Source Test Report for 2022 Carbon Monoxide Emission Testing Volatile Organic Compound And Carbon Monoxide Removal Efficiency Testing KAWASAKI MOTORS CORP USA

Pressure Control Oxidizer and Uncontrolled FG-Test Cell Exhaust

Prepared For:

Kawasaki Motors Corporation USA
5080 36th Street Southeast
Grand Rapids, MI 49525

For Submittal To:

Michigan Department of Environment, Great Lakes, and Energy
525 West Allegan Street
Lansing, MI 48933

Prepared By:

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STAC STACK TESTING ACCREDITATION COUNCIL

A2LA ACCREDITED TO ASTM D7036 ONLY CERT #3925.01

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Review and Certification

All work, calculations, and other activities and tasks performed and presented in this document were carried out by me or under my direction and supervision. I hereby certify that, to the best of my knowledge, Montrose operated in conformance with the requirements of the Montrose Quality Management System and ASTM D7036-04 during this test project. I have reviewed, technically and editorially, details, calculations, results, conclusions, and other appropriate written materials contained herein. I hereby certify that, to the best of my knowledge, the presented material is authentic, accurate, and conforms to the requirements of the Montrose Quality Management System and ASTM D7036-04.

Signature: _____ **Date:** 1/11/2023

Name: John Nestor **Title:** District Manager

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1.0 Introduction

1.1 Summary of Test Program

Kawasaki Motors Corporation (Kawasaki) contracted Montrose Air Quality Services, LLC (Montrose) to perform a compliance emission test program on the performance dynamo test cells, performance atmospheric chamber test cell, and endurance test cell Pressure Control Oxidizer exhaust (State Registration No.: P0677) located in Grand Rapids, Michigan. Testing was performed on September 19, 2022, for the purpose of satisfying the emission testing requirements pursuant to Michigan Department of Environment, Great Lakes, and Energy (EGLE) Permit to Install (PTI) 67-22.

The specific objectives were to:

- Verify the emissions of carbon dioxide (CO) from the stack (SV-EF5C) serving performance dynamo test cells, stack (SV-EF5D) serving the performance atmospheric chamber test cells, and Stack (SV-EF5A) serving the endurance test cells controlled by the pressure control oxidizer.
- Verify the removal efficiency (RE) of CO and volatile organic compounds (VOCs) for the endurance test cells controlled by the PCO.
- Conduct the test program with a focus on safety

Montrose performed the tests to measure the emission parameters listed in Table 1-1.

Table 1-1
Summary of Test Program

Test Date(s)	Unit ID/ Source Name	Activity/ Parameters	Test Methods	No. of Runs	Duration (Minutes)
9/19/2022	Performance Test Cell Exhaust Stack (SV-EF5C)	O_2/CO_2	EPA 3	3	5
		Flow	EPA 2	3	5-10
		H_2O	EPA 4	3	60
		CO	EPA 10	3	60
9/19/2022	Atmospheric Performance Test Cell Exhaust Stack (SV-EF5D)	O_2/CO_2	EPA 3	3	5
		Flow	EPA 2	3	5-10
		H_2O	EPA 4	3	60
		CO	EPA 10	3	60
9/19/2022	Endurance Cell PCO inlet and PCO Outlet Exhaust Stack (SV-EF5A)	O_2/CO_2	EPA 3	3	5
		Flow	EPA 2	3	5-10
		H_2O	EPA 4	3	60
		CO	EPA 10	3	60
		VOC	EPA 25a	3	60

To simplify this report, a list of Units and Abbreviations is included in Appendix C.1. Throughout this report, chemical nomenclature, acronyms, and reporting units are not defined. Please refer to the list for specific details.

This report presents the test results and supporting data, descriptions of the testing procedures, descriptions of the facility and sampling locations, and a summary of the quality assurance procedures used by Montrose. The average emission test results are summarized and compared to their respective permit limits in Table 1-2. Detailed results for individual test runs can be found in Section 4.0. All supporting data can be found in the appendices.

The testing was conducted by the Montrose personnel listed in Table 1-3. The tests were conducted according to the test plan (protocol) dated July 21, 2022, that was submitted to and approved by the EGLE.

Table 1-2
Summary of Average Compliance Results – SV-EF5C Performance Cell Stack

September 19, 2022

Parameter/Units	Average Results	Emission Limits
Carbon Monoxide (CO)		
lb/hr	14.8	NA
lb/gal	4.71	6.57 lb/gal

Table 1-3
Summary of Average Compliance Results – SV-EF5D Atmospheric Performance Cell Exhaust

September 19, 2022

Parameter/Units	Average Results	Emission Limits
Carbon Monoxide (CO)		
lb/hr	15.4	NA
lb/gal	4.87	6.57 lb/gal

Table 1-4
Summary of Average Compliance Results – SV-EF5A Endurance Cell Exhaust controlled by PCO.

