BTEC Inc.

# *CO, NOx, VOC, $CH_2O$, $PM_{10}$ and $PM_{2.5}$ Emissions Test Report*

*Prepared for:*

**General Motors LLC Orion Assembly**

Lake Orion, MI



GM Orion Assembly Plant
4555 Giddings Road
Lake Orion, MI 48359

Project No. 14-4594.00
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BTEC Inc.

## Executive Summary

BT Environmental Consulting, Inc. (BTEC) was retained by General Motors LLC (GM) to conduct a compliance emissions test program on five landfill gas engine generators at the GM Orion Assembly facility in Lake Orion, Michigan. The emissions test program included the following:

(1) Evaluation of the volatile organic compound (VOC), carbon monoxide (CO), and oxides of nitrogen (NOx) emission rates from five engine exhausts using USEPA Methods 7E, 10, 25A, and 320.

(2) Evaluation of the emission rates of particulate matter less than 10 microns in diameter ($PM_{10}$) and particulate matter less than 2.5 microns in diameter ($PM_{2.5}$), from one engine exhaust stack using USEPA Methods 5 and 202.

(3) Evaluation of the emission rates of formaldehyde ($CH_2O$) from one engine exhaust stack using USEPA Method 320.

Sampling was conducted on October 7-9th, 2014. Testing consisted of triplicate 60-minute test runs for VOC, CO, NOx, and $CH_2O$. PM sampling consisted of triplicate 128-minute test runs. Sampling was performed utilizing United States Environmental Protection Agency (USEPA) test methods. The results of the emissions test program are highlighted by Table E-I.

**Table E-I**
**Overall Results Summary**
**Sampling Dates: October 7-9, 2014**

| Source | Pollutant | Average Test Result | | Emission Limit | |
|---|---|---|---|---|---|
| | | (g/bh-hr) | (lb/hr) | (g/bh-hr) | (lb/hr) |
| Engine 1 | PM | NA | 0.23 | NA | 0.64 |
| | $CH_2O$ | NA | 1.6 | NA | 2.1 |
| | NOx | 0.43 | 2.1 | 2.0 | 2.97 |
| | CO | 1.92 | 9.5 | 3.5 | 17.3 |
| | VOC | 0.08 | 0.4 | 1.0 | 2.8 |
| Engine 2 | NOx | 0.42 | 2.1 | 2.0 | 2.97 |
| | CO | 1.89 | 9.4 | 3.5 | 17.3 |
| | VOC | 0.08 | 0.4 | 1.0 | 2.8 |
| Engine 3 | NOx | .41 | 2.0 | 2.0 | 2.97 |
| | CO | 1.86 | 9.2 | 3.5 | 17.3 |
| | VOC | 0 | 0 | 1.0 | 2.8 |
| Engine 4 | NOx | 0.36 | 1.8 | 2.0 | 2.97 |
| | CO | 1.90 | 9.4 | 3.5 | 17.3 |
| | VOC | 0 | 0 | 1.0 | 2.8 |
| Engine 5 | NOx | 0.29 | 1.4 | 2.0 | 2.97 |
| | CO | 1.88 | 9.3 | 3.5 | 17.3 |
| | VOC | 0 | 0 | 1.0 | 2.8 |

## 1. Introduction

BT Environmental Consulting, Inc. (BTEC) was retained by General Motors LLC (GM) to conduct a compliance emissions test program on five landfill gas engine generators at the GM Orion Assembly facility in Lake Orion, Michigan. The emissions test program included the following:

(1) Evaluation of the volatile organic compound (VOC), carbon monoxide (CO), and oxides of nitrogen (NOx) emission rates from five engine exhausts using USEPA Methods 7E, 10, 25A, and 320.

(2) Evaluation of the emission rates of particulate matter less than 10 microns in diameter ($PM_{10}$) and particulate matter less than 2.5 microns in diameter ($PM_{2.5}$), from one engine exhaust stack using USEPA Methods 5 and 202.

(3) Evaluation of the emission rates of formaldehyde ($CH_2O$) from one engine exhaust stack using USEPA Method 320.

Sampling was conducted on October 7-9th, 2014.Testing consisted of triplicate 60-minute test runs for VOC, CO, NOx, and $CH_2O$. PM sampling consisted of triplicate 128-minute test runs.

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). 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

The sources tested are located at the GM Orion Assembly facility located in Lake Orion, Michigan. Testing on all sources was conducted October 7-9th, 2014.

### 1.b Purpose of Testing

The purpose of the testing is to demonstrate compliance with Michigan PTI 86-13.

