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# VOC, NO<sub>x</sub>, and CO Test Report

*Prepared for:*

**Ford Motor Company**

Livonia Automatic Transmission New Product Center

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

Project No. 17-5039.00  
July 25, 2017

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



## EXECUTIVE SUMMARY

BT Environmental Consulting, Inc. (BTEC) was retained by Ford Motor Company (Ford) to evaluate volatile organic compounds (VOC), oxides of nitrogen (NO<sub>x</sub>), and carbon monoxide (CO) from a single thermal oxidizer under two separate fuel operating conditions. The source is located at the Livonia Automatic Transmission New Product Center located in Livonia, Michigan. The emissions test program was conducted from May 31<sup>st</sup>, 2017 to June 1<sup>st</sup>, 2017. The purpose of this report is to document the results of the test program.

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

**Table I**  
**Overall Results Summary**  
**Test Dates: May 31, 2017 and June 1, 2017**

Source	Test Dates	VOC (lb/hr)	CO (lb/hr)	NO <sub>x</sub> (lb/hr)
Gas	June 1, 2017	0.02	0.70	4.37
Diesel	May 31, 2017	0.00	0.01	1.40
Limit		9.5	208.0	84.5



## **1. Introduction**

BT Environmental Consulting, Inc. (BTEC) was retained by Ford Motor Company (Ford) to evaluate volatile organic compounds (VOC), oxides of nitrogen (NO<sub>x</sub>), and carbon monoxide (CO) from a single thermal oxidizer under two separate fuel operating conditions. The source is located at the Livonia Automatic Transmission New Product Center located in Livonia, Michigan. The emissions test program was conducted from May 31<sup>st</sup>, 2017 to June 1<sup>st</sup>, 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" (December 2013, see Appendix A). 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 on RTO 2 was conducted on May 31<sup>st</sup>, 2017 to June 1<sup>st</sup>, 2017, at the Ford plant in Livonia, Michigan.

### **1.b Purpose of Testing**

The purpose of the emissions test program was to verify VOC, NO<sub>x</sub>, and CO emission rates to demonstrate overall control efficiency to comply with the requirements of Michigan Department of Environmental Quality Air Quality Division Permit No. MI-ROP-M4734-2006 for the Livonia Transmission New Product Center.

### **1.c Source Description**

The unit is a thermal oxidizer.

### **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. Steve Smith Project Manager	BTEC 4949 Fernlee Ave. Royal Oak, MI	(248) 548-8072
Mr. Jake Zott Environmental Technician	BTEC 4949 Fernlee Ave. Royal Oak, MI	(248) 548-8070
Mr. Mike Nummer 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. Tom Maza MDEQ Air Quality Division	Michigan Department of Environmental Quality	(313)456-4709

**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-M4734-2006.

**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 Tables 3-4.



**Table 2**  
**Overall Results Summary**  
**Test Dates: May 31, 2017 to June 1, 2017**

Source	Test Dates	VOC (lb/hr)	CO (lb/hr)	NOx (lb/hr)
Gas	June 1, 2017	0.02	0.7	4.4
Diesel	May 31, 2017	0.00	0.01	1.4
Limit		9.5	208.0	84.5

## **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**

The facility operates 22 dynamometer test cells that are controlled by three thermal oxidizers.

### **3.c Raw and Finished Materials**

Pipeline quality natural gas is used in the oxidizers as combustion fuel.

### **3.d Process Capacity**

NA.

### **3.e Process Instrumentation**

The temperature of the thermal oxidizer was recorded every 15 minutes during the testing.

## **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.



#### 4.a Sampling Train and Field Procedures

The emissions test program will utilize the following 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"
- Method 7E - "Determination of Oxides of Nitrogen"
- Method 10 - "Determination of Carbon Monoxide"
- Method 25A - "Determination of Total Gaseous Organic Concentration using a Flame Ionization Analyzer"
- Method 205 - "Verification of Gas Dilution Systems for Field Instrument Calibrations"

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 was 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.

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 consists of a one-way squeeze bulb with connecting tubing and a set of Fyrite<sup>®</sup> combustion gas analyzers. Carbon dioxide and oxygen content were analyzed using the Fyrite<sup>®</sup> 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 was then determined gravimetrically.