September 19, 2022

Parameter/Units	Average Results	Emission Limits
Carbon Monoxide (CO)		
lb/hr	1.8	NA
lb/gal	0.61	6.57 lb/gal
Removal Efficiency	91%	90%
Volatile Organic Compounds (VOC)		
lb/hr	0.01	NA
Removal Efficiency	98%	95%

1.2 Key Personnel

A list of project participants is included below:

Facility Information

Source Location: Kawasaki Motor Corporation
Engines Division
5080 36th Street SE
Grand Rapids, MI 49512
Project Contact: Paul Marvin
Role: Regulatory Compliance Engineer
Telephone: 616-954-3016
Email: Paul.Marvin@kmc-usa.com

Testing Company Information

Testing Firm: Montrose Air Quality Services, LLC
Contact: John Nestor
Title: District Manager
Telephone: 248-765-5032
Email: jonestor@montrose-env.com

Test personnel and observers are summarized in Table 1-3.

Table 1-3
Test Personnel and Observers

Name	Affiliation	Role/Responsibility
John Nestor	Montrose	District Manager, QI
David Koponen	Montrose	Field Technician
Roy Zimmer	Montrose	Field Technician
Paul Marvin	Kawasaki Motors Corporation	Test Coordinator

2.0 Plant and Sampling Location Descriptions

2.1 Process Description, Operation, and Control Equipment

Kawasaki Motors Corporation operates twenty test cells where engines of up to 50 horse power are placed on dynamos to guarantee that parts meet performance specifications. Durability test cells (EU-TEST1 through EU-TEST9) are all equipped with a pressure control oxidizer for CO and VOC removal. The PCO temperature was operated at a minimum of 650 °F in accordance with the PTI. The remaining performance cells are uncontrolled.

2.2 Flue Gas Sampling Location

Information regarding the sampling location is presented in Table 2-1.

Table 2-1
Sampling Location

Sampling Location	Stack Inside Diameter (in.)	Number of Traverse Points
Performance Cell Exhaust Stack SV-EF5C	16.0	Gaseous: 3 Flow: 16
Atmospheric Performance Cell Exhaust Stack SV-EF5D	16.0	Gaseous: 3 Flow: 16
Endurance Cell Exhaust Stack SV-EF5VA	6.0	Gaseous: 3 Flow: 16

See Appendix A.1 for more information.

2.3 Operating Conditions and Process Data

Engines with a maximum rated displacement volume were chosen for this test. These engines were operated at wide open throttle (WOT) conditions to demonstrate worst case

conditions for the emission units. Plant personnel were responsible for establishing the test conditions and collecting all applicable unit-operating data. The process data that was provided is presented in Appendix B. Data collected includes the following parameters:

- Test Cell Air Conditions
- Torque
- Speed
- Engine temperatures
- Throttle opening percentage
- Gasoline Consumption in gallons per hour

3.0 Sampling and Analytical Procedures

3.1 Test Methods

The test methods for this test program have been presented in Table 1-1. Additional information regarding specific applications or modifications to standard procedures is presented below.

3.1.1 EPA Method 1, Sample and Velocity Traverses for Stationary Sources

EPA Method 1 is used to assure that representative measurements of volumetric flow rate are obtained by dividing the cross-section of the stack or duct into equal areas, and then locating a traverse point within each of the equal areas. Acceptable sample locations must be located at least two stack or duct equivalent diameters downstream from a flow disturbance and one-half equivalent diameter upstream from a flow disturbance.

The sample port and traverse point locations are detailed in Appendix A.

3.1.2 EPA Method 2, Determination of Stack Gas Velocity and Volumetric Flow Rate (Type S Pitot Tube)

EPA Method 2 is used to measure the gas velocity using an S-type pitot tube connected to a pressure measurement device, and to measure the gas temperature using a calibrated thermocouple connected to a thermocouple indicator. Typically, Type S (Staußcheibe) pitot tubes conforming to the geometric specifications in the test method are used, along with an inclined manometer. The measurements are made at traverse points specified by EPA Method 1.

3.1.3 EPA Method 3, Gas Analysis for the Determination of Dry Molecular Weight

EPA Method 3 is used to calculate the dry molecular weight of the stack gas using one of three methods. The first choice is to measure the percent O_2 and CO_2 in the gas stream. A gas sample is extracted from a stack by one of the following methods: (1) single-point, grab sampling; (2) single-point, integrated sampling; or (3) multi-point, integrated sampling.

The gas sample is analyzed for percent CO_2 and percent O_2 using either an Orsat or a Fyrite analyzer. The second choice is to use stoichiometric calculations to calculate dry molecular weight. The third choice is to use an assigned value of 30.0, in lieu of actual measurements, for processes burning natural gas, coal, or oil.

