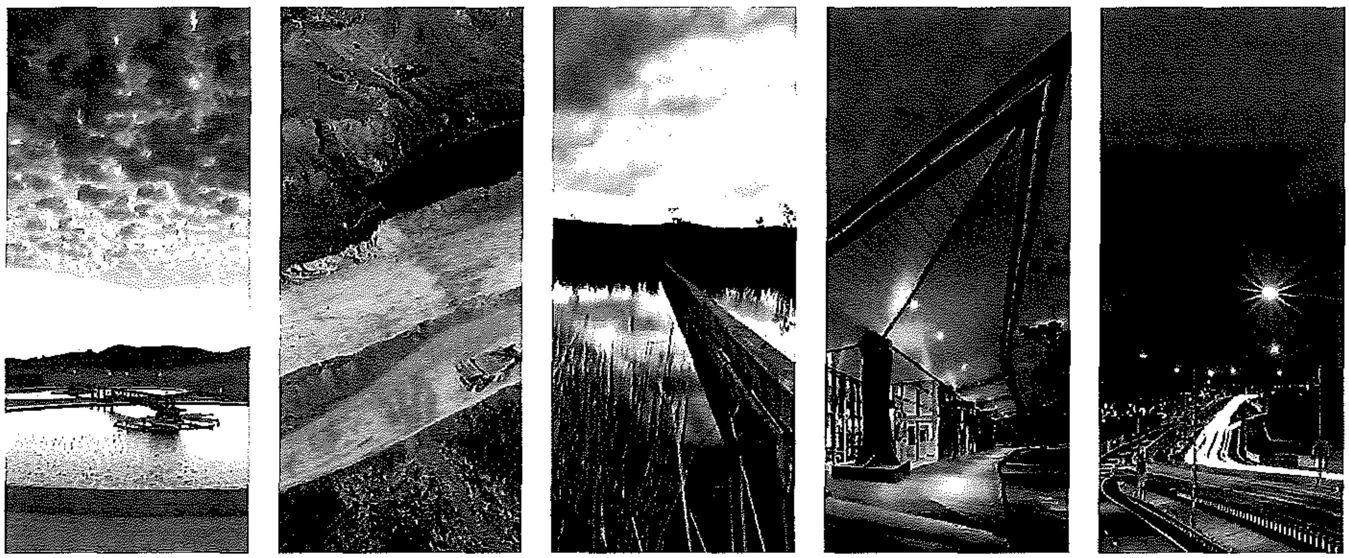

Emission Test Report ECU-TESTCELL 10

McLaren Performance Technologies
Livonia, Michigan

April 2016
2055 Niagara Falls Boulevard Niagara Falls New York 14304 USA
11110233 | 01 | Report No 2

Executive Summary

An emission testing program was completed by GHD on emission unit ECU-TESTCELL10 as a requirement of the facility's permit to install number 67-05B. Testing was performed March 23, 2016. The average results are summarized in the following table:

Summary of Emission Test Results

ECU-TESTCELL #	Parameter	Units	Average Result
10	CO	ppmvd	2064
		lbs/hr	14.5

1. Introduction

1.1 Project Overview

GHD Services Inc. (GHD) was retained by McLaren Performance Technologies (McLaren) to perform a stack emission test program at their test cell facility located in Livonia, Michigan. GHD has prepared this test report for submission to McLaren, and the Michigan Department of Environmental Quality (MDEQ).The emission test was performed on March 23, 2016.

1.2 Objective

The objective of this test program was to determine the emissions of CO from the exhaust of emission unit ECU-TESTCELL10 as a requirement of the facility's permit to install number 67-05B.

GHD understands that qualified, experienced, and professional consulting services are very important to the successful implementation of any project. All of GHD's senior source test field staff were qualified source test individuals (QSTI). GHD is an accredited Air Emissions Testing Body (AETB) by the Source Testing Accreditation Council (STAC) as documented by AETB Certificate # 3826.01, which is available upon request.