## Measurement of NOx Emissions

The NOx content of the gas stream was measured using a Thermo Model 42i NOx 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<sup>®</sup> sample line, through a refrigerated Teflon<sup>®</sup> sample conditioner to remove the moisture from the sample before it entered the NOx analyzer. Data was recorded on a PC equipped with data acquisition software. Recorded NOx concentrations were averaged and reported for the duration of each 60-minute test (as drift corrected per Method 7E). A drawing of the sampling train used for the testing program is presented as Figure 3.

In accordance with Method 7E, a 3-point (zero, mid, and high) bias check and calibration check was performed on the NOx 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.

## Measurement of CO Emissions

The CO content of the exhaust gas was evaluated according to procedures outlined in 40 CFR 60, Appendix A, Method 10. The CO content of the gas stream was measured using a Teledyne T300 CO 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<sup>®</sup> sample line, through a refrigerated sample conditioner with a peristaltic pump to remove the moisture from the sample before it entered the analyzer. Data was recorded on a PC equipped with Labview<sup>®</sup> II data acquisition software. CO concentrations were averaged and reported for the duration of each 60-minute test (as drift corrected per Method 7E).

In accordance with Method 10, a 3-point (zero, mid, and high) calibration check will be performed on the CO analyzer. Calibration drift checks will be performed at the completion of each run.

## Measurement of VOC Emissions

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<sup>®</sup> 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 IOtech<sup>®</sup> data acquisition software. BTEC used a JUM Model 109A Methane/Non-Methane THC hydrocarbon analyzer to determine the VOC concentration.

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

Methane concentrations were measured during the test program, but the VOC results are reported without methane subtraction.

In accordance with Method 25A, a 4-point (zero, low, 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**

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 outlet sampling locations satisfy the minimum criteria for Method 1.

#### **4.d Traverse Points**

Stack traverse point diagrams are appended as Figure 1.



## **5. Test Results and Discussion**

Each gas was below the limit.

### **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 Tables 3-4.

### **5.b Sampling Procedure Variations**

The emissions test program did not include sampling procedure variations.

### **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 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 C.

### **5.h Sample Calculations**

Sample calculations are provided in Appendix D.

### **5.i Field Data Sheets**

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



## 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**  
**RTO 2 (Gas) NOx, VOC, and CO Emission Rates**  
**Ford**  
**Livonia, Michigan**  
**BTEC Project No. 17-5039.00**  
**Sampling Dates: 6/1/2017**

Parameter	Run 1	Run 2	Run 3	Average
Test Run Date	6/1/2017	6/1/2017	6/1/2017	
Test Run Time	8:10-9:10	9:25-10:25	10:45-11:45	
Outlet Flowrate (dscfm)	8.265	8.492	8.876	8,544
Outlet Flowrate (scfm)	8.433	8.665	9.057	8,718
Gasoline Consumed (gal/hr)	21.43	24.46	24.97	23.62
Outlet Oxides of Nitrogen Concentration (ppmv)	57.81	74.26	84.43	72.17
Outlet NOx Concentration (ppmv, corrected as per USEPA 7E)	57.24	73.67	82.86	71.26
NOx Emission Rate (lb/hr)	3.41	4.50	5.35	4.42
NOx Emission Rate (lb/hr) (corrected as per USEPA 7E)	3.38	4.47	5.25	4.37
NOx Emission Rate (lb/gal) (corrected as per USEPA 7E)	0.16	0.18	0.21	0.18
Outlet Carbon Monoxide Concentration (ppmv)	17.52	18.92	19.08	18.51
Outlet CO Concentration (ppmv, corrected as per USEPA 7E)	17.76	19.22	19.44	18.81
CO Emission Rate (lb/hr)	0.63	0.70	0.74	0.69
CO Emission Rate (lb/hr) (corrected as per USEPA 7E)	0.64	0.71	0.75	0.70
CO Emission Rate (lb/gal) (corrected as per USEPA 7E)	0.03	0.03	0.03	0.03
Outlet VOC Concentration (ppmv as propane)	0.37	0.33	0.32	0.34
Outlet VOC Concentration (ppmv as carbon)	1.11	0.99	0.96	1.02
Outlet VOC Concentration (ppmv, corrected as per USEPA 7E)	0.27	0.23	0.26	0.26
VOC Emission Rate as Propane (lb/hr)	0.02	0.02	0.02	0.02
VOC Emission Rate as Carbon (lb/hr)	0.02	0.02	0.02	0.02
VOC Emission Rate as Propane(lb/hr) (corrected as per USEPA 7E)	0.02	0.01	0.02	0.02
VOC Emission Rate as Propane(lb/gal) (corrected as per USEPA 7E)	7.40E-04	5.69E-04	6.47E-04	6.52E-04