3.1.4 EPA Method 4, Determination of Moisture Content in Stack Gas

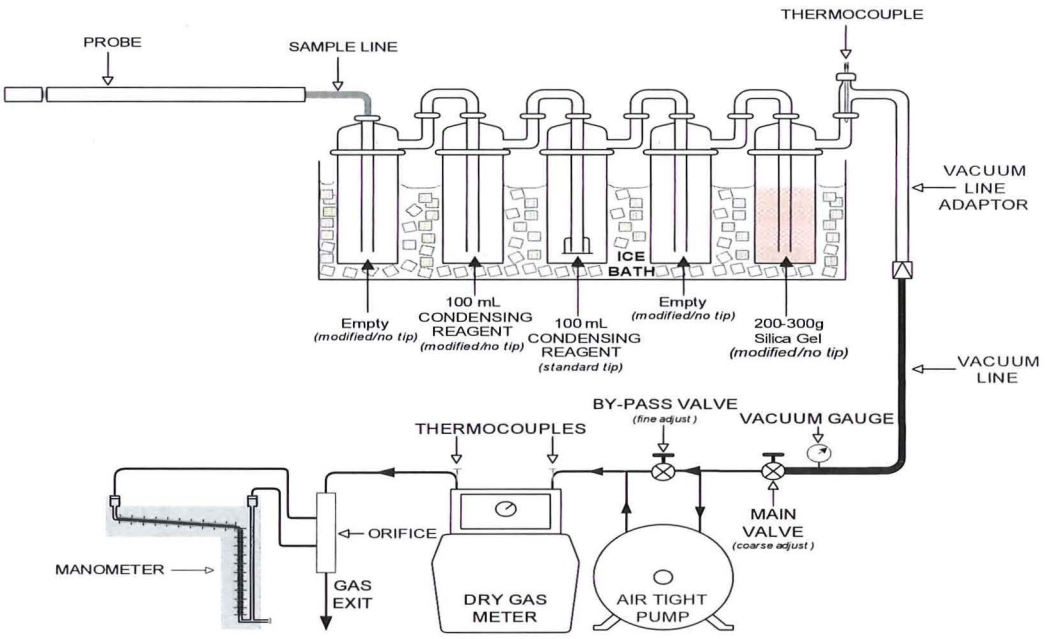
EPA Method 4 is a manual, non-isokinetic method used to measure the moisture content of gas streams. Gas is sampled at a constant sampling rate through a probe and impinger train. Moisture is removed using a series of pre-weighed impingers containing methodology-specific liquids and silica gel immersed in an ice water bath. The impingers are weighed after each run to determine the percent moisture.

Pertinent information regarding the performance of the method is presented below:

- Method Options:
  - Condensed water is measured gravimetrically
- Method Exceptions:
  - Moisture sampling is performed as a stand-alone method at a single point in the centroid of the stack

The typical sampling system is detailed in Figure 3-1.

FIGURE 3-1 EPA METHOD 4 (DETACHED) SAMPLING TRAIN

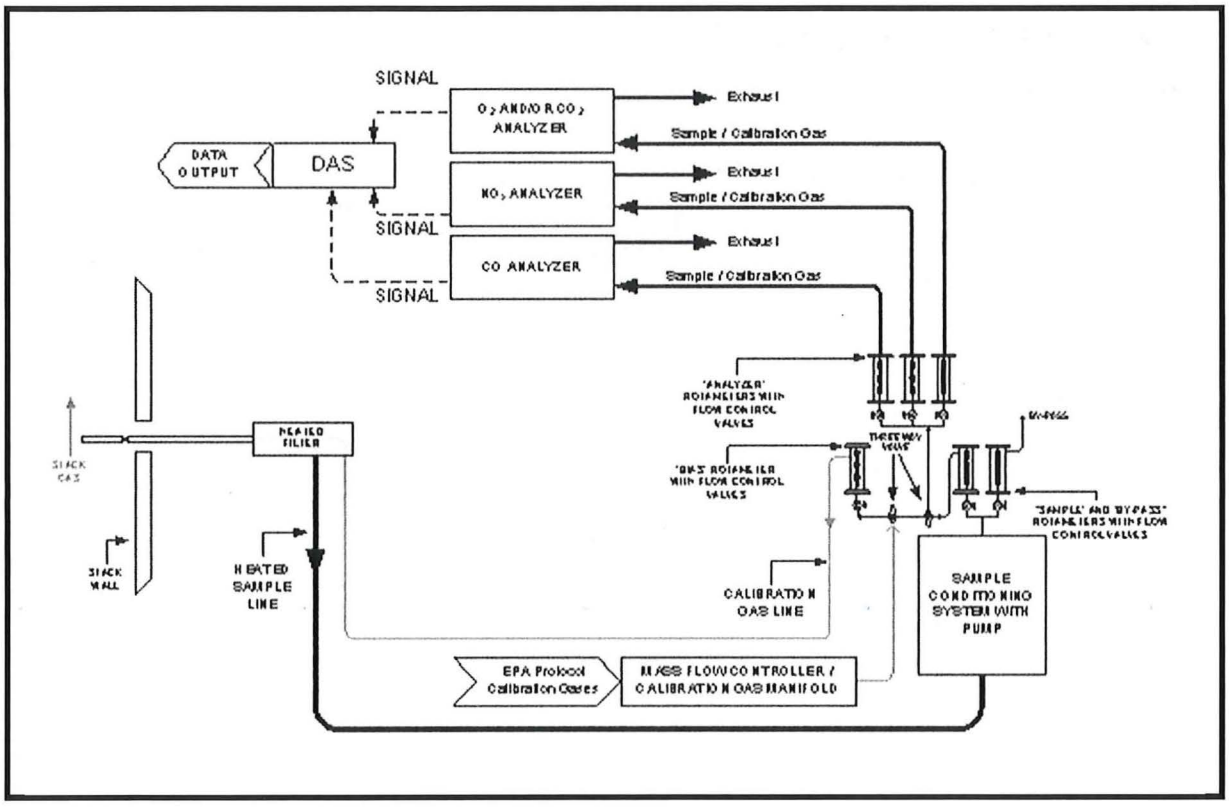


3.1.5 EPA Method 10, Determination of Carbon Monoxide Emissions from Stationary Sources (Instrumental Analyzer Procedure)

EPA Method 10 is an instrumental test method used to continuously measure emissions of CO. Conditioned gas is sent to an analyzer to measure the concentration of CO. The performance requirements of the method must be met to validate the data.

