



VOC Removal Efficiency Test Report

Prepared for:

Ford Motor Company

Ford Motor Company Michigan Assembly Plant

Ford Motor Company
Fairlane Plaza North
290 Town Center Drive
Dearborn, MI 48126

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AUG 22 2017

AIR QUALITY DIVISION

Project No. 17-5054.00
August 18, 2017

BT Environmental Consulting, Inc.
4949 Fernlee Avenue
Royal Oak, MI 48073
(248) 548-8070



EXECUTIVE SUMMARY

BT Environmental Consulting, Inc. (BTEC) was retained by Ford Motor Company (Ford) to evaluate the volatile organic compounds (VOC) Removal Efficiency (RE) of the Carbon Wheel System No. 1 at the Michigan Assembly Plant located in Wayne, Michigan. The emissions test program was conducted on June 22, 2017. The purpose of this report is to document the results of the test program.

Testing consisted of triplicate 60-minute test runs. The overall results of the emission test program are summarized by Table I.

Table I
Overall Results Summary
Test Date: June 22, 2017

Source	Removal Efficiency (%)
Carbon Wheel System 1	96.2



1. Introduction

BT Environmental Consulting, Inc. (BTEC) was retained by Ford Motor Company (Ford) to evaluate the volatile organic compounds (VOC) Removal Efficiency (RE) of the Carbon Wheel System No. 1 at the Michigan Assembly Plant located in Wayne, Michigan. The emissions test program was conducted on June 22, 2017. The purpose of this report is to document the results of the test program.

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." 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 emissions test program was conducted on June 22, 2017 at the Carbon Wheel System 1. The test program included evaluation of VOC emission rates at the inlets and outlet.

1.b Purpose of Testing

The purpose of the emissions test program was to verify VOC RE and demonstrate overall control efficiency to comply with the requirements of Michigan Department of Environmental Quality Air Quality Division Permit No. MI-ROP-A8650-2016 for the Michigan Assembly Plant.

1.c Source Description

The system consists of two carbon concentration wheels and an RTO.

1.d Testing Personnel

Names and affiliations for personnel involved in the emissions test program are summarized by Table 1.

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**Table 1
Test Personnel**

Name and Title	Affiliation	Telephone
Mr. Matthew Young Project Manager	BTEC 4949 Fernlee Ave Royal Oak, MI	(586) 744-9133
Mr. Dave Trahan Environmental Technician	BTEC 4949 Fernlee Ave Royal Oak, MI	(248) 548-8070
Mr. Shane Rabideau Environmental Technician	BTEC 4949 Fernlee Ave Royal Oak, MI	(248) 548-8070
Mr. Josh Boulianne Environmental Technician	BTEC 4949 Fernlee Ave Royal Oak, MI	(248) 548-8070
Ms. Susan Hicks Principal Environmental Engineer	Ford Motor Company Fairlane Plaza North 290 Town Center Drive, Suite 800 Dearborn, Michigan 48126	(313)594-3185
Mr. Mark Dziadosz MDEQ Air Quality Division	Michigan Department of Environmental Quality SE Michigan District 27700 Donald Ct. Warren, MI 48092	(586)753-3745
Mr. Stephen Weiss MDEQ Air Quality Division	Michigan Department of Environmental Quality Cadillac Place 3058 West Grand Blvd, Suite2- 300 Detroit, MI 48202-6058	(313) 456-4688



2. Summary of Results

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

2.a Operating Data

Process operating data for this emissions test program is provided in Appendix E.

2.b Applicable Permit

The applicable permit for this emissions test program is Permit No. MI-ROP-A8650-2016.

2.c Results

The results of the emissions test program are summarized by Table 2. Detailed data for each test run can be found in Table 3.

