BTEC Inc.

CO Capture Efficiency Emissions Test Summary Report

Prepared for:

General Motors Corporation

Detroit, Michigan

General Motors Powertrain Pontiac Dynamometer Lab Facility
895 Joslyn Road
Pontiac, Michigan

Project No. 15-4737.00
November 19, 2015

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

MICHIGAN DEPARTMENT OF ENVIRONMENTAL QUALITY
AIR QUALITY DIVISION

RENEWABLE OPERATING PERMIT
REPORT CERTIFICATION

Authorized by 1994 P.A. 451, as amended. Failure to provide this information may result in civil and/or criminal penalties.

Reports submitted pursuant to R 336.1213 (Rule 213), subrules (3)(c) and/or (4)(c), of Michigan's Renewable Operating Permit (ROP) program must be certified by a responsible official. Additional information regarding the reports and documentation listed below must be kept on file for at least 5 years, as specified in Rule 213(3)(b)(ii), and be made available to the Department of Environmental Quality, Air Quality Division upon request.

Source Name: General Motors LLC - Pontiac North Campus County: Oakland

Source Address: 895 Joslyn City: Pontiac, MI 48340

AQD Source ID (SRN): B4032 ROP No.: MI-ROP-B4032-2014 ROP Section No.: 2

Please check the appropriate box(es):

☐ **Annual Compliance Certification (Pursuant to Rule 213(4)(c))**

Reporting period (provide inclusive dates): From _____ To _____

☐ 1. During the entire reporting period, this source was in compliance with **ALL** terms and conditions contained in the ROP, each term and condition of which is identified and included by this reference. The method(s) used to determine compliance is/are the method(s) specified in the ROP.

☐ 2. During the entire reporting period this source was in compliance with all terms and conditions contained in the ROP, each term and condition of which is identified and included by this reference, **EXCEPT** for the deviations identified on the enclosed deviation report(s). The method used to determine compliance for each term and condition is the method specified in the ROP, unless otherwise indicated and described on the enclosed deviation report(s).

☐ **Semi-Annual (or More Frequent) Report Certification (Pursuant to Rule 213(3)(c))**

Reporting period (provide inclusive dates): From _____ To _____

☐ 1. During the entire reporting period, **ALL** monitoring and associated recordkeeping requirements in the ROP were met and no deviations from these requirements or any other terms or conditions occurred.

☐ 2. During the entire reporting period, all monitoring and associated recordkeeping requirements in the ROP were met and no deviations from these requirements or any other terms or conditions occurred, **EXCEPT** for the deviations identified on the enclosed deviation report(s).

☒ **Other Report Certification**

Reporting period (provide inclusive dates): From Nov. 19, 2015 To Nov. 19, 2015

Additional monitoring reports or other applicable documents required by the ROP are attached as described:

GM Pontiac CET is submitting the final capture efficiency test results as required by MI-ROP-B4032-2014. Enclosed is the final capture efficiency test report.

I certify that, based on information and belief formed after reasonable inquiry, the statements and information in this report and the supporting enclosures are true, accurate and complete

Rodney D Black	Director of Engineering Ops	248.857.2206
Name of Responsible Official (print or type)	Title	Phone Number

Signature of Responsible Official — Date: 19 Nov 2015

* Photocopy this form as needed.

EQP 5736 (Rev 11-04)

BTEC Inc.

EXECUTIVE SUMMARY

BT Environmental Consulting, Inc. (BTEC) was retained by General Motors LLC (GM) to conduct a compliance carbon monoxide (CO) capture efficiency (CE) test on two representative engine test cells at the GM Powertrain facility in Pontiac, Michigan. The CO CE test program was conducted on October 24th and 25th, 2015.

The purpose of the CE test program was to evaluate the CO capture efficiency of the engine test cell operations exhausting through seven representative emission points, identified as follows:

(1) D202 test cell engine exhaust;
(2) D204 test cell engine exhaust;
(3) D202 test cell room air exhaust;
(4) D204 test cell room air exhaust;
(5) D204 instrument bench exhaust;
(6) D204 PM bench exhaust;
(7) D202/D204 scavenge air exhaust.

Since only the D202 and D204 test cell engine exhaust points are routed to the thermal oxidizer, the CE of the two test cells is equal to the sum of CO emission rates from the D202 and D204 test cell engine exhausts divided by the sum of all CO emission points from the test cells. The below is a summary of the CE test results:

TEST RUN	CE Result (%)
1	99.65
2	99.77
3	99.79
Avg.	99.74

Table 2 summarizes the overall results of the emissions test program.