VOC Correction			
Co	0.10	0.10	0.07
Cma	29.70	29.70	29.70
Cm	29.82	29.22	29.12

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<sub>2</sub> = 64.05, C<sub>3</sub>H<sub>8</sub> = 44.10, carbon = 12.01)  
24.14 = molar volume of air at standard conditions (70°F, 29.92" Hg)  
35.31 = ft<sup>3</sup> per m<sup>3</sup>  
453600 = mg per lb  
Response factor obtained from introducing propane into methane analyzer: 2.3

Co= Average of initial and final zero gases  
Cma=Actual concentration of the calibration gas  
Cm= Average of initial and final calibration gases  
 $C_c = K \cdot C_{meas}$   
where Cc = Concentration as Carbon (ppmv), K= Carbon equivalent correction factor (3 for Propane)  
and C<sub>meas</sub> = concentration as measured (as propane)  
<sup>1</sup>emission rate calculated on dry basis  
<sup>2</sup>emission rate calculated on wet basis

**Equations**  
lb/hr = ppmv \* MW/24.14 \* 1/35.31 \* 1/453,600 \* scfm \* 60 for VOC  
lb/hr = ppmv \* MW/24.14 \* 1/35.31 \* 1/453,600 \* dscfm \* 60  
Conc<sub>(20.9%O<sub>2</sub>)</sub> = Conc \* (20.9 - 15)/(20.9 - %O<sub>2</sub>)  
lb/gal = (lb/hr)/(gal/hr)

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**Table 4**  
**RTO 2 (Diesel) NO<sub>x</sub>, VOC, and CO Emission Rates**  
**Ford**  
**Livonia, Michigan**  
**BTEC Project No. 17-5039.00**  
**Sampling Dates: 5/31/2017**

Parameter	Run 1	Run 2	Run 3	Average
Test Run Date	5/31/2017	5/31/2017	5/31/2017	
Test Run Time	8:20-9:20	10:15-11:15	11:45-12:45	
Outlet Flowrate (dscfm)	7.864	7.703	8.234	7.930
Outlet Flowrate (scfm)	8.024	7.860	8.391	8.092
Diesel Consumed (gal/hr)	7.65	8.08	7.20	7.64
Outlet Oxides of Nitrogen Concentration (ppmv)	23.10	26.16	26.18	25.15
Outlet NO <sub>x</sub> Concentration (ppmv, corrected as per USEPA 7E)	22.80	25.59	25.64	24.68
NO <sub>x</sub> Emission Rate (lb/hr)	1.30	1.44	1.54	1.42
NO <sub>x</sub> Emission Rate (lb/hr) (corrected as per USEPA 7E)	1.28	1.41	1.51	1.40
NO <sub>x</sub> Emission Rate (lb/gal) (corrected as per USEPA 7E)	0.17	0.17	0.21	0.18
Outlet Carbon Monoxide Concentration (ppmv)	0.09	0.13	0.35	0.19
Outlet CO Concentration (ppmv, corrected as per USEPA 7E)	0.00	0.17	0.36	0.18
CO Emission Rate (lb/hr)	0.00	0.00	0.01	0.01
CO Emission Rate (lb/hr) (corrected as per USEPA 7E)	0.00	0.01	0.01	0.01
CO Emission Rate (lb/gal) (corrected as per USEPA 7E)	0.00E+00	7.04E-04	1.79E-03	8.31E-04
Outlet VOC Concentration (ppmv as propane)	0.26	0.23	0.24	0.24
Outlet VOC Concentration (ppmv as carbon)	0.78	0.69	0.72	0.73
Outlet VOC Concentration (ppmv, corrected as per USEPA 7E)	0.10	0.06	0.05	0.07
VOC Emission Rate as Propane (lb/hr)	0.01	0.01	0.01	0.01
VOC Emission Rate as Carbon (lb/hr)	0.01	0.01	0.01	0.01
VOC Emission Rate as Propane(lb/hr) (corrected as per USEPA 7E)	0.01	0.00	0.00	0.00
VOC Emission Rate as Propane(lb/gal) (corrected as per USEPA 7E)	7.52E-04	3.69E-04	3.64E-04	4.95E-04