Test runs 2, 3 and 4 were used for this test program. Run 1 was discarded as requested by the MDEQ due to inconsistencies in facility operation.

1.3 Project Organization

The primary contacts for this project are as follows:

McLaren Project Manager:
Mr. Andrew Bosscher
32233 West Eight Mile Road
Livonia, MI 48152
Phone: (248) 473-3227

GHD's Project Manager is:
Mr. Steven Culmo
GHD Services Inc.
2055 Niagara Falls Boulevard
Niagara Falls, NY 14304
Phone: (716) 297-6150

Testing was performed by Mr. John Katalinas, QSTI, and Mr. Steve Zimmerman, QSTI.

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1.4 Source Description

McLaren conducts research and development tests of internal combustion engines. Engines are mounted on dynamic transient test stands utilizing various types of fuels with the purpose of evaluating performance and durability as well as providing emission certification tests on engines and engine components. Depending on the purpose of the test program and type of engine, a variety of test cycles are used. The engines can be tested with and without after treatment systems.

1.5 Certification

We certify that to the best of our knowledge, that this report has been checked for completeness, and the results presented therein are accurate, error free, legible, and representative of the actual emissions of the stack during testing.

Steven Culmo

Steven Culmo, QSTI

GHD Services Inc.

Andrew Bosscher, Project Manager

McLaren Performance Technologies

1.6 Test Plan

This test program was conducted in accordance with the reference methods (RMs) described in the United States Code of Federal Regulations, Title 40 Part 60 (40 CFR 60) Appendix A. These versions of the reference methods were obtained from the United States Environmental Protection Agency (USEPA) Emission Measurement Center (EMC) website (www.epa.gov/ttn/emc).

A summary of the test methods and durations is presented in Table 1.1.

Table 1.1 Emissions Testing Summary

Parameter	Reference Method	Number of Runs	Duration Minutes	Comments
Sample Point Location	RM 1	N/A	N/A	
Flow	RM 2	3	N/A	Pre/post for each run
Molecular Weight	RM 3A	3	N/A	Analyzer, once per run
Moisture	RM 4	3	Batch	Modified[1]
CO	RM 10	3	Batch	

[1]Was sampled utilizing a single point at the centroid of the stack.

2. Sampling and Analytical Procedures

This section provides a brief overview of the specific test methods that were used to determine the emission rates. All test methods were performed in accordance with the RMs provided in 40 CFR 60 Appendix A except as noted in the following sections.

2.1 Test Site Description and Sampling Port Location

Representative measurement of pollutant emissions and total volumetric flow rate from a stationary source requires a measurement site where the effluent stream is flowing in a known direction and cyclonic flow conditions are not present. These measurements were performed during setup activities and are included in Appendix A with the field data sheets.

Emission unit ECU-TESTCELL 10 was a round stack with an internal diameter of 11.75 inches. The sampling ports were located at 90 degrees relative to each other. Figure 2.1 diagrams the test locations and traverse point layout.

2.2 Sampling Methods and Descriptions

2.2.1 Sample and Velocity Traverses (RM 1)

According to RM 1, the cross section of the stack is divided into equal areas and a traverse point is then located within each of these areas. The number of traverse points in a cross section is determined by the number of duct diameters upstream and downstream from the test location to a flow disturbance.

2.2.2 Stack Gas Velocity and Volumetric Flow Rate (RM 2)

According to RM 2, the gas velocity in a stack is determined from the average velocity head with an "S" type pitot tube, gas density, stack temperature, and stack pressure. The average velocity head is determined using an inclined manometer and a standard type pitot tube with a known coefficient of 0.84 that is determined geometrically by standards set forth in RM 2. Stack temperature is taken at each traverse point using a type-K thermocouple. Static pressure is determined using a straight tap and an inclined manometer.

2.2.3 Gas Analysis for CO_2 and O_2 (RM 3A)

A gas sample was extracted from the stack and analyzed for percent CO_2 and O_2 according to RM 3A modified. Sample was drawn into continuously at each particulate matter traverse point. O_2 and.CO_2 concentrations were determined with Horiba analyzers, model MPA-510 (O_2) and VIA-510 (CO_2). Data from the analyzers were recorded on a data acquisition system (DAS) and is included in Appendix A.