The typical sampling system is detailed in Figure 3-2.

Figure 3-2
EPA Method 10 Carbon Monoxide Sampling Train

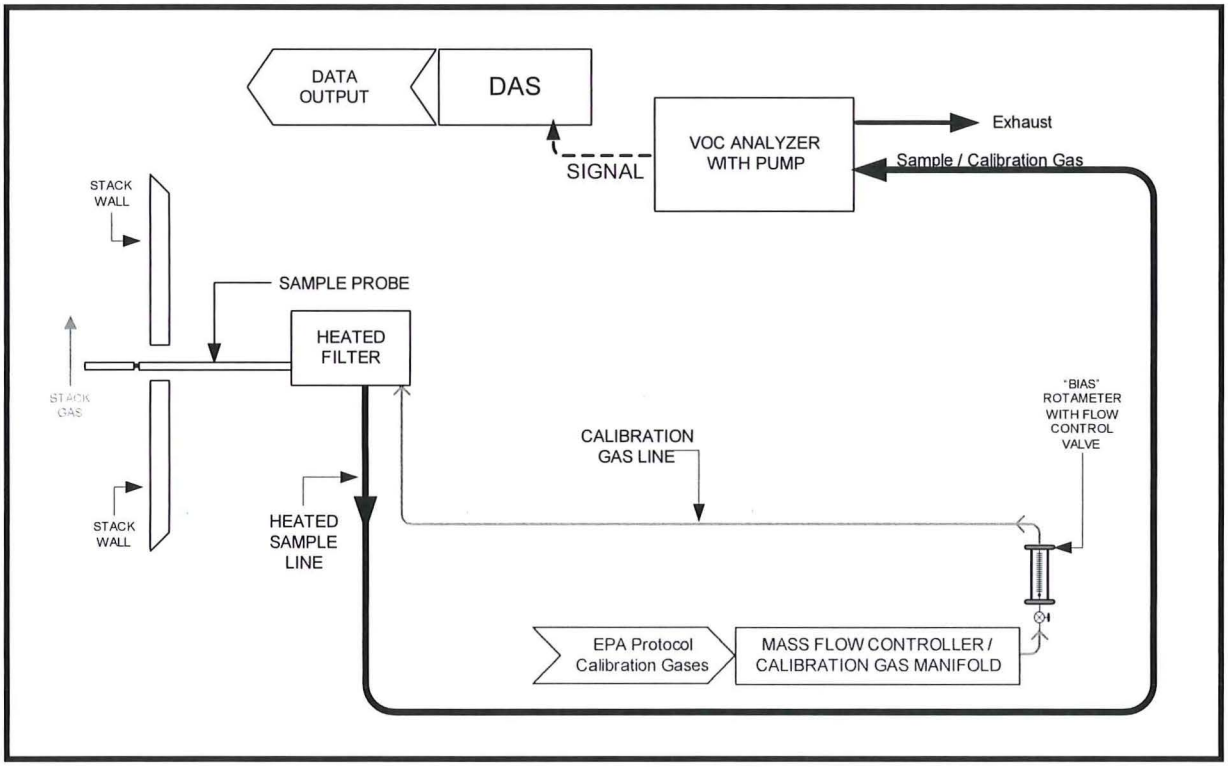


3.1.6 EPA Method 25A, Verification of Gas Dilutions Systems for Field Instrument Calibrations

EPA Method 25A is an instrumental test method used to measure the concentration of THC in stack gas. A gas sample is extracted from the source through a heated sample line and glass fiber filter to an FIA. Results are reported as volume concentration equivalents of the calibration gas or as carbon equivalents.

The typical sampling system is detailed in Figure 3-3.

Figure 3-3
EPA Method 25A Sampling Train



3.1.7 EPA Method 205, Verification of Gas Dilutions Systems for Field Instrument Calibrations

The EPA Method 205 is used to accurately dilute high-level EPA Protocol 1 calibration gases to intermediate levels for use when calibrating instrumental analyzers. A calibrated gas dilution system is used for these dilutions. The gas dilution system is recalibrated once per calendar year using NIST-traceable primary flow standards with an uncertainty ≤ 0.25 percent. A field evaluation is also performed to verify the dilution ratios for each project. To

perform the field evaluation, two diluted standards are prepared using the high-level supply gas. The diluted gas is alternately introduced in triplicate to a pre-calibrated analyzer, the average instrument response is calculated, and the average predicted concentration is calculated using the dilution ratios. No single injection should differ by more than ± 2% from the average instrument response for that dilution. For each level of dilution, the difference between the average concentration output recorded by the analyzer and the predicted concentration is calculated. The average concentration output from the analyzer should be within ± 2% of the predicted value. Next, a mid-level supply gas is injected three different times directly into the analyzer while bypassing the dilution system. The average analyzer output is calculated. The difference between the certified concentration of the mid-level supply gas and the average instrument response should be within ± 2%. If the gas dilution system meets the criteria listed above, it may be used throughout the field test.