VOC Correction			
Co	0.16	0.18	0.20
Cma	29.70	29.70	29.70
Cm	29.93	29.66	29.45

Run 1 CO result was negative after drift correction, replaced with zero.

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, NO<sub>x</sub> = 46.01, SO<sub>2</sub> = 64.05, C<sub>3</sub>H<sub>8</sub> = 44.10, carbon = 12.01)

24.14 = molar volume of air at standard conditions (70°F, 29.92" Hg)

35.31 = ft<sup>3</sup> per m<sup>3</sup>

453600 = mg per lb

Response factor obtained from introducing propane into methane analyzer:

2.3

Co = Average of initial and final zero gases

Cma = Actual concentration of the calibration gas

Cm = Average of initial and final calibration gases

C<sub>c</sub> = K · C<sub>m,meas</sub>

where C<sub>c</sub> = Concentration as Carbon (ppmv), K = Carbon equivalent correction factor (3 for Propane)

and C<sub>m,meas</sub> = concentration as measured (as propane)

<sup>1</sup>emission rate calculated on dry basis

<sup>2</sup>emission rate calculated on wet basis

**Equations**

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

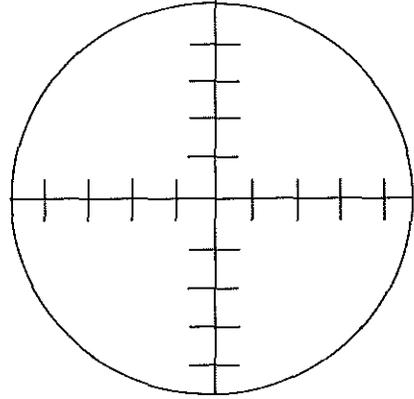
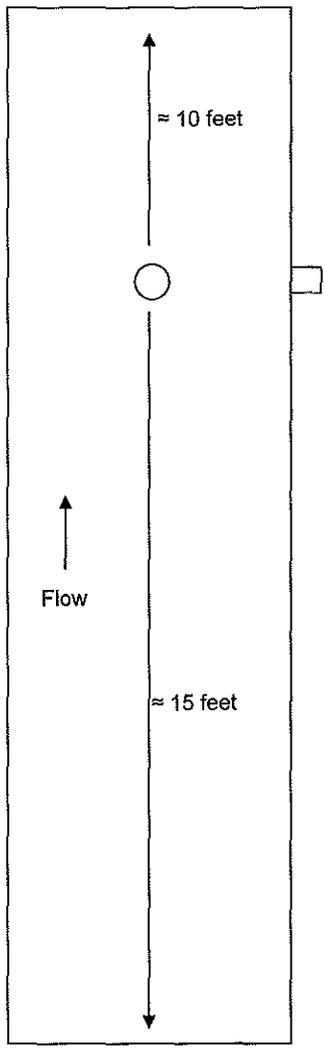
lb/hr = ppmv \* MW/24.14 \* 1/35.31 \* 1/453,600 \* dscfm \* 60

