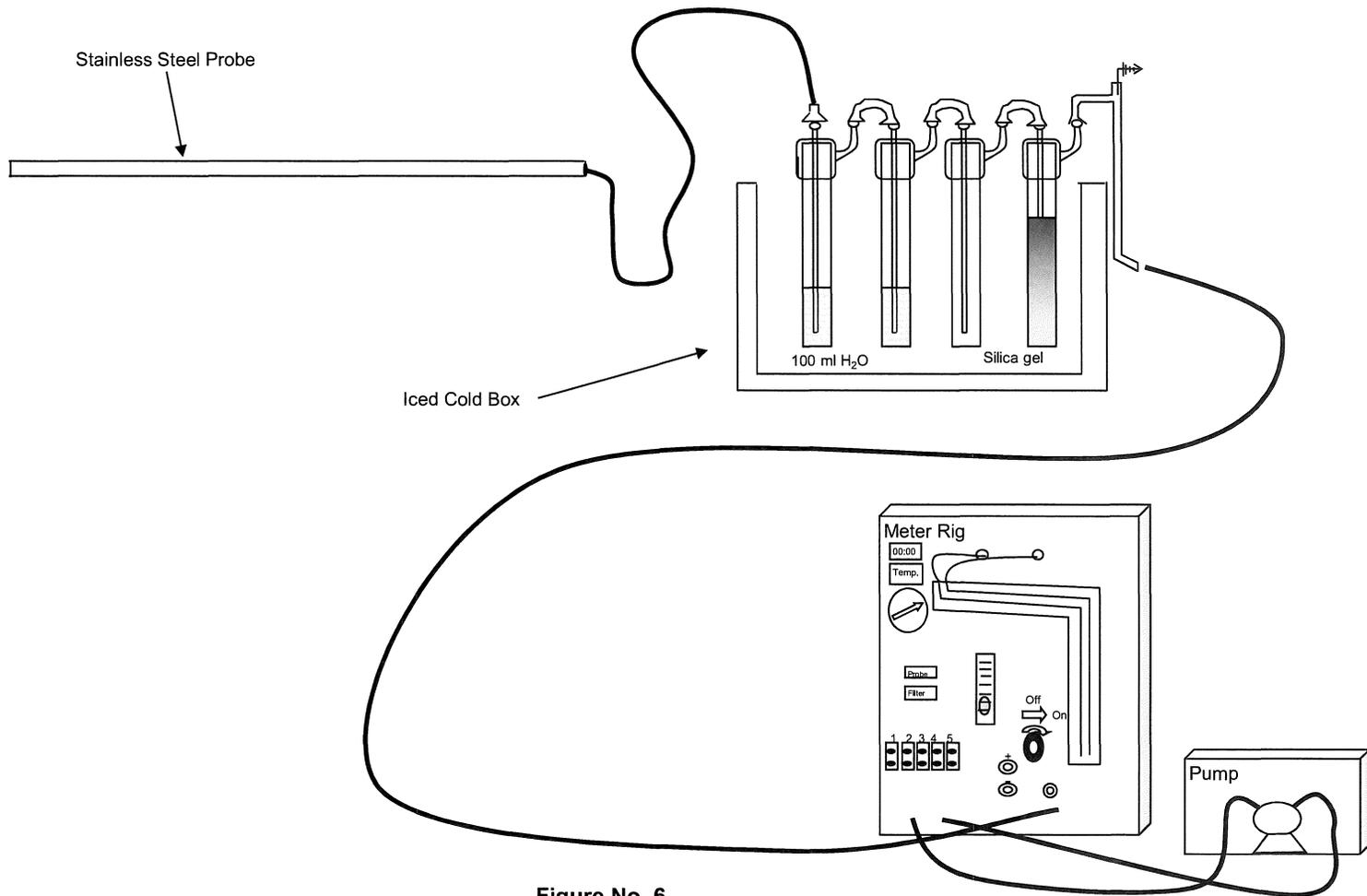


Figure No. 6

Site:
USEPA Method 4
Ford FRAP
Flat Rock, Michigan

Sampling Date:
May 29, 2019

Montrose Air Quality Services
4949 Fernlee Avenue
Royal Oak, Michigan 48073