2.2.4 Moisture Determination (RM 4)

The determination of effluent moisture was performed according to procedures outlined in Method 4. The sampling train consisted of a sample probe with a glass wool in-stack filter and a series of impingers. The probe was positioned at the centroid of the stack and one point. Gas was extracted at a constant rate; moisture was removed from the sample stream and determined gravimetrically. Field data sheets are included in Appendix A.

2.2.5 Carbon Monoxide (RM 10)

CO analysis was performed in accordance with RM 10. Analysis was performed on a TECO Model 48H Gas Filter Correlation, Non-dispersive Infrared Analyzer (GFC NDIR). The GFC eliminates the interferences from moisture or CO_2. The operational range was 0-19000 ppm. CO analysis was continuous with one minute average concentrations recorded on a DAS. Three (3), 1-hour test runs were performed. Field data sheets are included in Appendix A.

3. Quality Assurance and Quality Control

The test program was designed and implemented with emphasis on completeness and data quality. Comprehensive QA/QC is built into GHD's program to ensure data collection is of known precision and accuracy and is complete, representative, and comparable. Data comparability is achieved by the use of standard units of measure as specified by the test methods.

3.1 Equipment and Sampling Preparation

Sampling equipment is cleaned and functions are checked and calibrated prior to use in the field. Each parameter sampling method requires specific cleaning methods of the glassware, train components, and recovery containers. These materials are then sealed prior to shipment to the field.

The QA/QC procedures for sampling operations include performing leak checks before and after each sample run. These are performed on all train components including vacuum sample trains, pitot lines, and gas bag systems. If pre-test leak checks do not meet the criteria, the trains are adjusted to do so. Post-test leak checks are mandatory, performed, and recorded on field data sheets.

3.2 Leak Checks

3.2.1 Sampling Trains

Both pre-and post-run leak checks were conducted. A pre-test leak check is performed to verify integrity of the vacuum system. A leak check is mandatory at the conclusion of each sampling run. The leak check was conducted in accordance with the procedures outlined in RM 5, Section 8.4, except that it is conducted at a vacuum equal to or greater than the maximum value reached during the sampling run. If the leakage rate is found to be no greater than 0.02 cubic feet per minute (cfm) or four percent of the sample rate, the results are acceptable and no correction is applied to the total volume of dry gas metered. All leak checks were within acceptable criteria.

3.2.2 Pitot Tubes

The pitot tubes used during the test program were leak checked prior to the test series and following each traverse set. The leak check was performed according to RM 2, Section 8.1 by placing flexible tubing over one side of the pitot tube tip. The tubing was pinched off when the pitot is pressurized to greater than 3 inches of water. No loss of pressure for 15 seconds indicates a successful leak check. This procedure was repeated for the other side of the pitot tube as well. All pitot leak checks were within acceptable criteria.

3.3 Calibrations

The results of all calibrations are presented in Table 3.1 and are included in Appendix B.

3.3.1 Meter box Calibrations

Following the procedures outlined in RM 5, Section 10.3.1, a standard dry gas meter is substituted for a wet test meter per RM 5, Section 16.1. Primarily, the meter calibration factors (Y and ΔH@) are determined at multi-point calibration runs at a variety of flow rates. Factors calculated at the individual runs must agree within 2 percent of each other. The factors are then averaged and that average is posted on the meter box.

After each sampling run, calculations from Alternative Method 5 Post-Test Calibration (ALT-009) are performed. If the average Yqa is within 5 percent of the posted Y, the post-test calibration is acceptable. The post run average Yqa for the meter box used was within 5 percent of the posted Y.

3.3.2 Pitot Calibrations

Pitot tubes are calibrated following the procedures outlined in EPA Method 2, Section 10.1. Pitot tubes were given a baseline coefficient when they meet certain geometrically measured angles and dimensions as set forth in the method.