Conc<sub>O<sub>2</sub></sub> = Conc \* (20.9 - 15)/(20.9 - %O<sub>2</sub>)

lb/gal = (lb/hr)/(gal/hr)



diameter = 44 inches



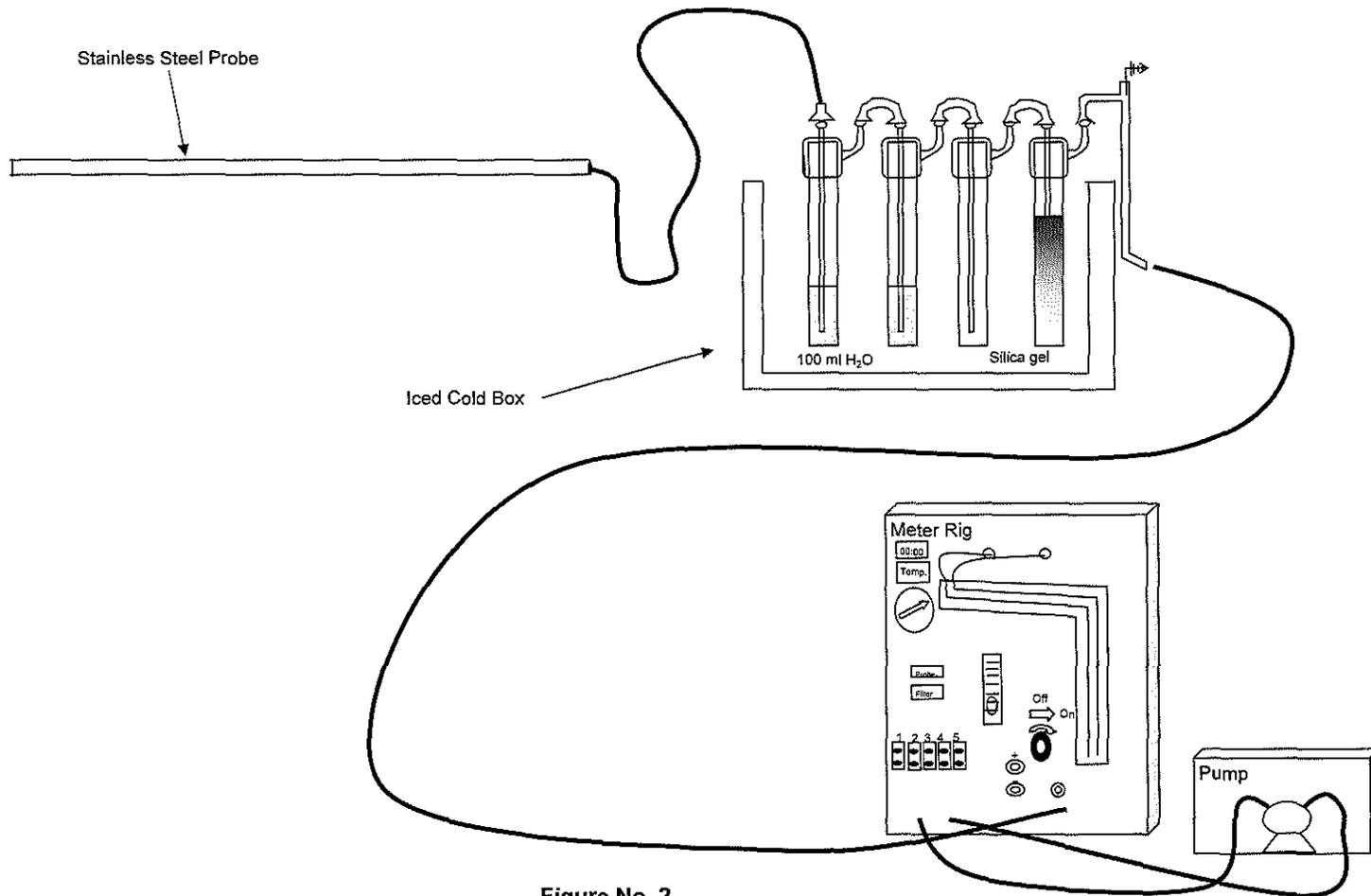
Not to Scale

Points	Distance "
1	1.4
2	4.6
3	8.5
4	14.2
5	29.8
6	35.5
7	39.4
8	42.6

Figure No. 1

Site: RTO 2 Ford Livonia, Michigan	Sampling Date: May 31-June 1, 2017	BT Environmental Consulting, Inc. 4949 Fernlee Avenue Royal Oak, Michigan 48073
---------------------------------------------	---------------------------------------	---------------------------------------------------------------------------------------