BTEC Inc.

1. Introduction

BT Environmental Consulting, Inc. (BTEC) was retained by General Motors LLC (GM) to conduct a compliance carbon monoxide (CO) capture efficiency (CE) test on two representative engine test cells at the GM Powertrain facility in Pontiac, Michigan. The CO CE test program was conducted on October 24th and 25th, 2015.

The purpose of the CE test program was to evaluate the CO capture efficiency (CE) of the engine test cell operations exhausting through seven representative emission points, identified as follows:

(1) D202 test cell engine exhaust;
(2) D204 test cell engine exhaust;
(3) D202 test cell room air exhaust;
(4) D204 test cell room air exhaust;
(5) D204 instrument bench exhaust;
(6) D204 PM bench exhaust;
(7) D202/D204 scavenge air exhaust.

Since only the D202 and D204 test cell engine exhaust points are routed to the thermal oxidizer, the CE of the two test cells is equal to the sum of CO emission rates from the D202 and D204 test cell engine exhausts divided by the sum of all CO emission points from the test cells. Testing at all emission points was simultaneous.

The purpose of this document is to present the results of the CE compliance 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). The following is a summary of the emissions report in the format suggested by the AQD test report format guide.

1.a Identification, Location, and Dates of Test

Engine test cells D202 and D204 were evaluated for CO CE using Methods 1, 2, 3, 4, 10, and 19 codified at Title 40, Part 60, Appendix A, of the Code of Federal Regulations (40 CFR 60, Appendix A). The engine test cells are located at the General Motors Powertrain Engineering Development Center. The CO CE testing was conducted on October 24th and 25th, 2015.

1.b Purpose of Testing

The objective of the test program was to determine the overall capture efficiency (CE) of carbon monoxide (CO) from the test cell operations.

1.c Source Description

The General Motors engine test cell facility was built to test internal combustion engines for research and development purposes using a wide variety of fuels and test protocols, many mandated by the U.S. EPA. The engines at the facility are fueled by unleaded gasoline, leaded gasoline, diesel, and other fuels. A variety of test cycles are used depending on the test program and type of engine. The facility is designed to include over 90 engine test cells.

Exhaust gases from the test cells are diverted to a main exhaust header which leads to the inlet of the regenerative thermal oxidizers (RTOs). RTOs 1 and 2 share one common inlet feed; similarly, RTOs 3 and 4 share common ductwork which leads to the inlet of these RTOs. Each RTO has individual exhaust stacks.

1.d Test Program Contact

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

Ms. Lisa M. Parks
Staff Environmental Engineer
General Motors LLC
Worldwide Facilities Group
30200 Mound Road, Bldg. 1-11
Mail Code: 480-111-1N
Warren, Michigan 48090
(248) 410-2591

Ms. Lauren Smith
Environmental Engineer
General Motors LLC
Pontiac Engineering Center
850 Glenwood
Mail Code: 483-710-106
Pontiac, Michigan 48340
(248) 836-8298

Mr. Barry P. Boulianne
Senior Project Manager
BT Environmental Consulting, Inc.
4949 Fernlee Avenue
Royal Oak, MI 48073
313-449-2361

1.e Test Personnel

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

Table 1
Test Personnel

Name and Title	Affiliation	Telephone
Ms. Lisa Parks Staff Environmental Engineer	General Motors LLC Global Environmental Compliance and Sustainability Group 30200 Mound Road Warren, Michigan 48090	(248) 410-2591
Ms. Lauren Smith Environmental Engineer	General Motors LLC Pontiac Engineering Center 850 Glenwood Mail Code: 483-710-106 Pontiac, Michigan 48340	(248) 836-8298
Mr. Mark Womack	General Motors LLC Pontiac Engineering Center 850 Glenwood Mail Code: 483-710-106 Pontiac, Michigan 48340	(248) 563-6739
Mr. Matt Young Project Manager	BTEC 4949 Fernlee Royal Oak, MI 48073	(248) 548-8070
Mr. Shane Rabideau Environmental Technician	BTEC 4949 Fernlee Royal Oak, MI 48073	(248) 548-8070
Mr. Paul Molenda Environmental Technician	BTEC 4949 Fernlee Royal Oak, MI 48073	(248) 548-8070
Mr. Todd Wessel	BTEC 4949 Fernlee Royal Oak, MI 48073	(248) 548-8070
Mr. Steve Smith	BTEC 4949 Fernlee Royal Oak, MI 48073	(248) 548-8070
Mr. Tom Maza	MDEQ Air Quality Division	(313) 456-4709
Ms. Joyce Zhu	MDEQ Air Quality Division	(586) 753-3748

2. Summary of Results

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

2.a Operating Data

Test Cell D202 was operating a 2.0L turbocharged in-line (4) cylinder engine running through a typical validation test. Test Cell D204 was operating a 1.4L turbocharged in-line (4) cylinder engine running through a typical developmental test cycle. The three emission test runs were a minimum of 180 minutes in duration and data from the test cell room CO monitors was recorded for the purpose of attempting to correlate test cell room CO monitor data with system capture efficiency. Test cell engine operating data for the emissions test program is included in Appendix D.