3.3.3 Thermocouple Calibration

Thermocouples are calibrated according to the Approved Alternative Method (ALT-011), Alternative Method 2 Thermocouple Calibration Procedure. This alternative method utilizes single-point calibration procedure at room temperature of the thermocouple being calibrated were made. If the thermocouple being calibrated and the CAL-PAL are within +/- 2.0 degrees F of each other, the calibration is acceptable.

3.3.4 Barometer Calibrations

Prior to being sent in the field, GHD's barometer is compared to the barometer from the National Weather Service (NWS) located at the Niagara Falls Airport. If the GHD barometer disagrees by more than ±2.3 mm (0.1 in.) of Hg from the barometer located at the airport, the GHD barometer is adjusted until it agrees with the NWS barometer.

GHD's office and the NWS station elevations are within ten feet of each other, thus eliminating the need for any elevation correction.

When in the field, barometer readings are taken from the GHD barometer. At the conclusion of field work, the barometer is brought back, checked against the NWS barometer, and corrected if necessary. Readings taken in the field are corrected based on the degree of error between the GHD barometer and the NWS barometer.

3.4 CEMS Sampling Performance Specifications

Calibration for GHD's emissions monitoring systems is performed in accordance with procedures outlined in RM 7E.

3.4.1 Linearity and Calibration Error Determination

The purpose of this procedure was to establish an initial calibration curve and to assure that each calibration point is accurate to within 2 percent of the monitor span value. This was accomplished following procedures outlined in RM 7E, Section 8.2 by first introducing the low (zero) calibration gas directly to the instrument and adjusting the instrument to read zero. Next the span gas was introduced directly to the instrument and the instrument was adjusted to read the calibration gas concentration. Following the zero and span adjustments, the zero, mid, and span gas was introduced directly to the instrument and the responses were recorded.

3.4.2 System Bias Check

The sample system bias, as required in RM 7E, Section 8.2 is determined. Following the calibration error (CE) check, the calibration gases are introduced into the sample probe prior to the filter. The gases were transported to the analyzers in the same manner as the source sample. The responses are recorded and compared to the CE values. If the two measurements agree by less than 5 percent of the monitors span the system meets the requirements.

3.4.3 System Response Time

The system response time is initially checked during set-up activities following procedures in RM 7E, Section 8.2.6. The system response time is defined as the time it takes the measurement system to respond to a change in gas concentration at each sampling point when the system is operating normally at its target sample flow rate.

3.4.4 Post Test Drift Check

Following the procedures outlined in RM 7E, Section 8.5, a post test drift check is performed immediately following each run. Zero gas is introduced into the sample probe prior to the filter and the response is recorded. The mid calibration is introduced in the same manner. The system bias is calculated as in the system bias check and compared to the system bias from the previous run. If the values differ by less than 3 percent of the analyzer span the results meet the requirements.

3.4.5 Stratification Test

A stratification test was conducted during setup day. The test was conducted in accordance with RM 7E, Section 8.1.2. Each sample point was measured for a minimum of twice the response time. The concentrations at these individual points were found to be within +/- 5 percent of the overall average concentration.

3.5 Data Reduction

The QA/QC procedure for data reduction includes using computer spreadsheet programs to generate tables of results. Data input files and equations are double-checked by a second person, and tables are checked for transposition errors with spot calculations being performed by hand.

Table 3.1 Calibration Summary

Equipment	Reference	Calibrated With	Limit	Equipment ID	Calibration Date	Calibration Within Limits
Meter box pre-test	RM 5, Section 10.3 and 16.1	Standard Dry Gas Meter	Y: avg. within +/- 5% at all calibration points	BE04906	10/09/15	Yes
Meter box post-test	USEPA Alt. 009	Y_{qa} Check	Yqa avg. within +/- 5 percent of meter box value	BE04906	03/23/16	Yes
Pilot Assembly	RM 2, Section 10.1.5.5.5, and 10.3	Calipers and Reference Thermocouple	Specification as set forth in RM 2 Figures 2.2, 2.3 and 2.4	4193D	03/28/16	Yes
Barometer	RM 2, Section 10.4	RM 2, Section 10.4	+/- 0.1 " Hg	BE04922	03/28/16	Yes