Table 2
Overall Results Summary
Test Date: June 22, 2017

Source	Removal Efficiency (%)
Carbon Wheel System 1	96.2

2.d Emission Regulation Comparison

NA

3. Source Description

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

3.a Process Flow Diagram

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

3.b Process Description

Michigan Assembly is an automotive assembly plant located in Wayne, 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 the 3-Wet paint system. The 3-Wet system consists of dual spray booths and oven; the bodies receive a solvent borne surface primer, basecoat and clearcoat that is applied to interior and exterior surface areas. All three materials are applied using robotic bell applicators. The surfaces are then dried in the oven. After exiting the 3-Wet oven, the vehicles are routed to inspection and blackout/cavity wax booth.

3.c Raw and Finished Materials

NA.

3.d Process Capacity

NA.

3.e Process Instrumentation

The rotary concentrator desorb temperature was recorded every 15-minutes during each test run. Process data was collected by Ford personnel and can be found in Appendix D.

4. Sampling and Analytical Procedures

Sections 4.a through 4.d provide a summary of the sampling and analytical procedures used to verify emission rates and removal efficiency. Regarding the measurement of air flowrates at the concentrator inlet and outlet locations, the following should be noted:

- Flowrates at each location (Inlet from Basecoat, Inlet from Clearcoat, and RTO Outlet) were measured using a Shortridge digital differential pressure monitor rather than a manometer.
- At the Inlet from Basecoat and Inlet from Clearcoat locations, velocity pressures at several duct traverse locations were negative. For the purpose of calculating exhaust gas flowrates at these locations, all traverse points for which the velocity pressures were negative were considered to not be traverse points (i.e., no value was incorporated into the overall average square root of the velocity pressures instead of using a value of zero for that traverse point).
- Measurement of exhaust gas flowrates from the concentrator desorption duct were not possible and a value of 9,110 scfm was used for each test run (from previous test data).

4.a Sampling Train and Field Procedures

Stack gas velocity traverses were conducted in accordance with the procedures outlined in Methods 1 and 2 (see Figures 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 at each traverse location. 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 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. Both sampling locations were evaluated for cyclonic flow and deemed acceptable for flowrate measurement.

Exhaust gas molecular weight was determined according to Method 3. The equipment used for the Method 3 evaluation consisted of a one-way squeeze bulb with connecting tubing and a set of Fyrite[®] combustion gas analyzers. CO₂ and O₂ content was analyzed using the Fyrite[®] procedure.

Exhaust gas moisture content was evaluated using Method 4 with triplicate test runs conducted at the outlet. 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 4.

VOC concentrations were measured at the inlet and outlet of the carbon concentrator according to USEPA Method 25A, "Determination of Total Gaseous Organic Concentration Using a Flame Ionization Analyzer." The samples were collected through a probe and heated sample line, and into the analyzers, in accordance with Method 25A procedures. BTEC used a VIG hydrocarbon analyzer and two J.U.M. Model 109A analyzers to determine the VOC concentrations at the inlet and outlet. Although the J.U.M. Model 109A analyzers are capable of measuring exhaust gas methane concentrations as well as THC concentrations, methane concentrations were not measured for this test program.

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 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 FIDs to determine the average ppm for THC (as propane), as well as the average ppm for methane (as 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 the 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 ppm for THC reported as the calibration gas, propane, in equivalent units.

The second FID reports methane only. The sample enters a chamber containing a catalyst that destroys all of the hydrocarbons present in the gas stream other than methane. As with the THC sample, the methane gas concentration is sent to the DAS and recorded. The methane concentration, reported as methane, can then be converted to methane, reported as propane, by dividing the measured methane concentration by the analyzer's response factor.

The analyzer's response factor is obtained by introducing a methane calibration gas to the calibrated J.U.M. 109A. The response of the analyzer's THC FID to the methane calibration gas, in ppm as propane, is divided by the Methane analyzer's response to the methane calibration gas, in ppm as methane.

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 State's 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 schematic drawing of the continuous emission system is provided as Figure 5.

4.b Recovery and Analytical Procedures

Molecular weight and moisture content and samples were recovered and analyzed consistent with the specification of Methods 3 and 4.