### 1.c Source Description

General Motors LLC Orion Assembly Plant (GM) has been granted permit to install PTI 86-13 for five landfill gas engine generators to produce electricity at the plant.

Each engine generator is rated at 1600 kW electrical output (2242 hp). The total combined maximum electrical output will be 8000 kW or 8 MW. The maximum heat input capacity for each engine is approximately 15 MMBtu/hr. The heat capacity of landfill gas is estimated at 500 btu/scf.

GM's Orion Assembly Plant is located near two nonhazardous solid waste landfills and has access to the landfill gas. The engine generators are specifically designed to burn the landfill gas.

The combined exhaust from all five engine generators vents through the existing powerhouse stack located at the plant.

### 1.d Test Program Contact

The contact for information regarding the test program as well as the test report is:

Mr. Robert Fenn
Environmental Engineer
General Motors LLC
Orion Assembly
455 Giddings
Lake Orion, MI 48359
248 941 5353



Ms. Jessica Lilley
Environmental Engineer
General Motors LLC
Engineering Center
30200 Mound Rd – Bldg 1-11
Warren, MI 48090-9010
MC:480-111-1N
586 863 8490

### 1.e Test Personnel

Names and affiliations for personnel who were present during the testing program are summarized by Table 2.

**Table 2**
**Test Personnel**

| Name | Affiliation |
|---|---|
| Jessica Lilley | GM-WTC |
| Robert Fenn | GM-Orion |
| Lindsey Wells | PATI |
| Barry Boulianne | BTEC |
| Matthew Young | BTEC |
| Paul Draper | BTEC |
| Steve Smith | BTEC |
| Mark Dziadosz | MDEQ |
| Bob Byrnes | MDEQ |
| Melissa Byrnes | MDEQ |

## 2. Summary of Results

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

### 2.a Operating Data

Process and control equipment operating data relevant to the emissions test program is provided in Appendix A.

### 2.b Applicable Permit

The emission units tested at GM Orion are included in PTI 86-13.

### 2.c Results

The results of the emissions test program are summarized by Table 1. Detailed results are summarized in Tables 4-10.

### 2.d Emission Regulation Comparison

The Emission regulations are summarized by the following table.

**Table 3**
**PTI 86-13 Emission Limitations**

| Pollutant | Emission Limit (g/hp-hr) | Emission Limit (lb/hr) |
|---|---|---|
| VOC | 1.0 (g/hp-hr) | 2.8 lb/hr |
| NOx | 2.0 (g/hp-hr) | 2.97 lb/hr |
| CO | 3.5 (g/hp-hr) | 17.3 lb/hr |
| $PM_{10}$ | NA | 0.64 lb/hr |
| $PM_{2.5}$ | NA | 0.64 lb/hr |
| $CH_2O$ | NA | 2.1 lb/hr |

Limit applies to each engine in FGENGINES.

## 3. Source Description

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

### 3.a Process Description

Each engine generator is rated at 1600 kW electrical output (2242 hp). The total combined maximum electrical output will be 8000 kW or 8 MW. The maximum heat input capacity for each engine is approximately 15 MMBtu/hr. The heat capacity of landfill gas is estimated at 500 btu/scf.

GM's Orion Assembly Plant is located near two nonhazardous solid waste landfills and has access to the landfill gas. The engine generators are specifically designed to burn the landfill gas.

The combined exhaust from all five engine generators vents through the existing powerhouse stack located at the plant

### 3.b Process Flow Diagram

Due to the simplicity of the engine operations, a process flow diagram is not necessary.

### 3.c Raw and Finished Materials

The engine generators burn landfill gas and generate electrical output.

### 3.d Process Capacity

Each engine generator is rated at 1600 kW electrical output (2242 hp). The total combined maximum electrical output will be 8000 kW or 8 MW. The maximum heat input capacity for each engine is approximately 15 MMBtu/hr. The heat capacity of landfill gas is estimated at 500 btu/scf.

### 3.e Process Instrumentation

The kilowatt output and the landfill gas usage of each engine was monitored and recorded every 10 minutes for the duration of each test.

## 4. Sampling and Analytical Procedures

Sections 4.a through 4.d provide a summary of the sampling and analytical procedures used during the testing.

### 4.a Sampling Train and Field Procedures

Sampling and analytical methodologies for the emissions test program can be separated into five categories as follows:

(1) Measurement of exhaust gas velocity, molecular weight, and moisture content;
(2) Measurement of exhaust gas total PM concentration using USEPA Methods 5 and 202;
(3) Measurement of exhaust gas NOx and CO using USEPA Methods 7E and 10;
(4) Measurement of exhaust gas VOC concentration using USEPA Method 25A; and
(5) Meaurement of exhaust gas NOx, CO, VOC, and $CH_2O$ using USEPA Method 320.

