Derenzo and Associates, Inc.
Environmental Consultants

EMISSION TEST REPORT

Title	Compliance Test Report for Verification of Carbon Monoxide and Nitrogen Oxides Emissions from Engine Dynamometer Test Cells
Report Date	October 21, 2014
Test Date(s)	August 19-20, 2014

Facility Information	
Name:	Ricardo, Inc.
Street Address:	40000 Ricardo Drive
City, County:	Van Buren Township, Wayne County
Phone:	(734) 397-6666

Facility Permit Information			
State Registration Number:	N6962	ROP No.:	MI-ROP-N6962-2009
		PTI No. :	370-08b

Testing Contractor	
Company	Derenzo and Associates, Inc.
Mailing Address	39395 Schoolcraft Road Livonia, Michigan 48150
Phone	(734) 464-3880
Project No.	1310002B

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DEQ

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 Ricardo, Inc. County Wayne

Source Address 40000 Ricardo Dr. City Van Buren Twp.

AQD Source ID (SRN) N6962 ROP No. MI-ROP-N6962-2010 ROP Section No. Section 1

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 ______ To ______

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

Enclosed compliance test report for engine dynamometer test cell air pollutant emission verification. The testing was conducted in accordance with the Test Plan dated November 13, 2013 and the facility was operated in compliance with the permit conditions or at the maximum routine operating conditions for the facility or as specified by the test conditions.

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

Mark Christie	VP Engineering Operations	(734) 394-3730
Name of Responsible Official (print or type)	Title	Phone Number

M. J. Christie
Signature of Responsible Official

Oct 22nd 2014
Date

* Photocopy this form as needed.

EQP 5736 (Rev 11-04)

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COMPLIANCE TEST REPORT
FOR
VERIFICATION OF
CARBON MONOXIDE
AND NITROGEN OXIDES EMISSIONS
FROM ENGINE DYNAMOMETER TEST CELLS

1.0 INTRODUCTION

Ricardo, Inc. (Ricardo) State Registration Number (SRN) N6962 retained Derenzo and Associates, Inc. to conduct a testing program for the determination of carbon monoxide (CO) and nitrogen oxides (NO_x) emissions from the exhaust of one (1) compression ignited (CI) internal combustion (IC) engine and one (1) spark ignited (SI) IC engine at the Ricardo facility located at 40000 Ricardo Dr., Van Buren Township, Wayne County, Michigan.

Testing was conducted on a diesel fueled CI-IC engine operated in EU-TESTCELL-09 and on a gasoline fueled SI-IC engine operated in EU-TESTCELL-10, following the provisions specified in Michigan Department of Environmental Quality, Air Quality Division (MDEQ-AQD) Renewable Operating Permit (ROP) No. MI-ROP-N6962-2009. Condition V.1. for Flexible Group FG-TESTCELLS of the ROP requires Ricardo to verify CO and NO_x emission rates and applicable emission factors from a representative engine in FG-TESTCELLS once during the term of the ROP (current term expires March 26, 2015).

The compliance testing was performed by Derenzo and Associates, Inc. (Derenzo and Associates), an environmental consulting and testing company founded in 1989. Derenzo and Associates representatives Tyler Wilson and Dan Wilson performed the field sampling and measurements on August 19-20, 2014. Mr. Tom Maza and Ms. Jill Zimmerman from the MDEQ-AQD were on-site to observe portions of the compliance testing.

The exhaust gas sampling and analysis was performed using procedures specified in the Test Plan dated November 13, 2013.

Appendix A contains a copy of the test plan approval letter.

Questions regarding this emission test report should be directed to:

Mr. Tyler J. Wilson
Environmental Consultant
Derenzo and Associates, Inc.
39395 Schoolcraft Road
Livonia, MI 48150
(734) 464-3880

Mr. Craig Assenmacher
Manager, Powertrain Development and Calibration
Ricardo, Inc.
40000 Ricardo Drive
Van Buren Twp., MI 48111
(734) 394-4161

2.0 SUMMARY OF TEST RESULTS

Performance testing for the exhaust of EU-TESTCELL-09 and EU-TESTCELL-10 verified the NO_x and CO emission rates, to be used in emissions calculations, for CI and SI fuels.

The exhausts from EU-TESTCELL-09 and EU-TESTCELL-10 were each monitored for three (3) one-hour test periods during which the CO, NO_x, oxygen (O_2) and carbon dioxide (CO_2) exhaust gas concentrations were measured using instrumental analyzers. Exhaust gas moisture content was determined by the chilled impinger methodology. Velocity pressure measurements were performed near the beginning and ending of each test using a Pitot tube for exhaust gas velocity determination. The testing was performed while the IC engines operated at normal, representative operating conditions. A summary of the measured CO and NO_x emission rates for Ricardo, Inc. are presented in Table 2.1.