3.2 Process Test Methods

The test plan did not require that process samples be collected during this test program; therefore, no process sample data are presented in this test report.

4.0 Test Discussion and Results

4.1 Field Test Deviations and Exceptions

No field deviations or exceptions from the test plan or test methods occurred during this test program.

4.2 Presentation of Results

The average results are compared to the permit limits in Table 1-2. The results of individual compliance test runs performed are presented in Table 4-1. Emissions are reported in units consistent with those in the applicable regulations or requirements. Additional information is included in the appendices as presented in the Table of Contents.

Table 4-1
CO Emissions Results – Performance Test Cells (SV-EF5C)

Parameter/Units	Run 1	Run 2	Run 3	Average
Date	9/19/2022	9/19/2022	9/19/2022	--
Time	**11:20-12:19**	**13:15-14:14**	**14:55-15:54**	--
Process Data *				
Gasoline Consumption, Gal/hr	3.158	3.142	3.171	--
Throttle EFI CMD (WOT), %	100.0%	100.0%	100.0%	--
Sampling & Flue Gas Parameters				
sample duration, minutes	60	60	60	--
Flow, acfm	433	469	474	459
Flow, scfm	420	420	424	421
Flow, dscfm	409	405	409	408
Carbon Monoxide (CO)				
Ppmvd	8935.4	8485.1	8488.0	8636.1
lb/hr	15.93	15.00	15.14	15.36
lb/gal	5.04	4.78	4.78	4.87

* Process data was provided by Kawasaki personnel.

Table 4-2
CO Emissions Results – Atmospheric Performance Test Cells (SV-EF5D)

Parameter/Units	Run 1	Run 2	Run 3	Average
Date	9/19/2022	9/19/2022	9/19/2022	--
Time	**12:05-13:04**	**13:40-14:39**	**15:15-16:14**	--
Process Data *				
Gasoline Consumption, Gal/hr				--
Throttle EFI CMD (WOT), %	100.0%	100.0%	100.0%	--
Sampling & Flue Gas Parameters				
sample duration, minutes	60	60	60	--
Flow, acfm	2,001	2,040	2,009	2,017
Flow, scfm	1,884	1,919	1,884	1,896
Flow, dscfm	1,856	1,877	1,841	1,858
Carbon Monoxide (CO)				
ppmvd	1837.8	1834.2	1804.4	1825.5
lb/hr	14.88	15.02	14.49	14.79
lb/gal	4.67	4.81	4.63	4.71

* Process data was provided by Kawasaki personnel.

Table 4-1
CO and VOC Emissions Results – Endurance Test Cells PCO Inlet and Exhaust (SV-EF5A)

Parameter/Units	Run 1	Run 2	Run 3	Average
Date	9/19/2022	9/19/2022	9/19/2022	--
Time	**17:15-18:14**	**18:45-19:44**	**20:00-20:59**	--
Process Data *				
Gasoline Consumption, Gal/hr				--
Throttle EFI CMD (WOT), %	100.0%	100.0%	100.0%	--
Sampling & Flue Gas Parameters				
sample duration, minutes	60	60	60	--
Flow, acfm	1,231	1,038	985	1,085
Flow, scfm	758	645	671	691
Flow, dscfm	736	628	651	672
Carbon Monoxide (CO)				
Inlet, ppmvd	6673.0	6578.3	6969.0	6740.1
Inlet, lb/hr	21.41	18.03	19.80	19.75
Inlet, lb/gal	6.98	5.92	6.73	6.55
Outlet, ppmvd	642.7	633.7	610.3	628.9
Outlet, lb/hr	2.1	1.7	1.7	1.8
Outlet, lb/gal	0.67	0.57	0.59	0.61
Removal Efficiency, %	90	91	91	91
Volatile Organic Compounds (VOC)				
Inlet, ppmvd	73.74	66.74	68.83	69.77
Inlet, lb/hr	0.38	0.30	0.32	0.33
Inlet, lb/gal	0.13	0.10	0.11	0.11
Outlet, ppmvd	2.0	3.1	0.6	1.9
Outlet, lb/hr	0.01	0.01	0.00	0.01
Outlet, lb/gal	0.0035	0.0045	0.0010	0.0030
Removal Efficiency, %	97	96	99	98

* Process data was provided by Kawasaki personnel.

5.0 Internal QA/QC Activities

5.1 QA/QC Audits

EPA Method 10 and 25a calibration audits were all within the measurement system performance specifications for the calibration drift checks, system calibration bias checks, and calibration error checks.

5.2 QA/QC Discussion

Montrose did not have a Qualified Individual (QI) for EPA Method 10 onsite during the test event as per ASTM D7036-04 requirements. However, upon data review, all EPA Method 10 data quality objectives were met.

5.3 Quality Statement

Montrose is qualified to conduct this test program and has established a quality management system that led to accreditation with ASTM Standard D7036-04 (Standard Practice for Competence of Air Emission Testing Bodies). Montrose participates in annual functional assessments for conformance with D7036-04 which are conducted by the American Association for Laboratory Accreditation (A2LA). All testing performed by Montrose is supervised on site by at least one Qualified Individual (QI) as defined in D7036-04 Section 8.3.2. Data quality objectives for estimating measurement uncertainty within the documented limits in the test methods are met by using approved test protocols for each project as defined in D7036-04 Sections 7.2.1 and 12.10. Additional quality assurance information is included in the report appendices. The content of this report is modeled after the EPA Emission Measurement Center Guideline Document (GD-043).