2.b Applicable Permit

The engine test cells are covered by MI-ROP-B4032-2014.

2.c Results

The overall results of the CO CE test program are summarized in Table 2. Detailed flowrate and CO concentration test results are included in Appendix A.

2.d Emission Regulation Comparison

The site is operated under permit MI-ROP-B4032-2014 which is designed to include over 90 test cells designated as FG-TESTCELLMACT for the collection of all equipment and activities associated with the engine test cells/stands. The test cells are controlled by four natural gas-fired regenerative thermal oxidizers (RTOs) and the following permit conditions apply:

- Limits CO or THC to 20 ppmvd or 96 recent reduction in emissions

The objective of the test program was to determine the overall capture efficiency (CE) of carbon monoxide (CO) from the test cell operations.

3. Source Description

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

3.a Process Description

The General Motors engine test cell facility was built to test internal combustion engines for research and development purposes using a wide variety of fuels and test protocols, many mandated by the U.S. EPA. The engines at the facility are fueled by unleaded gasoline, leaded gasoline, diesel, and other fuels. A variety of test cycles are used

depending on the test program and type of engine. The facility is designed to include over 90 engine test cells.

Exhaust gases from the test cells are diverted to a main exhaust header which leads to the inlet of the regenerative thermal oxidizers (RTOs). RTOs 1 and 2 share one common inlet feed; similarly, RTOs 3 and 4 share common ductwork which leads to the inlet of these RTOs. Each RTO has individual exhaust stacks.

3.b Process Flow Diagram

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

3.c Raw and Finished Materials

The relevant raw material included in this emissions test program was gasoline. Engine fuel flowrate data is included in Appendix D. A sample of the gasoline was collected and submitted for ultimate analysis as well as heating value and density. The results of this analysis are included in Appendix E.

3.d Process Capacity

FG-TESTCELLMACT limits CO or THC to 20 ppmvd or 96 recent reduction in emissions. Each RTO is rated at 27,000 scfm.

3.e Process Instrumentation

Engine operating data is included in Appendix D.

4. Sampling and Analytical Procedures

Sections 4.a through 4.d provide a summary of the sampling procedures used to evaluate CO emission rates at the seven sampling points.

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 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 10 - "Determination of Carbon Monoxide Emissions from Stationary Sources"
- Method 19 - "Determination of Sulfur Dioxide Removal Efficiency and Particulate Matter, Sulfur Dioxide, and Nitrogen Oxide Emission Rates"

The CO content of the exhaust gas was evaluated according to procedures outlined in 40 CFR 60, Appendix A, Method 10, *"Determination of Carbon Monoxide Emissions from Stationary Sources."* 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 electronic sample conditioner to remove the moisture from the sample before it entered the CO analyzer. Data was recorded on a PC equipped with PDaqview® data acquisition software.

Exhaust gas flowrates at the seven emission points were evaluated according to one of three different methodologies as summarized by Table 3. In general, the flowrate of exhaust gas from the engines was calculated using the engine fuel flowrate, the exhaust gas oxygen content (as measured by Method 3A), and the ultimate analysis and gross heating value of the fuel. The flowrate of exhaust gas from the two room air exhausts and the scavenge air exhaust was measured using Methods 1 through 4. The exhaust gas flowrate from the Instrument (i.e., emissions test) Bench and the PM Bench was measured using a rotameter and a dry gas meter in conjunction with a rotameter, respectively.

4.b Recovery and Analytical Procedures

The CE test program did not include the collection of samples.

4.c Sampling Ports

Sampling port locations met the minimum criteria of Method 1.

4.d Traverse Points

Exhaust duct traverse point locations are summarized by Figures 1, 2, and 3.

5. Test Results and Discussion

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

5.a Results Tabulation

The results of the emissions test program are summarized in Table 2. Detailed flowrate and CO concentration results are included in Appendix A and Appendix B. Field Data and

Field Notes are available in Appendix A. Analyzer raw data is provided in electronic form in Appendix D.