Sampling and analytical methodologies by category are summarized below.

*Exhaust Gas Velocity, Molecular Weight, and Moisture Content*

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, Section 4.1.1, 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. A diagram of the sample points is provided in Figure 1.

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 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 3A. The $O_2/CO_2$ content of the gas stream was measured using a Servomex O2/CO2 analyzer.

Exhaust gas 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.

*Particulate Matter – Method 5/202*

40 CFR 60, Appendix A, Method 5, *"Determination of Particulate Emissions from Stationary Sources"* and 40 CFR 60, Appendix A, Method 202, *"Dry Impinger Method for Determining Condensable Particulate Emissions from Stationary Sources"* was used to measure PM concentrations and calculate PM emission rates (see Figure 2 for a schematic of the sampling train).

BTEC's Nutech® Model 2010 modular isokinetic stack sampling system consisted of (1) a Steel nozzle, (2) a glass probe, (3) a heated filter holder, (4) a vertical condenser, (5) an empty pot bellied impinger, (6) an empty modified Greenburg-Smith (GS) impinger, (7) unheated filter holder with a teflon filter, (8) a second modified GS impinger with 100 ml of deionized water, and a third modified GS impinger containing approximately 300 g of silica gel desiccant, (9) a length of sample line, and (10) a Nutech® control case equipped with a pump, dry gas meter, and calibrated orifice.

A sampling train leak test was conducted before and after each test run. After completion of the final leak test for each test run, the filter was recovered, and the nozzle and the front half of the filter holder assembly were brushed and triple rinsed with acetone. The acetone rinses were collected in a pre-cleaned sample container. The impinger train was then

purged with nitrogen for one hour at a flow rate of 14 liters per minute. The CPM filter was recovered and placed in a petri dish. The back half of the filter housing, the condenser, the pot bellied impinger, the moisture drop out impinger, and the front half of the CPM filter housing and all connecting glassware were triple rinsed with deionized water which was collected in a pre-cleaned sample container. The same glassware was then rinsed with acetone which was collected in a pre-cleaned sample container labeled as the organic fraction. The glassware was then double rinsed with hexane which was added to the same organic fraction sample bottle.

BTEC labeled each container with the test number, test location, and test date, and marked the level of liquid on the outside of the container. In addition, blank samples of the acetone, DI water, hexane, and filter were collected. BTEC personnel carried all samples to BTEC's laboratory (for filter and acetone gravimetric analysis) in Royal Oak, Michigan. Samples were transported to the Bureau Veritas laboratory in Novi, Michigan for Method 202 analysis by Bureau Veritas Analytics personnel.

### *NOx and Carbon Monoxide*

40 CFR 60, Appendix A, Method 7E, *"Determination of Nitrogen Oxides Emissions from Stationary Sources (Instrumental Analyzer Procedure)" and* 40 CFR 60, Appendix A, Method 10, *"Determination of Carbon Monoxide Emissions from Stationary Sources (Instrumental Analyzer Procedure)"* were used to measure NOx and CO concentrations and calculate emission rates (see Figure 5 for a schematic of the sampling train) on Engines 3-5.

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 analyzers. Data was recorded on a PC equipped with Labview® II data acquisition software. Recorded NOx and CO concentrations were averaged and reported for the duration of each test (as drift corrected per Method 7E). The analyzers were calibrated for a range of 0 to 100 ppm for NOx and 0-1000 ppm for CO.

In accordance with Method 7E, a 3-point (zero, mid, and high) calibration check was performed on each analyzer. Calibration drift checks were performed at the completion of each run.

### *Volatile Organic Compounds*

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 data

acquisition software. BTEC used a J.U.M 109 Methane/Nonmethane hydrocarbon analyzer to determine the VOC concentrations on Engines 3-5. (see figure 3 for a schematic of the sampling train.)

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. 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 analyzer was calibrated for a range of 0-1000 ppm for propane and 0-5000 ppm for methane.

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 day of testing.

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.

***FTIR***

40 CFR 60, Appendix A, Method 320, *"Measurement of Vapor Phase Organic and Inorganic Emissions by Extractive Fourier Transform Infrared (FTIR) technology"* was used to measure NOx, CO, and VOC concentrations on Engines 1 and 2, and $CH_2O$ concentrations on Engine 1 (see Figure 6 for a schematic of the sampling train).