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Appendix A
Field Data and Calculations

Appendix A.1
Sampling Locations

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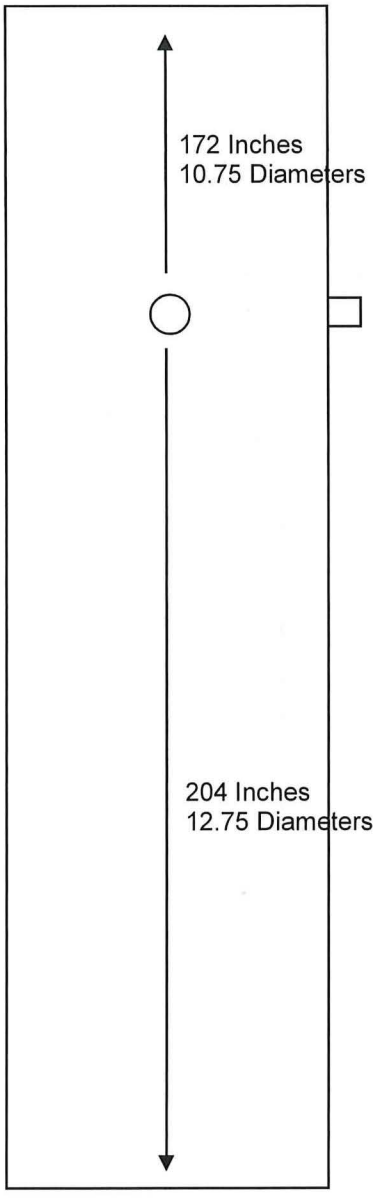

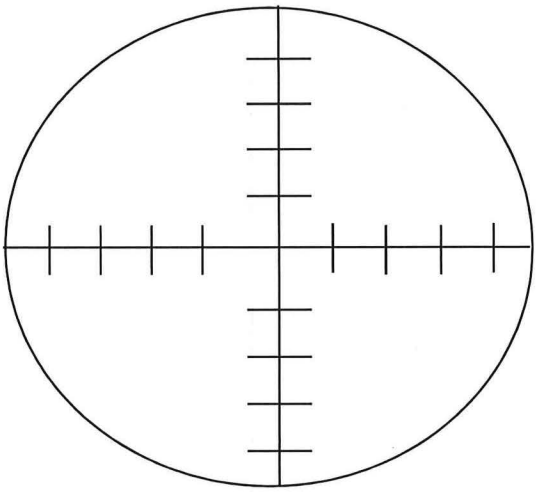

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2	1.7	
3	3.1	
4	5.2	
5	10.8	
6	12.9	
7	14.3	
8	15.0	* Adjusted Point

Site: **Kawasaki Motor Coporation** **Grand Rapids, MI** **SV-EF5A Endurance Test Cell Exhaust**	**Sampling Dates:** **September 19, 2022**	**Montrose Air Quality Services, LLC** **4949 Fernlee** **Royal Oak, Michigan**

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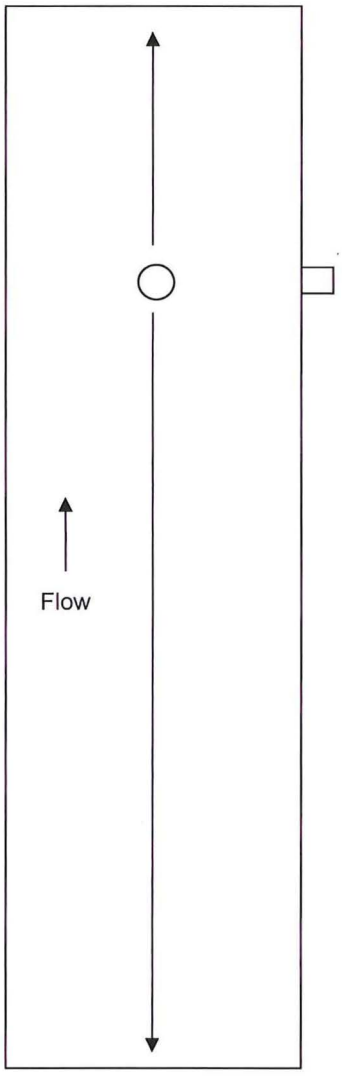
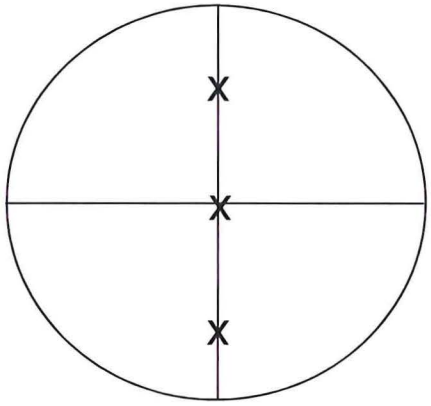
diameter = 16 inches





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Points	Distance "
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2	8.0
3	13.3