5.b Discussion of Results

The objective of the test program was to determine the overall capture efficiency (CE) of carbon monoxide (CO) from the test cell operations.

5.c Sampling Procedure Variations

The CO concentration leaving the D204 Instrument Bench should be the same as that in the D204 engine exhaust, the CO concentration in the D204 Instrument Bench exhaust is assumed to be the same as that in the D204 engine exhaust.

5.d Process or Control Device Upsets

No upset conditions occurred during testing.

5.e Control Device Maintenance

The emissions test program did not include the evaluation of control device performance.

5.f Re-Test Changes

The CO emissions test program was not a re-test.

5.g Audit Sample Analyses

Audit samples were not relevant for this emissions test program.

5.h Calibration Sheets

Included in Appendix B are certificates of analysis for the calibration gases used in this CE test program and calibration data for the gas dilution system used in this CE test program.

5.i Sample Calculations

Sample calculations are provided as Appendix C.

5.j Field Data Sheets

Copies of field data sheets and relevant field notes are provided in Appendix A.

5.k Laboratory Data

Fuel analytical results are summarized in Appendix E.

Table 1
Test Personnel

Name	Affiliation
Lisa Parks	GM
Lauren Smith	GM
Mark Womack	GM
Todd Wessel	BTEC
Matthew Young	BTEC
Steve Smith	BTEC
Shane Rabideau	BTEC
Paul Molenda	BTEC
Tom Maza	MDEQ
Joyce Zhu	MDEQ

Table 2
Overall Results Summary
GM Pontiac Powertrain
D202 and D204 Test Cell CO Capture Efficiency Testing
Test Dates: October 24-25, 2015

Test Run	Run Date	Run Time	D202 Room Air Exhaust Gas Flowrate (dscfm)	D204 Room Air Exhaust Gas Flowrate (dscfm)	Scavenge Air Exhaust Gas Flowrate (dscfm)	Analyzer Bench Exhaust Gas Flowrate (scfm)	PM Sampler Exhaust Gas Flowrate (scfm)	D202 Room Air CO Concentration (ppmvd)	D204 Room Air CO Concentration (ppmvd)	Scavenge Air CO Concentration (ppmvd)	Analyzer Bench CO Concentration (from D204 Exhaust) (ppmvd)	Toxic Air Vent/ PM Sampler CO Concentration (ppmvd)	D202 Room Air CO Emission Rate (lbs/hr)	D204 Room Air CO Emission Rate (lbs/hr)	Scavenge Air CO Emission Rate (lbs/hr)	Toxic Air Vent CO Emission Rate (lbs/hr)	D202 CO Emission Rate (lbs/hr)	D204 CO Emission Rate (lbs/hr)	Overall CE (%)
1	10/24/2015	11:31-12:01, 12:34-14:59, 15:17-15:23	15,102	15,007	3,375	0.33	0.82	4.59	0.18	1.35	1736.61	122.9	0.30	0.01	0.02	0.00	91.49	0.19	99.64
2	10/24/2015	16:26-19:37	14,830	13,838	3,206	0.33	0.80	5.11	0.00	1.1	1505.6	132.8	0.20	0.00	0.02	0.00	93.01	0.19	99.77
3	10/25/2015	8:00-11:09	15,111	15,021	3,487	0.33	0.80	2.76	0.03	1.04	2087.17	207.13	0.18	0.00	0.02	0.00	97.35	0.25	99.79

Notes:

(1) Emissions from the Toxic Vent are approximated as the sum of the constant flowrate through the analyzer bench (as measured by rotameter) times the CO concentration measured in the D204 engine exhaust (i.e., assuming the CO concentration in the exhaus analyzers is the same as in the engine exhaust plus the flowrate through the PM sampler (as measured by GM) times the CO concentration in the PM sampler exhaust measured by BTEC.

Table 3
Exhaust Gas Flowrate Measurement Methodologies

Emission Point	Flowrate Measurement Methodology
D202 Test Cell Engine Exhaust	1. Method 19, Equation 19-1 2. Fuel Sample to Determine F-Factor (Equation 19-13) 3. Fuel Sample for Gross Heating Value
D204 Test Cell Engine Exhaust	
D202 Test Cell Room Air Exhaust	1. Methods 1-4
D204 Test Cell Room Air Exhaust	
D204 Instrument Bench Exhaust	1. Measure inlet flowrate using a Rotameter or an electronic flowrate measurement device
D204 PM Bench Exhaust	
D202/D204 Scavenge Air Exhaust	1. Methods 1-4

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Stack Dimensions:

Depth:	36	inches
Width:	36	inches

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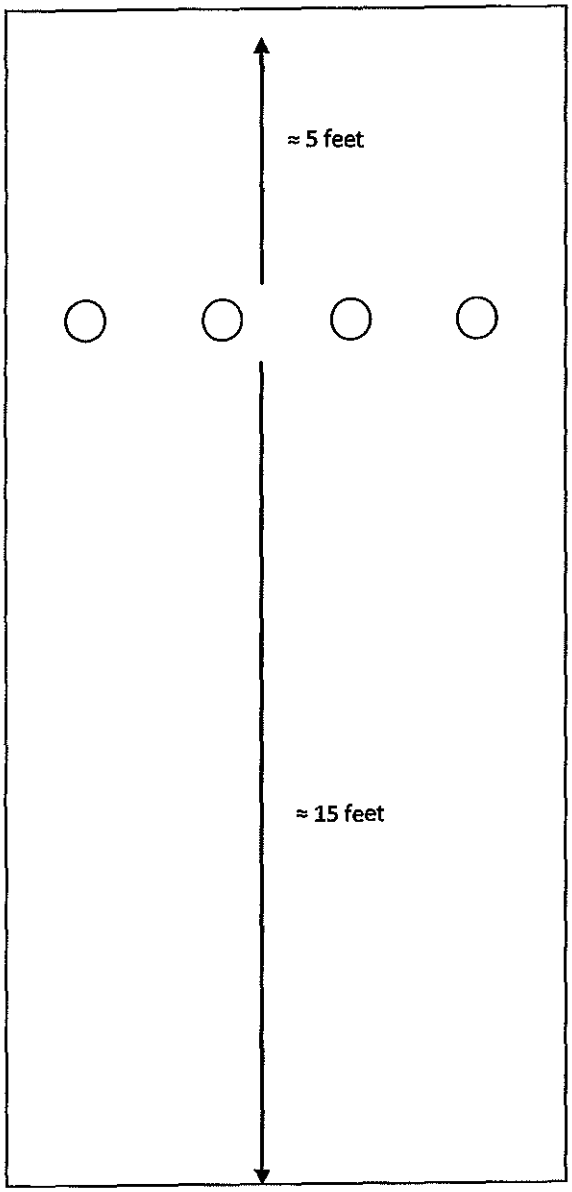
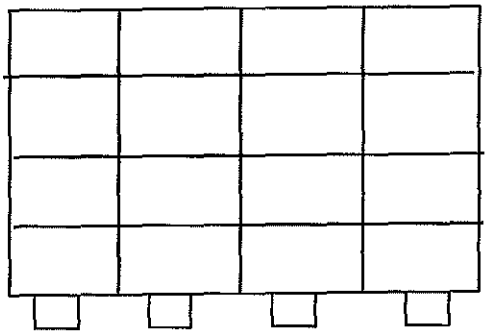