4.c Sampling Ports

The inlet and outlet sampling locations satisfy the minimum criteria for Method 1.

4.d Traverse Points

Stack traverse point diagrams are appended as Figures 1-3.



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 (see section 2c). Detailed data for each test run can be found in Table 3.

5.b Sampling Procedure Variations

Regarding the measurement of air flowrates at the concentrator inlet and outlet locations, the following should be noted:

- Flowrates at each location (Inlet from Basecoat, Inlet from Clearcoat, and RTO Outlet) were measured using a Shortridge digital differential pressure monitor rather than a manometer.
- At the Inlet from Basecoat and Inlet from Clearcoat locations, velocity pressures at several duct traverse locations were negative. For the purpose of calculating exhaust gas flowrates at these locations, all traverse points for which the velocity pressures were negative were considered to not be traverse points (i.e., no value was incorporated into the overall average square root of the velocity pressures instead of using a value of zero for that traverse point).
- Measurement of exhaust gas flowrates from the concentrator desorption duct were not possible and a value of 9,110 scfm was used for each test run (from previous test data).

5.c Process or Control Device Upsets

No upset conditions occurred during testing.

5.d Control Device Maintenance

There has been no major maintenance performed during the past three months.

5.e Retest

This is not a retest.

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 are presented as well as raw analyzer test data (provided electronically on CD) are provided in Appendix A.

5.j Laboratory Data

Since all analysis was performed on site through the use of online analyzers there are no laboratory results for this test program.

Table 3
Carbon Wheel System 1 VOC Removal Efficiency Summary
Ford MAP
Wayne, MI

Parameter	Run 1	Run 2	Run 3	Average
Sampling Date	6/22/2017	6/22/2017	6/22/2017	
Sampling Time	8:15-9:15	10:20-11:20	12:35-13:35	
Basecoat Flowrate (scfm)	23,224	22,366	18,081	21,224
Clearcoat Flowrate (scfm)	14,391	17,428	18,619	16,813
Desorb Flowrate (scfm)	9,110	9,110	9,110	9,110
Outlet Flowrate (scfm)	16,600	17,610	15,663	16,624
Total Outlet Airflow	25,710	26,720	24,773	25,734
Basecoat VOC Concentration (ppmv propane)	294.0	321.9	285.6	300.5
Basecoat VOC Concentration (ppmv, corrected as per USEPA 7E)	289.8	314.6	279.0	294.4
Basecoat VOC Mass Flowrate (standard lb/hr)	46.0	48.1	34.5	42.9
Clearcoat VOC Concentration (ppmv propane)	77.5	79.3	78.9	78.6
Clearcoat VOC Concentration (ppmv, corrected as per USEPA 7E)	78.5	80.3	79.4	79.4
Clearcoat VOC Mass Flowrate (standard lb/hr)	7.7	9.6	10.1	9.1
Outlet VOC Concentration (ppmv propane)	9.1	11.6	11.9	10.9
Outlet VOC Concentration (ppmv, corrected as per USEPA 7E)	9.0	11.9	12.5	11.2
Outlet VOC Mass Emission Rate (standard lb/hr)	1.6	2.2	2.1	2.0
VOC Removal Efficiency (%)	97.0	96.2	95.2	96.2

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: ft³ per m³

453600: mg per lb

Equations

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

Total inlet	38,037
Total Outlet	25,734
Difference	12,302

Inlet 1 VOC Correction			
Co	2.75	4.49	4.41
Cma	298	298	298
Cm	302.27	305.16	304.75

