BTEC Inc.

Thermal Oxidizers (TOs) NOx, O_2, CO, and VOC Emissions Test Report

Prepared for:

Ford Motor Company

Dynamometer Laboratory
1701 Village Road
Dearborn, Michigan 48124

Project No. 14-4618.00
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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 Ford Motor Company (Ford) to conduct a compliance emissions test program on four thermal oxidizers (TOs) at the Ford Dynamometer Test Laboratory in Dearborn, Michigan. This emissions testing program included evaluation of oxides of nitrogen (NOx), oxygen (O_2), carbon monoxide (CO), and volatile organic compounds (VOC) prior to and after each TO during a single mobilization to the Dearborn facility.

The purpose of this document is to present the test results for this emissions testing program. Sampling and analysis for this emissions test program was conducted from December 9-11, 2014.

Testing consisted of triplicate 60-minute test runs with sampling conducted at the four TO inlet and outlet sampling locations. The emissions test program was required by Michigan Department of Environmental Quality (MDEQ) Air Quality Division (AQD) Permit No. MI-PTI-B6230-2013. The results of the emission test program are summarized by Tables I and II.

MDEQ AQD has published a guidance document entitled "Format for Submittal of Source Emission Test Plans and Reports" (December 2013). This document is provided as Appendix A. The following is a summary of the emissions test plan in the format suggested by the aforementioned document.

Table I
TO Test Program Results Summary
Test Date: December 9-11, 2014

TO-1	
Test Parameter	**Outlet Emission Rate**
NOx Emission Rate	0.63 lb/MMBtu
NOx Emission Rate	0.075 lb/gal
CO Emission Rate	0.01 lb/MMBtu
CO Emission Rate	0.001 lb/gal
VOC Emission Rate	0.00 lb/MMBtu
VOC Emission Rate	0.000 lb/gal
CO Destruction Efficiency	98.8 % DE
VOC Destruction Efficiency	99.5 % DE
TO-2	
Test Parameter	**Outlet Emission Rate**
NOx Emission Rate	0.55 lb/MMBtu
NOx Emission Rate	0.067 lb/gal
CO Emission Rate	0.00 lb/MMBtu
CO Emission Rate	0.001 lb/gal
VOC Emission Rate	0.00 lb/MMBtu
VOC Emission Rate	0.000 lb/gal
CO Destruction Efficiency	99.3 % DE
VOC Destruction Efficiency	99.7 % DE
TO-3	
Test Parameter	**Outlet Emission Rate**
NOx Emission Rate	0.39 lb/MMBtu
NOx Emission Rate	0.047 lb/gal
CO Emission Rate	0.00 lb/MMBtu
CO Emission Rate	0.000 lb/gal
VOC Emission Rate	0.00 lb/MMBtu
VOC Emission Rate	0.000 lb/gal
CO Destruction Efficiency	99.8 % DE
VOC Destruction Efficiency	99.4 % DE
TO-4	
Test Parameter	**Outlet Emission Rate**
NOx Emission Rate	0.48 lb/MMBtu
NOx Emission Rate	0.057 lb/gal
CO Emission Rate	0.01 lb/MMBtu
CO Emission Rate	0.001 lb/gal
VOC Emission Rate	0.00 lb/MMBtu
VOC Emission Rate	0.000 lb/gal
CO Destruction Efficiency	98.8 % DE
VOC Destruction Efficiency	99.7 % DE

Note: VOC emission rate is as propane; minus methane; and corrected per Method 7E

Table II
TO Test Program Results Summary Averages
Test Date: December 9-11, 2014

All TO Average	
Test Parameter	**Outlet Emission Rate**
NOx Emission Rate	0.51 lb/MMBtu
NOx Emission Rate	0.062 lb/gal
CO Emission Rate	0.00 lb/MMBtu
CO Emission Rate	0.001 lb/gal
VOC Emission Rate	0.00 lb/MMBtu
VOC Emission Rate	0.000 lb/gal
CO Destruction Efficiency	99.3 % DE
VOC Destruction Efficiency	99.6 % DE

Note: VOC emission rate is as propane; minus methane; and corrected per Method 7E

1. Introduction

BT Environmental Consulting, Inc. (BTEC) was retained by Ford Motor Company (Ford) to conduct a compliance emissions test program on four thermal oxidizers (TOs) at the Ford Dynamometer Test Laboratory in Dearborn, Michigan. This emissions testing program included evaluation of oxides of nitrogen (NOx), oxygen (O_2), carbon monoxide (CO), and volatile organic compounds (VOC) prior to and after each TO during a single mobilization to the Dearborn facility.