Not to Scale

Points	Distance "
1	4.5
2	13.5
3	22.5
4	31.5

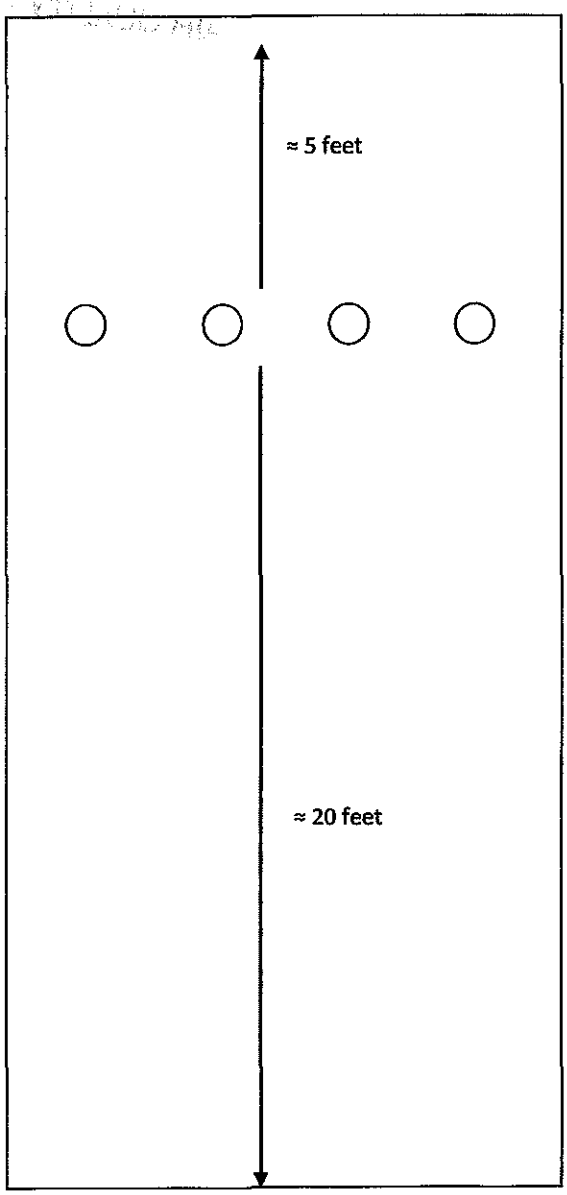
Figure No. 1

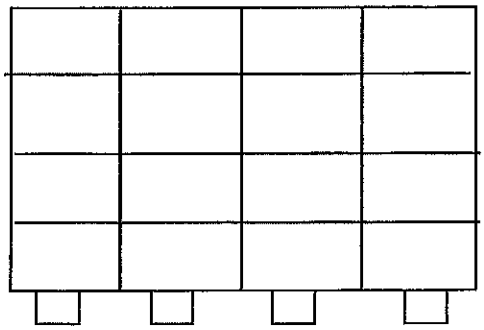
Site: **D202 Room Exhaust** **GM Pontiac Dyno** **Pontiac, MI**	**Sampling Date:** **October 24 & 25, 2015**	**BT Environmental Consulting, Inc.** **4949 Fernlee Avenue** **Royal Oak, Michigan 48073**

BTEC Inc.

Stack Dimensions:

Depth:	36	inches
Width:	36	inches





Not to Scale

Points	Distance "
1	4.5
2	13.5
3	22.5
4	31.5

Figure No. 2

Site:
D204 Room Exhaust
GM Pontiac Dyno
Pontiac, MI

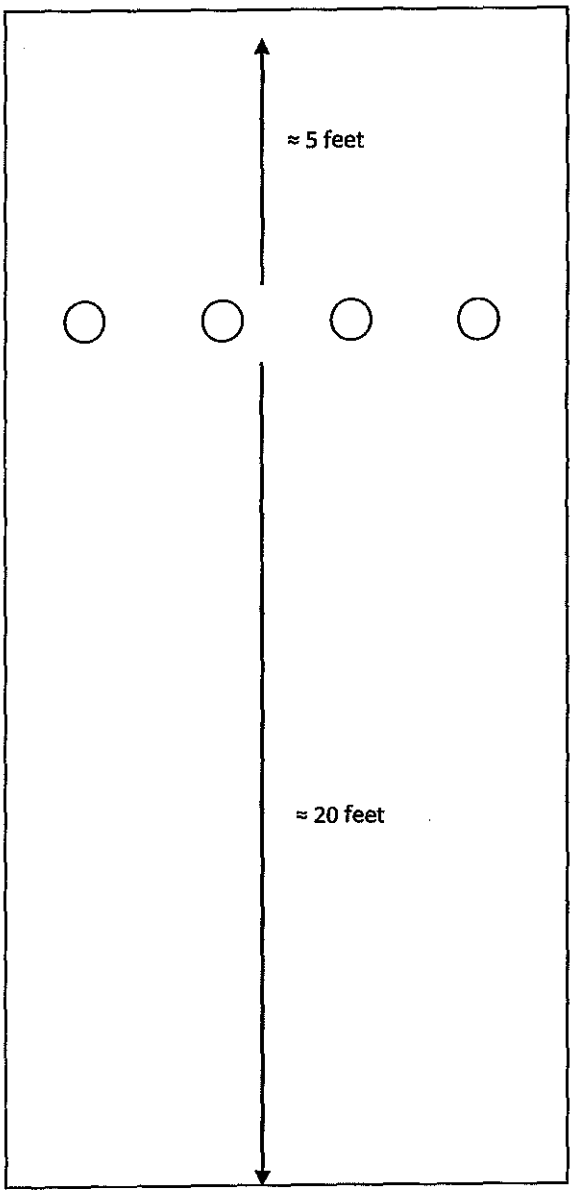
Sampling Date:
October 24 & 25, 2015

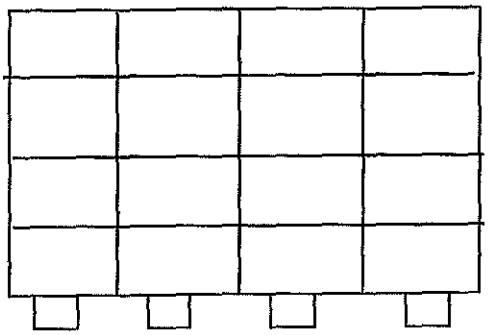
BT Environmental Consulting, Inc.
4949 Fernlee Avenue
Royal Oak, Michigan 48073

BTEC Inc.