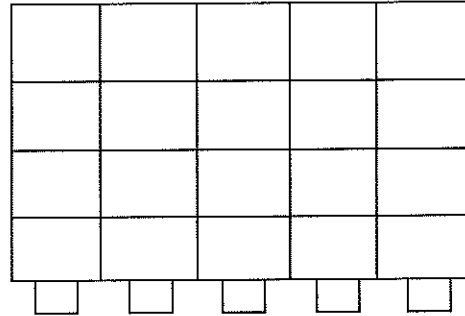
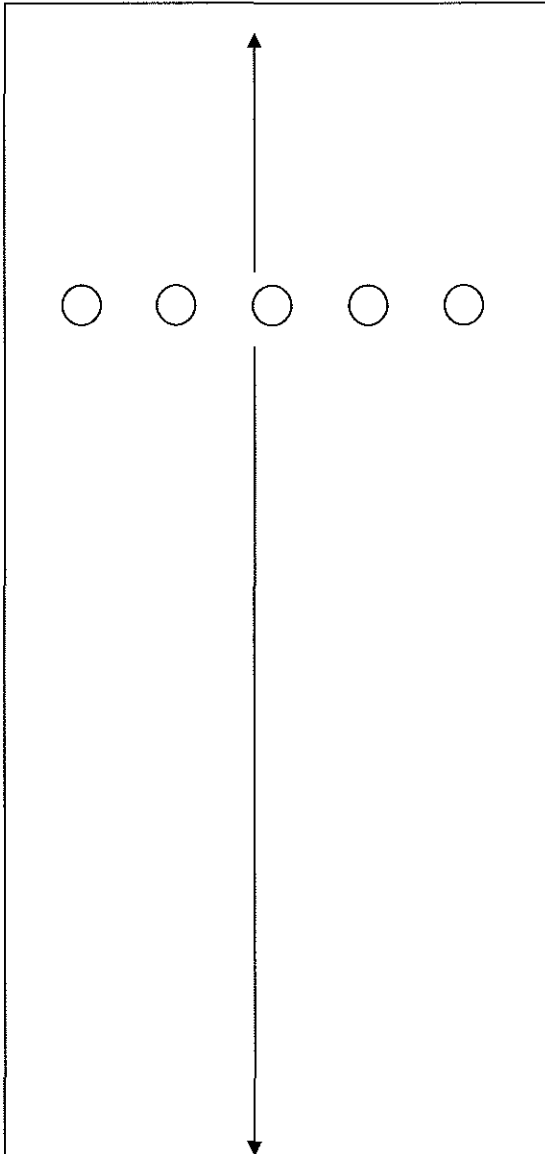
Inlet 2 VOC Correction			
Co	-0.13	-0.48	-0.42
Cma	79.5	79.5	79.5
Cm	78.49	78.47	78.92

Outlet VOC Correction			
Co	-0.16	-0.45	-0.68
Cma	14.9	14.9	14.9
Cm	15.12	14.63	14.30



Stack Dimensions:

Depth: 126 inches
Width: 60 inches



Not to Scale

Points	Distance "
1	15.8
2	47.3
3	78.8
4	110.3

Figure No. 1

Site:
CW Basecoat Inlet
Ford Motor Company
Wayne, Michigan

Sampling Date:
June 22, 2017

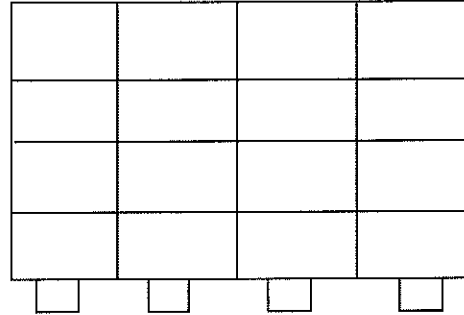
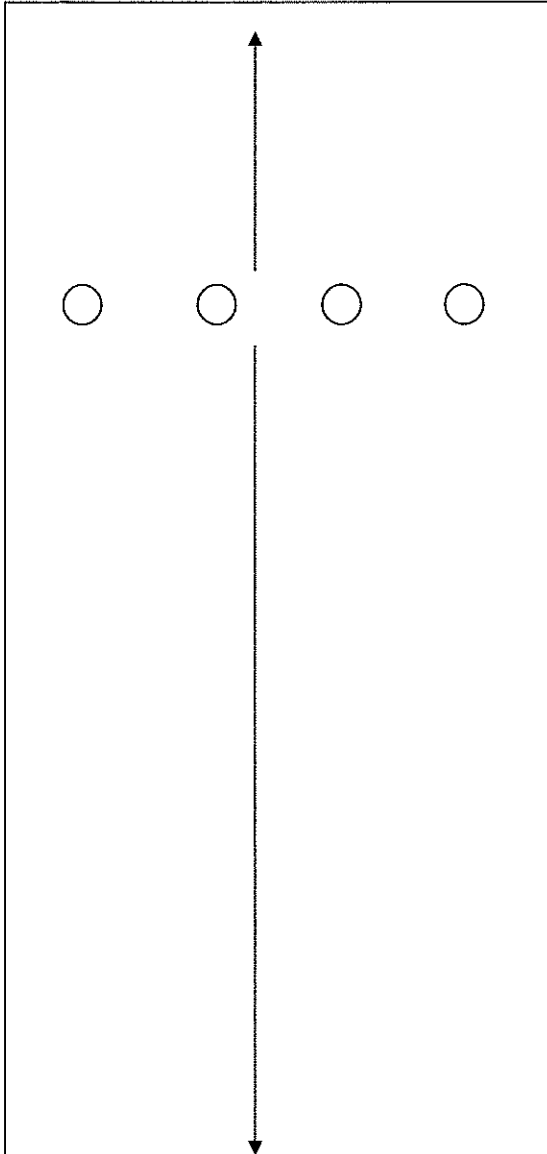
**BT Environmental Consulting,
Inc.**
4949 Fernlee Avenue
Royal Oak, Michigan 48073



Stack Dimensions:

Depth: 60 inches

Width: 75 inches



Not to Scale

Points	Distance "
1	7.5
2	22.5
3	37.5
4	52.5

Figure No. 2

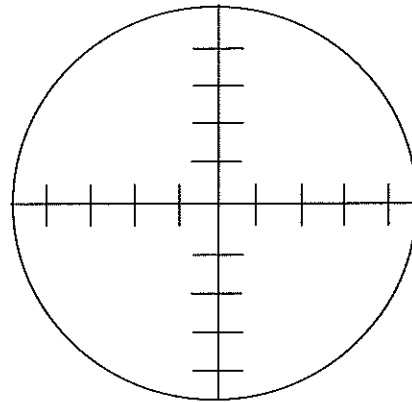
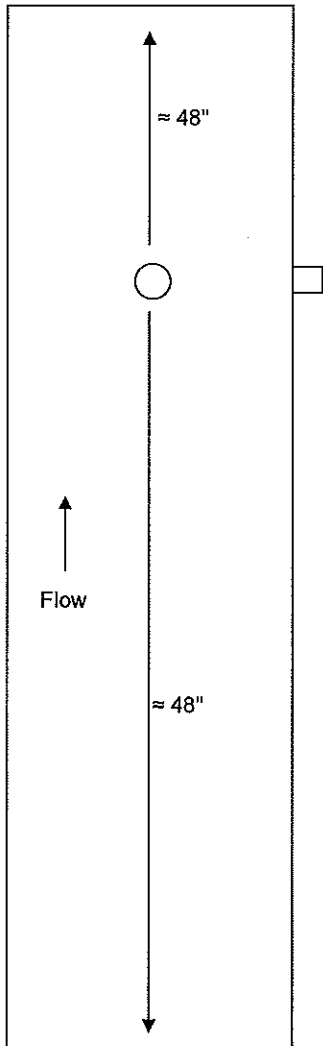
Site:
CW Clearcoat Inlet
Ford Motor Company
Wayne, Michigan