Table 2.1 Summary of measured CO and NO_x emission rates for the diesel fueled CI-IC engine and the gasoline fueled SI-IC engine

Test ID	Diesel Fueled CI Engine CO Emission Rate (lb/1000 gal)	Diesel Fueled CI Engine NO_x Emission Rate (lb/1000 gal)	Gasoline Fueled SI Engine CO Emission Rate (lb/1000 gal)	Gasoline Fueled SI Engine NOx Emission Rate (lb/1000 gal)
Test No. 1	0.01	105	110	36.6
Test No. 2	0.02	104	131	38.9
Test No. 3	0.01	9.81	149	35.8
Average	0.02	72.8	130	37.0

3.0 SOURCE DESCRIPTION

3.1 General Process Description

Ricardo operates twelve (12) engine dynamometer test cells at its Van Buren Township facility (identified as Flexible Group FG-TESTCELLS). Each cell has the capacity to test engines using either CI fuels (e.g., diesel, biodiesel, kerosene) or SI fuels (gasoline, ethanol, methanol, CNG). The engine exhaust manifolds are connected to the test cell exhaust system and engine exhaust gases are released to atmosphere through a vertical exhaust stack. Each test cell has a dedicated exhaust system and vertical exhaust stack.

3.2 Rated Capacities, Type and Quantity of Raw Materials Used

During the performance testing a:

- 3.0L, 148 horsepower, Inline-4 (4-cylinder) diesel engine was operated in EU-TESTCELL-09.
- 2.3L, 340 horsepower, Inline-4 (4-cylinder) gasoline engine was operated in EU-TESTCELL-10.

These engines are representative of the typical size and power of engines operated at Ricardo. Table 3.1 presents a summary of the specifications for the engines that were included in the testing program.

Table 3.1 Specifications for engines included in the testing program

Test Cell	Fuel	Engine Size / Displacement	Engine Power	No. Cylinders
EU-TestCell-09	Diesel	3.0 Liters	148 horsepower	4
EU-TestCell-10	Gasoline	2.3 Liters	340 horsepower	4

Typical fuel use for the diesel fueled (CI) IC engine is 2-3 gallons per hour. Typical fuel use for the gasoline fueled (SI) IC engine is 1.5 gallons per hour.

3.3 Emission Control System Description

The IC engines are permitted to operate with and without catalytic converters. The permitted emission rates are based on operation without catalytic control, but Ricardo operates the majority of its IC engines with catalysts. Therefore, during the performance testing the IC engines were operated with catalysts.

3.4 Process Operating Conditions During the Compliance Testing

During the compliance testing program the CI-IC engine was operated at an average engine speed of 2,600 revolutions per minute (rpm) and average engine torque of 370 Newton-meters (Nm). The average diesel fuel use rate was 6.78 gallons per hour.

During the compliance testing program the SI-IC engine was operated at an average engine speed of 4,000 rpm and average engine torque of 253 Nm. The average gasoline fuel use rate was 10.2 gallons per hour.

Appendix B provides operating records for the CI and SI IC engines.

4.0 SAMPLING AND ANALYTICAL PROCEDURES

A test plan for the compliance testing was prepared by Ricardo and Derenzo and Associates and reviewed by the MDEQ-AQD. This section provides a summary of the sampling and analytical procedures that were used during the test and presented in the test plan.

4.1 Sampling Locations (USEPA Method 1)

The sampling location for the vertical EU-TESTCELL-09 (diesel fueled IC engine) exhaust stack satisfied the USEPA Method 1 criteria for a representative sample location. The inner diameter of the stack is 5.75 inches. The stack is equipped with two (2) sample ports, opposed 90°, that provided a sampling location 38.0 inches (6.61 duct diameters) downstream and 49.0 inches (8.52 duct diameters) upstream from any flow disturbance.

The sampling location for vertical EU-TESTCELL-10 (gasoline fueled IC engine) exhaust stack satisfied the USEPA Method 1 criteria for a representative sample location. The inner diameter of the stack is 5.75 inches. The stack is equipped with two (2) sample ports, opposed 90°, that provided a sampling location 38.0 inches (6.61 duct diameters) downstream and 49.0 inches (8.52 duct diameters) upstream from any flow disturbance.