The purpose of this document is to present the test results for this emissions testing program. Sampling and analysis for this emissions test program was conducted from December 9-11, 2014.

The Air Quality Division (AQD) of Michigan's Department of Environmental Quality (MDEQ) 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 was conducted on December 9-11, 2014 at the Ford Dynamometer Laboratory in Dearborn, Michigan.

1.b Purpose of Testing

The emissions test program was required by MDEQ AQDPermit No. MI-PTI-B6230-2013.

1.c Source Description

Ford's Dynamometer Laboratory is located in Dearborn, Michigan.

Ford Dynamometer Laboratory tests engines for vehicles manufactured by Ford. Testing is performed in any of approximately 30 Dynamometer Test Cells located in the Dynamometer Laboratory (F&G Wings). The dynamometers are controlled by four thermal oxidizers (TOs).

1.d Test Program Contacts

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

Table 1
Test Personnel

Name and Title	Affiliation	Telephone
Ms. Susan Hicks Senior Environmental Engineer	Ford Motor Company Fairlane Plaza North 290 Town Center Drive, Suite 800 Dearborn, Michigan 48126	(313) 594-3185
Mr. Barry Boulianne Senior Project Manager	BTEC 4949 Fernlee Ave. Royal Oak, MI 48073	(313) 449-2361
Mr. Randal Tysar Environmental Engineer	BTEC 4949 Fernlee Ave. Royal Oak, MI 48073	(248) 548-8070
Mr. Matt Young Project Manager	BTEC 4949 Fernlee Ave. Royal Oak, MI 48073	(248) 548-8070
Mr. Kenny Felder Environmental Technician	BTEC 4949 Fernlee Ave. Royal Oak, MI 48073	(248) 548-8070
Mr. Tom Maza	MDEQ Air Quality Division	(313) 456-4709

2. Summary of Results

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

2.a Operating Data

Process operating, fuel usage and fuel analytical data for this emissions test program is provided in Appendix D. A summary of the room data has been provided. Each room recorded process data during each run, the sheets are available upon request.

2.b Applicable Permit

The applicable permit for this emissions test program is Permit No. MI-PTI-B6230-2013. Permit emission limitations are summarized in Table 2.

Table 2
Permit Emission Limitations

Pollutant	Emission Limitation	Emission Limitation Units
NOx	1,200	lb/day
NOx	37.5	tons/year
CO	1,416	lb/day
CO	44.3	tons/year

VOC emissions testing were performed to establish an emission factor to be used for recordkeeping purposes.

2.c Results

The results of the emissions test program are summarized by Table 3 (see Section 5.a).

3. Source Description

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

3.a Process Description

30 Dynamometer Test Cells located in the Dynamometer Laboratory (F&G Wings). The dynamometers are controlled by four thermal oxidizers (TOs).

3.b Process Flow Diagram

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

3.c Raw and Finished Materials

Raw materials for the test cells include fuels supplied to the engines. Fuel usage data for the emissions test program is provided in Appendix D.

3.d Process Capacity

The F & G Wing has 30 test cells controlled by 4 thermal oxidizers, each oxidizer is designed for 95% destruction efficiency. During each test the status of each cells operating parameters were recorded. A summary is provided in the process data in appendix D.

3.e Process Instrumentation

Operating data recorded during the emissions test program is provided 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 from the test cells.

4.a Sampling Train and Field Procedures

- 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"
- Method 4 - "Determination of Moisture Content in Stack Gases"
- Method 7E - "Determination of Nitrogen Oxide Emissions from stationary Sources"
- Method 10 - "Visual Determination Carbon Monoxide Emissions from Stationary Sources"
- Method 19 - "Determination of Sulfur Dioxide Removal Efficiency and Particulate Matter, Sulfur Dioxide and Nitrogen Oxide Emission Rates"
- Method 25A - "Determination of Total Gaseous Concentration Using a Flame Ionization Analyzer" (JUM 109A methane subtraction at the outlet)

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, on each TO, 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. CO_2 and O_2 content was analyzed using the Fyrite® procedure.

Exhaust gas moisture content was evaluated using Method 4 with a single test run conducted at the TO inlet and triplicate test runs at the TO 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 1.

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 TECO 48 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® 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® II data acquisition software. Recorded CO concentrations were averaged and reported for the duration of each 60-minute test (as drift corrected per Method 7E). The analyzer was calibrated for a range of 0 to 500 ppm.