Sampling Date:
June 22, 2017

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



diameter = 126 inches



Not to Scale

Points	Distance "
1	4.0
2	13.2
3	24.4
4	40.7
5	85.3
6	101.6
7	112.8
8	122.0

Figure No. 3

Site:
Combo Outlet
Ford Motor Company
Wayne, Michigan

Sampling Date:
June 22, 2017

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



Stainless Steel Probe

Iced Cold Box

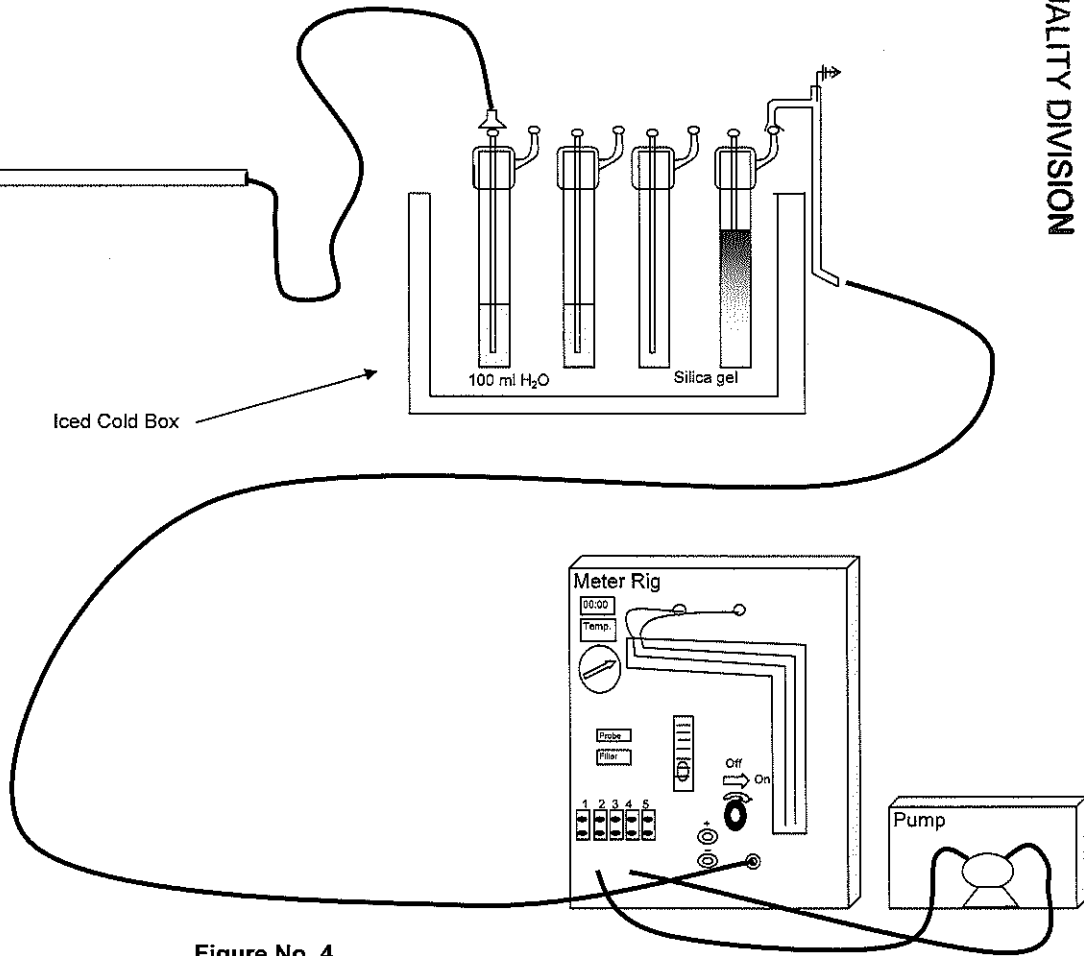


Figure No. 4

Site:
USEPA Method 4
Ford Motor Company
Wayne, Michigan

Sampling Date:
June 22, 2017

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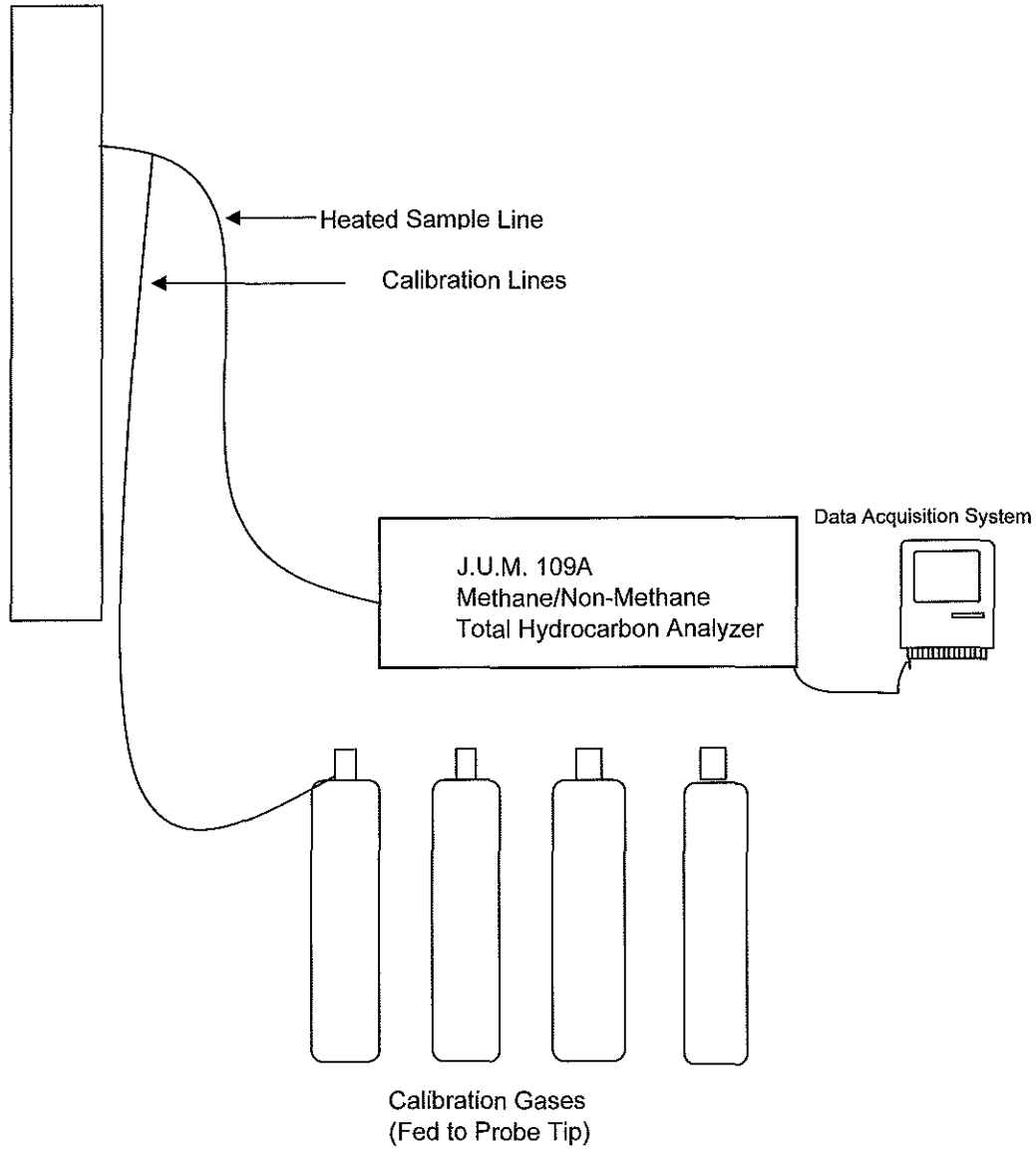


Figure No. 5

Site:
USEPA Method 25A
Ford Motor Company
Wayne, Michigan

Sampling Date:
June 22, 2017

BT Environmental Consulting, Inc.
4949 Fernlee Ave
Royal Oak, MI