Figure No. 2

Site:	Sampling Date:	
Kawasaki Motor Coporation Grand Rapids, MI SV-EF5A Endurance Test Cell Exhaust	September 19, 2022	Montrose Air Quality Services 4949 Fernlee Avenue Royal Oak, Michigan 48073

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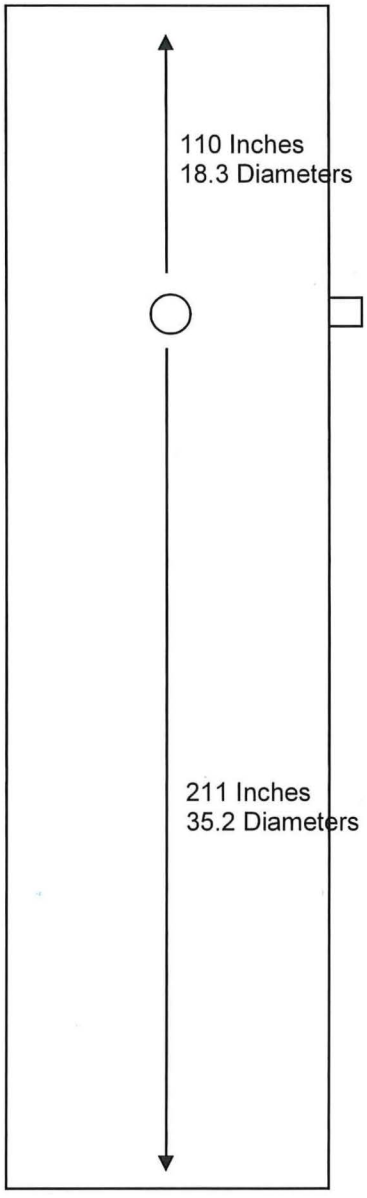
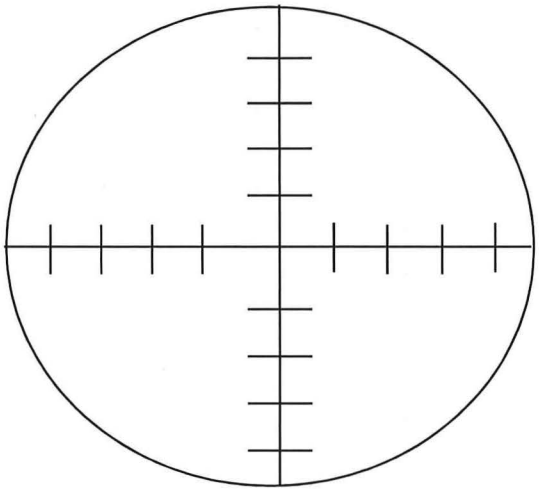
diameter = 6 Inches





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3	4.5	
4	5.0	* Adjusted Point

Site: **Kawasaki Motor Coporation** **Grand Rapids, MI** **SV-EF5D Atmospheric Performance Test Cell Exhaust**	**Sampling Dates:** **September 19, 2022**

Montrose Air Quality Services, LLC
4949 Fernlee
Royal Oak, Michigan

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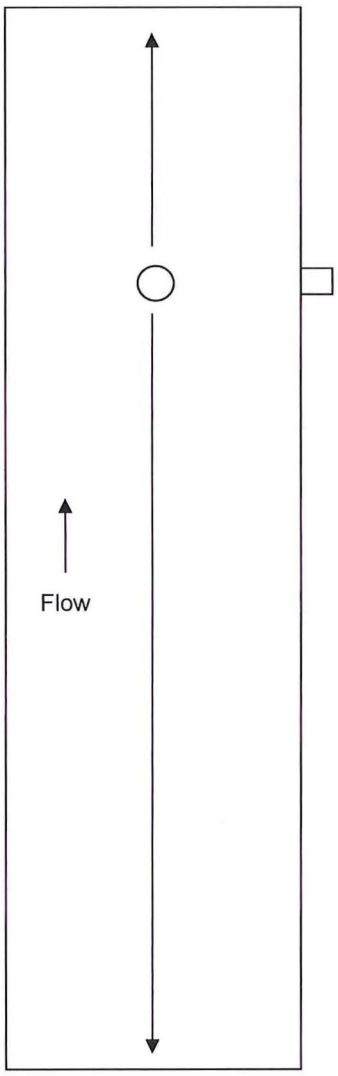
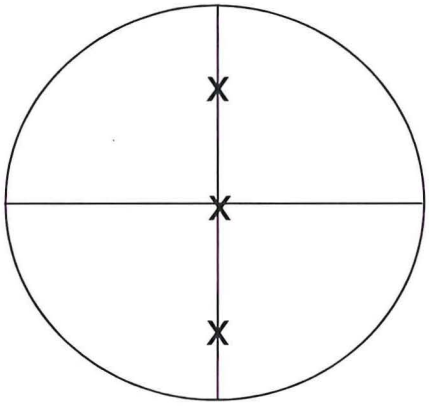
diameter = 6 inches





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2	3.0
3	5.0

Figure No. 2

Site: **Kawasaki Motor Coporation** **Grand Rapids, MI** **SV-EF5D Atmospheric Performance Test Cell Exhaust**	**Sampling Date:** **September 19, 2022**
	Montrose Air Quality Services **4949 Fernlee Avenue** **Royal Oak, Michigan 48073**