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

The NO_x content of the TO outlet gas was measured using a TECO 42C NO_x gas analyzer. A sample of the gas stream was be drawn through an insulated stainless-steel probe with an in-line glass fiber filter to remove any particulate, a heated Teflon® sample line, and through a Universal Analyzers 3080PV electronic sample conditioner to remove the moisture from the sample before it entered the analyzer. Data was recorded at 4-second intervals on a PC equipped with a data acquisition system.

VOC concentrations were measured at the inlet and outlet of the TO 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 THC hydrocarbon analyzer to determine the VOC concentration at the inlet of the TO. A J.U.M. Model 109A methane/non-methane hydrocarbon analyzer was used at the outlet of the TO to determine the methane/non-methane concentrations.

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. The response factor was determined to be approximately 2.1.

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 3.

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 stacks showing sampling ports in relation to upstream and downstream disturbances are included as Figures 4-5.

4.d Traverse Points

Each stack was traversed at a total of six points consistent with the requirements of Method 1 and as illustrated by Figures 4-5.

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 4-15.

Table 3A
TO Test Program Results Summary
Test Date: December 9-11, 2014

TO-1	
Test Parameter	**Outlet Emission Rate**
NOx Emission Rate	0.63 lb/MMBtu
NOx Emission Rate	0.075 lb/gal
CO Emission Rate	0.01 lb/MMBtu
CO Emission Rate	0.001 lb/gal
VOC Emission Rate	0.00 lb/MMBtu
VOC Emission Rate	0.000 lb/gal
CO Destruction Efficiency	98.8 % DE
VOC Destruction Efficiency	99.5 % DE
TO-2	
Test Parameter	**Outlet Emission Rate**
NOx Emission Rate	0.55 lb/MMBtu
NOx Emission Rate	0.067 lb/gal
CO Emission Rate	0.00 lb/MMBtu
CO Emission Rate	0.001 lb/gal
VOC Emission Rate	0.00 lb/MMBtu
VOC Emission Rate	0.000 lb/gal
CO Destruction Efficiency	99.3 % DE
VOC Destruction Efficiency	99.7 % DE
TO-3	
Test Parameter	**Outlet Emission Rate**
NOx Emission Rate	0.39 lb/MMBtu
NOx Emission Rate	0.047 lb/gal
CO Emission Rate	0.00 lb/MMBtu
CO Emission Rate	0.000 lb/gal
VOC Emission Rate	0.00 lb/MMBtu
VOC Emission Rate	0.000 lb/gal
CO Destruction Efficiency	99.8 % DE
VOC Destruction Efficiency	99.4 % DE
TO-4	
Test Parameter	**Outlet Emission Rate**
NOx Emission Rate	0.48 lb/MMBtu
NOx Emission Rate	0.057 lb/gal
CO Emission Rate	0.01 lb/MMBtu
CO Emission Rate	0.001 lb/gal
VOC Emission Rate	0.00 lb/MMBtu
VOC Emission Rate	0.000 lb/gal
CO Destruction Efficiency	98.8 % DE
VOC Destruction Efficiency	99.7 % DE

Note: VOC emission rate is as propane; minus methane; and corrected per Method 7E

Table 3B
TO Test Program Results Summary Averages
Test Date: December 9-11, 2014

All TO Average	
Test Parameter	**Outlet Emission Rate**
NOx Emission Rate	0.51 lb/MMBtu
NOx Emission Rate	0.062 lb/gal
CO Emission Rate	0.00 lb/MMBtu
CO Emission Rate	0.001 lb/gal
VOC Emission Rate	0.00 lb/MMBtu
VOC Emission Rate	0.000 lb/gal
CO Destruction Efficiency	99.3 % DE
VOC Destruction Efficiency	99.6 % DE

Note: VOC emission rate is as propane; minus methane; and corrected per Method 7E

5.b Discussion of Results

The overall results of the emissions test program are summarized by Table 3. Detailed results for the emissions test program are summarized by Tables 4-11.

The individual TO test results have been combined to create an average emissions summarized by Table 3B.

5.c Sampling Procedure Variations

Due to structural constraints of the sampling locations, volumetric flowrate determinations were performed at the inlet of each TO and the outlet of only TO #1. Outlet flow was assumed to be 10% higher at the outlet due to combustion air.

5.d Process or Control Device Upsets

No upset conditions occurred during testing.

5.e Control Device Maintenance

There was no control equipment maintenance performed during 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.