**BTEC Inc.**

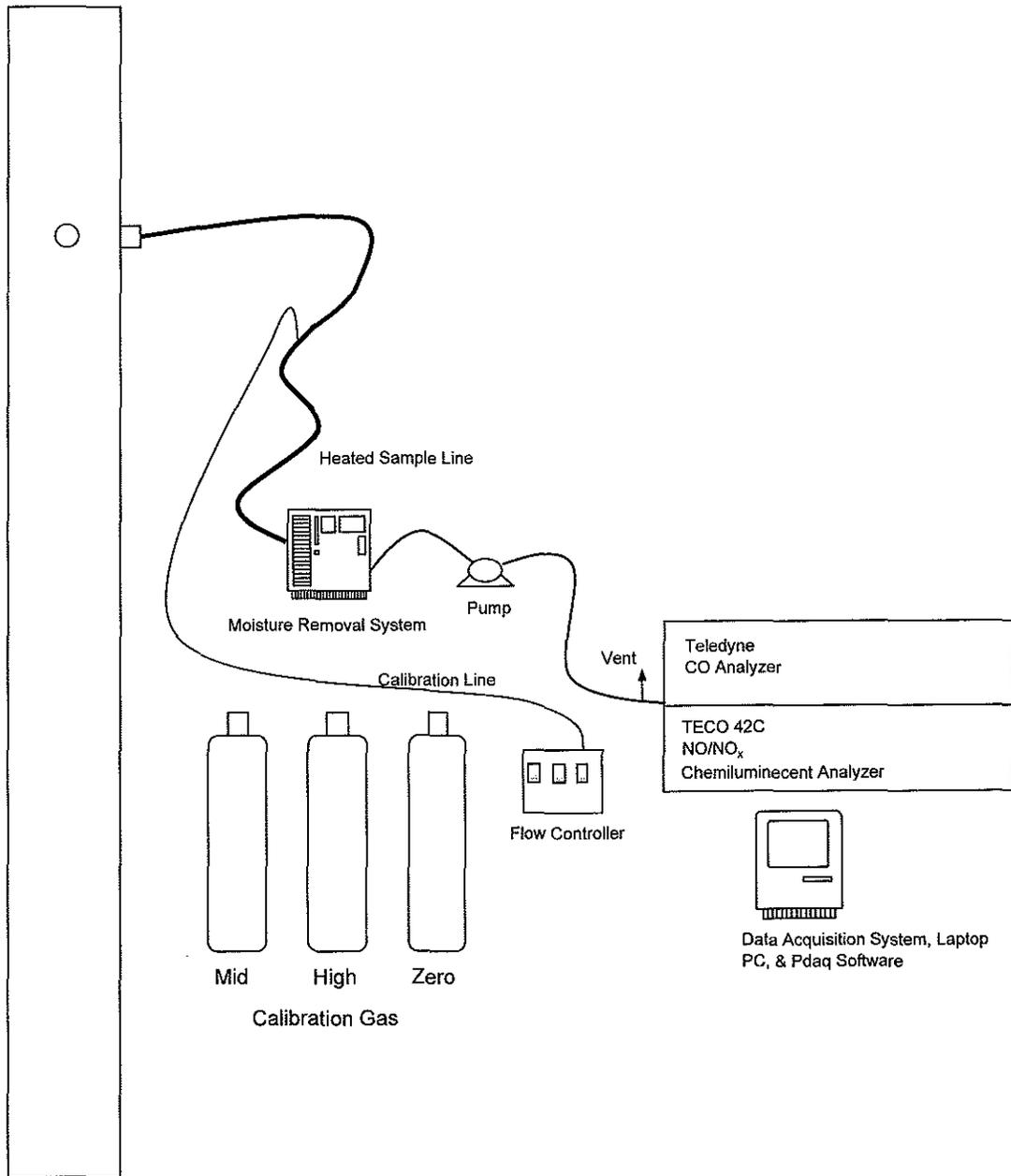


**Figure No. 2**

**Site:**  
USEPA Method 4  
Ford  
Livonia, Michigan

**Sampling Date:**  
May 31-June 1, 2017

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



**Figure No. 3**

**Site:**  
**USEPA Method 7E and 10**  
**Ford**  
**Livonia, Michigan**