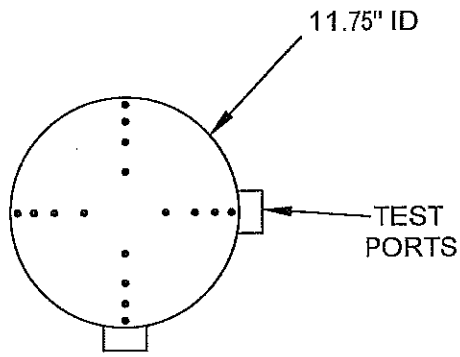
4. Results

Test results are presented in Table 4.1

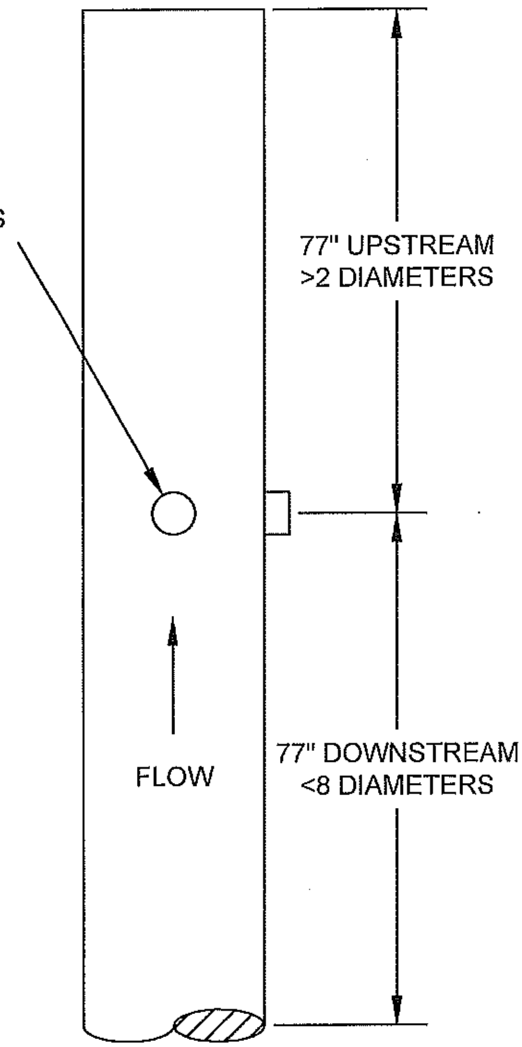
Table 4.1 Results Summary ECU TESTCELL10

Parameter[1]	Units	Run 2	Run 3	Run 4	Average	Permit Limit
Date		03/23/16	03/23/16	03/23/16		
Run Time		10:40-11:39	12:14-13:13	13:59-14:58		
Stack Temperature	^0F	194	187	193	191	
Stack Flow	dscfm	1774	1570	1561	1489	
Stack Moisture	percent	2.5	1.8	2.3	2.2	
Stack O_2	percent	20.00	19.80	19.90	19.90	
Stack CO_2	percent	1.30	1.30	1.30	1.30	
CO	ppmvd	1941	2065	2185	2064	
	lbs/hr	14.6	14.1	14.9	14.5	

[1]Stack parameters were taken from the RM2 and RM4 runs.



STACK TEST PORT
CROSS SECTION



TRAVERSE POINT	DISTANCE FROM STACK WALL (INCHES)
1	0.50*
2	1.23
3	2.28
4	3.80
5	7.95
6	9.47
7	10.52
8	11.25*

* ADJUSTED PER RM1

McLaren Performance Technologies
Livonia, Michigan

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SAMPLE LOCATION TRAVERSE POINT DIAGRAM
ECU - TESTCELL 10

FIGURE 2.1

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