FTIR data was collected using a MKS MultiGas 2030 FTIR spectrometer, serial number 017922822. The sampling system consisted of: 2 ft., 1/4 inch diameter, stainless steel probe; 100 ft., 3/8 inch diameter, Teflon heated transfer lines, maintained at 191°C; and a 0.01µ glass filter for particulate matter removal.

The FTIR was equipped with a temperature-controlled, 5.11 meter multipass gas cell maintained at 191°C. Gas flows and sampling system pressures were monitored using a rotometer and pressure transducer. All data were collected at 0.5 $cm^{-1}$ resolution. Each

spectrum was derived from the coaddition of 64 scans, with a new data point generated approximately every one minute.

Direct FTIR measurements of $N_2$, acetaldehyde, NO, CO and ethylene gas standards were made at each test location to confirm concentrations.

A calibration transfer standard (CTS), 100.5 ppm ethylene standard (Airgas Cylinder # SG9112651BAL), was analyzed before and after testing at each test location. The concentration determined for all CTS runs were within ± 5% of the certified value of the standard. The ethylene was passed through the entire system (system purge) to determine the sampling system response time and to ensure that the sampling system was leak-free at the stack location.

See the FTIR Report by Prism included in Appendix E for a more detailed explanation of the FTIR sampling train.

### 4.b Recovery and Analytical Procedures

Descriptions of the recovery procedures are provided in section 4.a for each sampling method.

### 4.c Sampling Ports

Diagrams of the stack showing sampling ports are included as Figure 1.

### 4.d Traverse Points

Diagrams of the stack showing traverse points are included as Figure 1.

## 5. Test Results and Discussion

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

### 5.a Results Tabulation

The overall results of the emissions test program are summarized by Table 1. Emission limits are summarized by Table 3. Detailed results for the emissions test program are summarized by Tables 4-10.

### 5.b Discussion of Results

The average results of the Testing Program are below the corresponding limits.

**Table 1**
**Overall Results Summary**
**Sampling Dates: October 7-9, 2014**

| Source | Pollutant | Average Test Result | | Emission Limit | |
|---|---|---|---|---|---|
| | | (g/bh-hr) | (lb/hr) | (g/bh-hr) | (lb/hr) |
| Engine 1 | PM | NA | 0.23 | NA | 0.64 |
| | $CH_2O$ | NA | 1.6 | NA | 2.1 |
| | NOx | 0.43 | 2.1 | 2.0 | 2.97 |
| | CO | 1.92 | 9.5 | 3.5 | 17.3 |
| | VOC | 0.08 | 0.4 | 1.0 | 2.8 |
| Engine 2 | NOx | 0.42 | 2.1 | 2.0 | 2.97 |
| | CO | 1.89 | 9.4 | 3.5 | 17.3 |
| | VOC | 0.08 | 0.4 | 1.0 | 2.8 |
| Engine 3 | NOx | .41 | 2.0 | 2.0 | 2.97 |
| | CO | 1.86 | 9.2 | 3.5 | 17.3 |
| | VOC | 0 | 0 | 1.0 | 2.8 |
| Engine 4 | NOx | 0.36 | 1.8 | 2.0 | 2.97 |
| | CO | 1.90 | 9.4 | 3.5 | 17.3 |
| | VOC | 0 | 0 | 1.0 | 2.8 |
| Engine 5 | NOx | 0.29 | 1.4 | 2.0 | 2.97 |
| | CO | 1.88 | 9.3 | 3.5 | 17.3 |
| | VOC | 0 | 0 | 1.0 | 2.8 |

### 5.c Sampling Procedure Variations

A spill during the first step of the extraction process resulted in a loss of about 90mL of the aqueous fraction on Run 3. The condensable fraction lab results of Run 3 should be considered biased low by approximately 20%, as shown in Table 5. The results for Run 3 have been corrected to account for this bias, and are shown in Table 4.

After the completion of run 2 on engine 4, BTEC CEMS sampling data was accidently lost due to a file saving error, therefore run 2 on engine 4 was voided. BTEC ran an additional test (Run 4) to account for the lost data. Handwritten data sheets for the voided run are available in Appendix B.

### 5.d Process or Control Device Upsets

No process or control device upsets occurred during the emissions test program.

### 5.e Control Device Maintenance

There was no control equipment maintenance performed during the emissions test program.

### 5.f Audit Sample Analyses

Audit samples were not analyzed as part of this emissions test program.

### 5.g Calibration Sheets

Calibration documents are provided as Appendix C.

### 5.h Sample Calculations

Sample calculations are provided as Appendix D.

### 5.i Field Data Sheets

Field data sheets are provided in Appendix B.

### 5.j Laboratory Data

Laboratory analytical data is provided in Appendix E.