Stack Dimensions:

Depth:	24	inches
Width:	20	inches





Not to Scale

Points	Distance "
1	3.0
2	9.0
3	15.0
4	21.0

Figure No. 3

Site: **Scavenge Air Exhaust** **GM Pontiac Dyno** **Pontiac, MI**	**Sampling Date:** **October 24 & 25, 2015**	**BT Environmental Consulting, Inc.** **4949 Fernlee Avenue** **Royal Oak, Michigan 48073**

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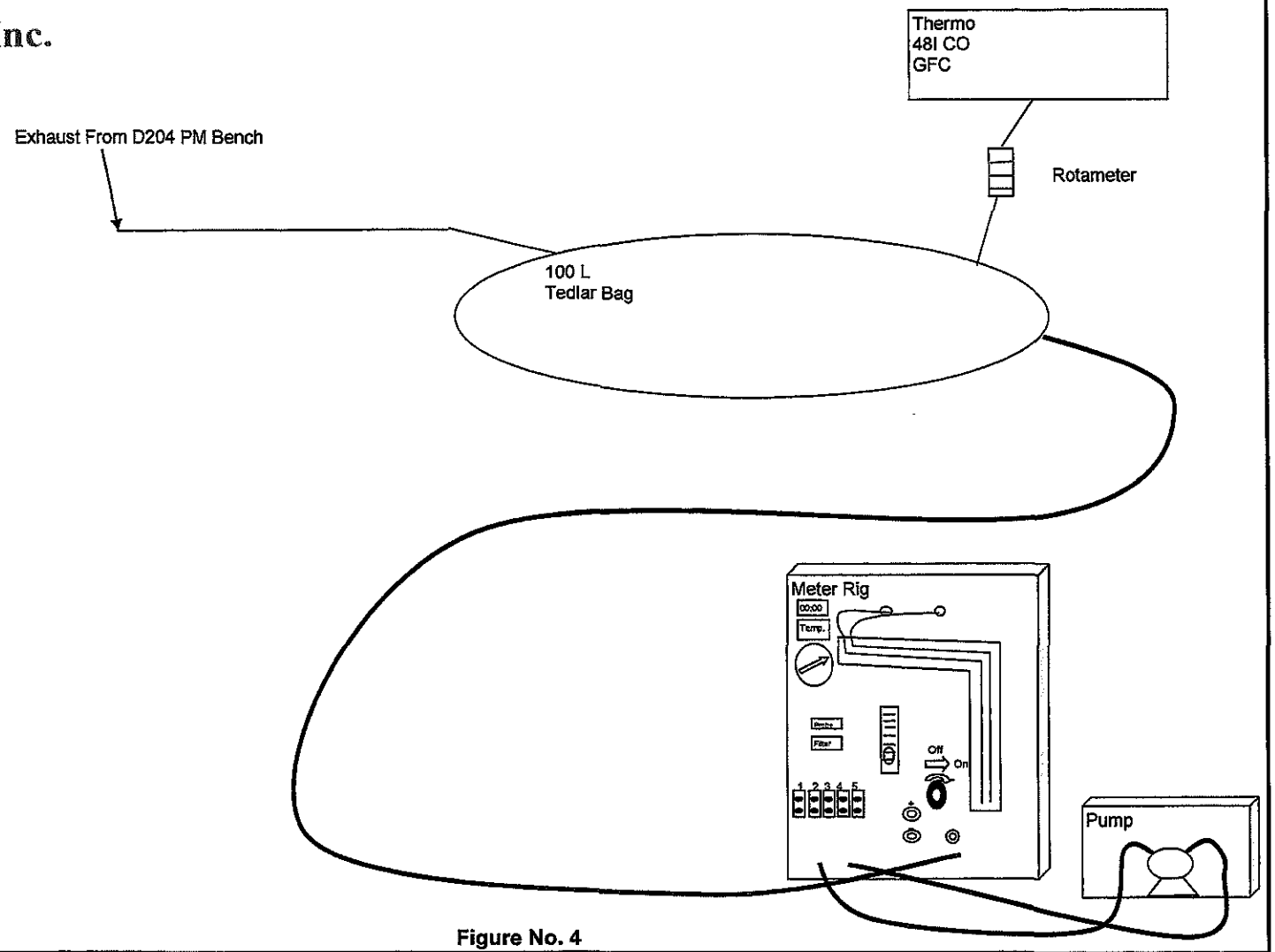

Figure No. 4

Site: **PM Bench Exhaust Sampler** **GM Pontiac Dyno** **Pontiac, MI**	**Sampling Date:** **October 24 & 25, 2015**	**BT Environmental Consulting, Inc.** **4949 Fernlee Avenue** **Royal Oak, Michigan 48073**

BTEC Inc.