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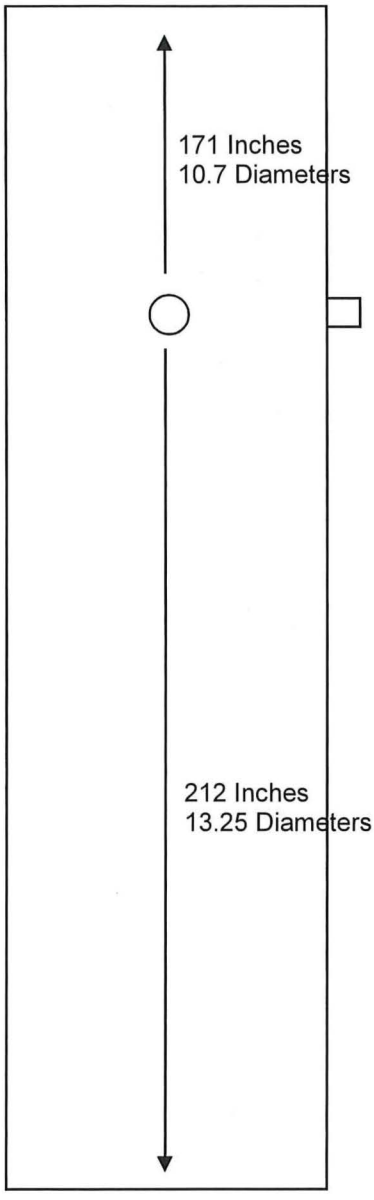
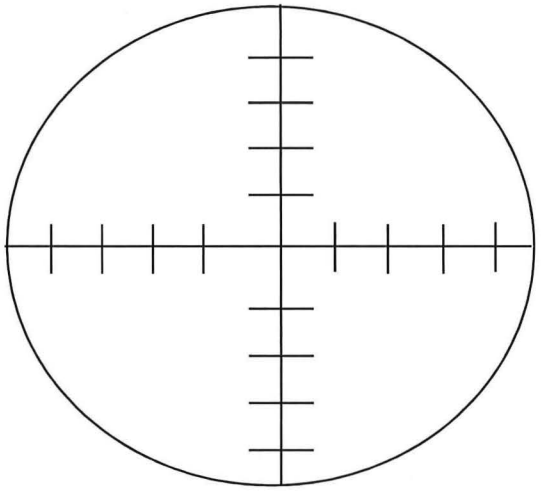
diameter = 16





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Points	Distance "	
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3	3.1	
4	5.2	
5	10.8	
6	12.9	
7	14.3	
8	15.0	* Adjusted Point

Site:
Kawasaki Motor Coporation
Grand Rapids, MI
SV-EF5C Performance Test Cell Exhaust

Sampling Dates:
September 19, 2022

Montrose Air Quality Services, LLC
4949 Fernlee
Royal Oak, Michigan

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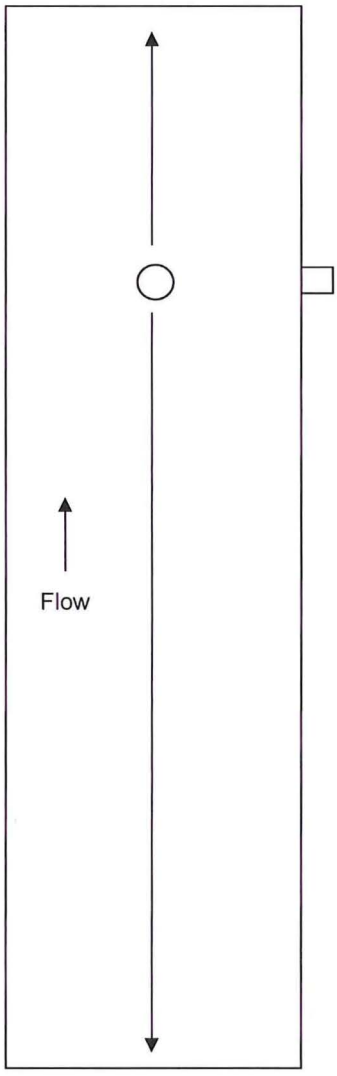
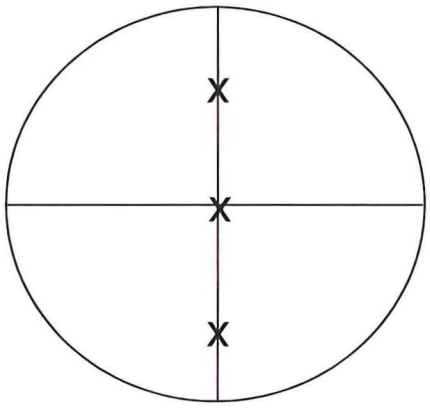
diameter = 16 inches





Not to Scale

Points	Distance "
1	2.7
2	8.0
3	13.3

Figure No. 2

Site: **Kawasaki Motor Coporation** **Grand Rapids, MI** **SV-EF5C Performance Test Cell Exhaust**	**Sampling Date:** **September 19, 2022**	**Montrose Air Quality Services** **4949 Fernlee Avenue** **Royal Oak, Michigan 48073**