**Sampling Date:**  
**May 31-June 1, 2017**

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

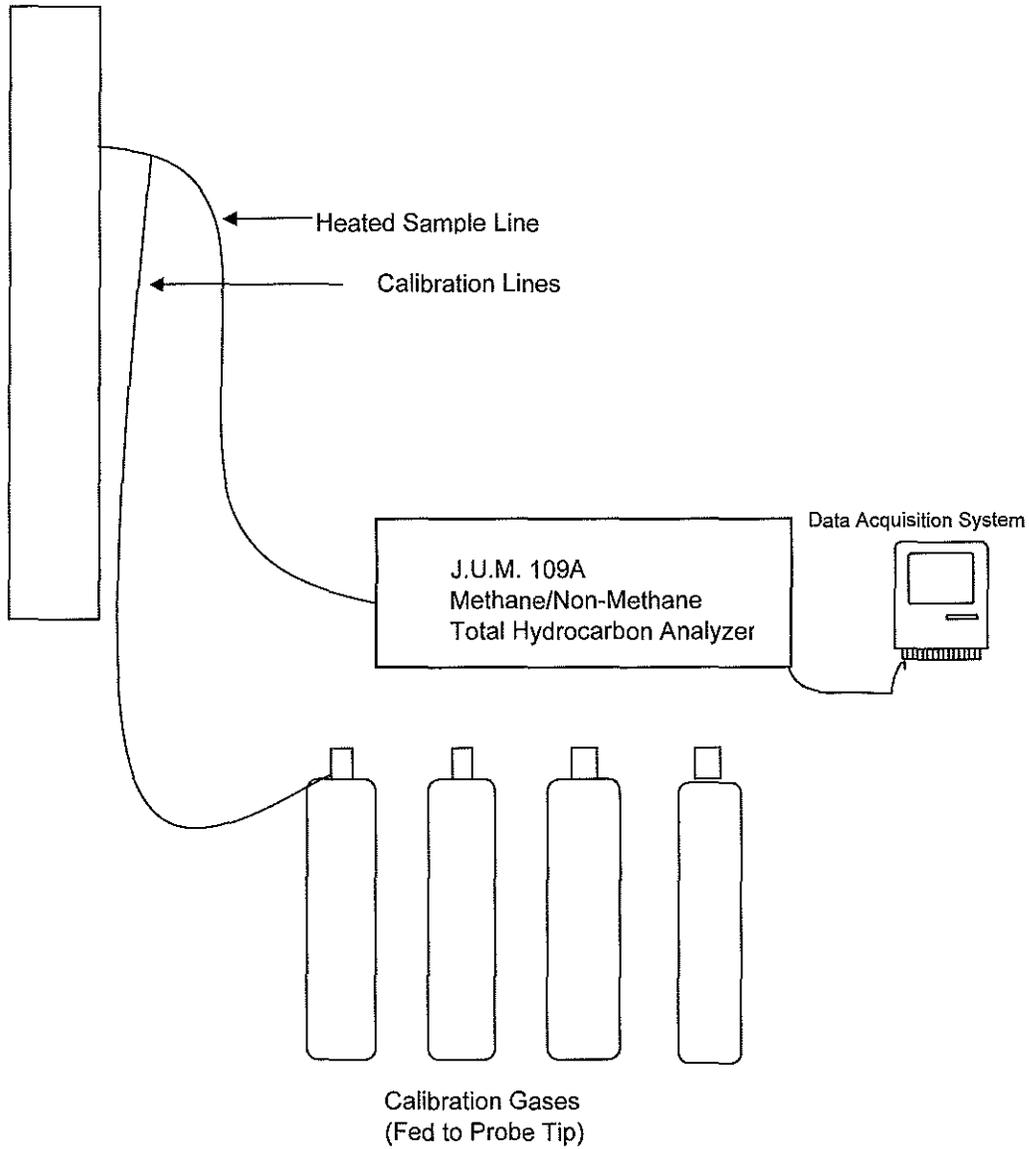


Figure No. 4

Site:  
USEPA Method 25A  
Ford  
Livonia, Michigan

Sampling Date:  
May 31-June 1, 2017

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