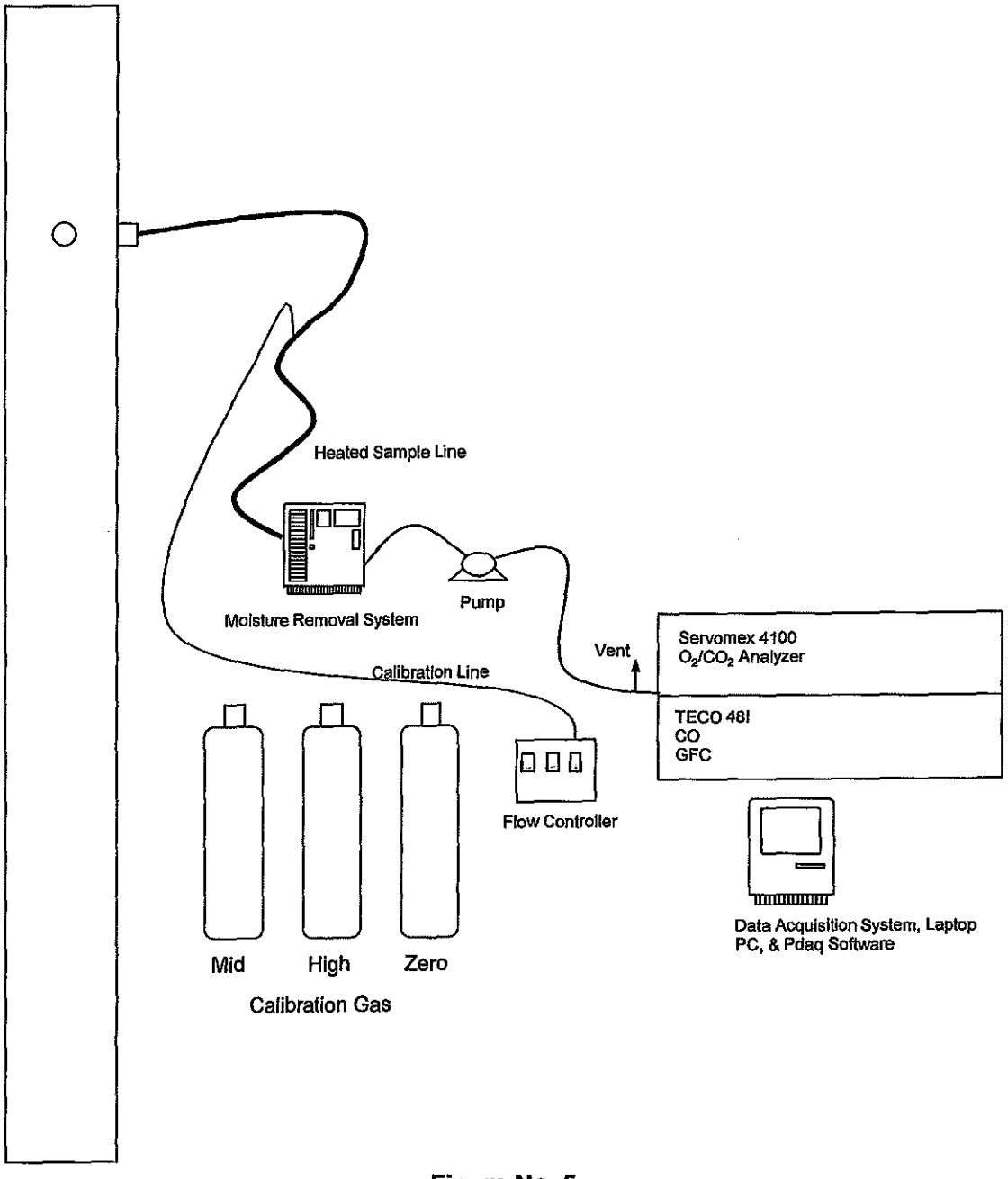

Figure No. 5

Site:	Sampling Date:	
USEPA Method 3A, and 10 GM Pontiac Dyno Pontiac, MI	October 24 & 25, 2015	BT Environmental Consulting Inc. 4949 Fernlee Avenue Royal Oak, MI 48073