Velocity pressure traverse locations for the sampling points were determined in accordance with USEPA Method 1.

Appendix C provides diagrams of the performance test sampling locations.

4.2 Exhaust Gas Velocity Determination (USEPA Method 2)

Exhaust gas velocity pressure and temperature were measured at the sampling locations near the beginning and ending of each one-hour sampling period in accordance with USEPA Method 2. An S-type Pitot tube connected to a red-oil manometer was used to determine velocity pressure.

Gas temperature was measured using a K-type thermocouple mounted to the Pitot tube. The Pitot tube and connective tubing were leak-checked after setting up the equipment at each exhaust stack to verify the integrity of the measurement system.

The absence of cyclonic flow for both sampling locations was verified using the S-type Pitot tube and oil manometer. The Pitot tube was positioned at selected velocity traverse points with the planes of the face openings of the Pitot tube perpendicular to the stack cross-sectional plane. The Pitot tube was then rotated to determine the null angle (rotational angle as measured from the perpendicular, or reference, position at which the differential pressure is equal to zero).

4.3 Exhaust Gas Molecular Weight Determination (USEPA Methods 3A and 4)

CO_2 and O_2 content in both exhaust gas streams was measured continuously throughout each one-hour test period in accordance with USEPA Method 3A. The exhaust gas CO_2 content was monitored using a Servomex 4900 single beam single wavelength (SBSW) infrared gas analyzer. The exhaust gas O_2 content was monitored using a Servomex 4900 gas analyzer that uses a paramagnetic sensor.

During each one-hour pollutant sampling period, a continuous sample of the exhaust gas stream was extracted from the stack using a stainless steel probe connected to a Teflon® heated sample line. The sampled gas was conditioned by removing moisture prior to being introduced to the analyzer; therefore, measurement of O_2 and CO_2 concentrations correspond to standard dry gas conditions. The instrument was calibrated using appropriate calibration gases to determine accuracy and system bias (described in Section 4.6.1 of this document).

Moisture content of the exhaust gas was determined in accordance with the USEPA Method 4 chilled impinger method. During each pollutant sampling period, a gas sample was extracted at a constant rate from the source using a non-heated, stainless steel sample probe followed by chilled impingers containing DI water, where moisture was removed from the sample stream. At the conclusion of each sampling period the moisture gain in the impingers was determined gravimetrically.

Appendix D presents gas sampling procedures and diagrams for the USEPA Method 3A and 4 sampling trains.

4.4 NO_x and CO Concentration Measurements (USEPA Method 7E and 10)

NO_X and CO pollutant concentrations in both exhaust gas streams was determined using a Thermo Environmental Instruments, Inc. (TEI) Model 42c High Level chemiluminescence NO_X analyzer and Fuji Model ZRF NDIR CO analyzer.

Three (3) one-hour sampling periods were performed for each test cell exhaust. Throughout each one-hour test period, a continuous sample of the engine exhaust gas was extracted from the stack using the Teflon® heated sample line and gas conditioning system described in Section 4.3 and Appendix D of this document, and delivered to the instrumental analyzers. Instrument response for each analyzer was recorded on an ESC Model 8816 data logging system that monitored the analog output of the instrumental analyzers continuously and logged data as one-minute averages. Prior to, and at the conclusion of each test, the instruments were calibrated using appropriate upscale calibration and zero gas to determine analyzer calibration error and system bias (described in Section 4.6 of this document).

Sampling times were recorded on field data sheets.

The sample probe was placed in the stack upstream from the sample port openings.

Appendix D presents gas sampling procedures and diagrams for the USEPA Method 7E and 10 sampling train.

4.5 Instrumental Analyzer Quality Assurance Verification

4.5.1 Instrument Calibration and System Bias Checks

At the beginning of the testing program for each IC engine, initial three-point instrument calibrations were performed by injecting calibration gas directly into the inlet sample port for each instrument. System bias checks were preformed prior to and at the conclusion of each sampling period by introducing the appropriate upscale calibration gas and zero gas into the sampling system (at the base of the stainless steel sampling probe prior to the particulate filter and Teflon® heated sample line) and verifying the instrument response against the initial instrument calibration readings.

The instruments were calibrated with USEPA Protocol 1 certified concentrations of CO_2, O_2, NO_x and CO and zeroed using nitrogen. A STEC Model SGD-710C 10-step gas divider was used to obtain intermediate calibration gas concentrations as needed.

4.5.2 Sampling System Response Time Determination

The response time of the sampling system was determined prior to the compliance test program by introducing upscale gas and zero gas, in series, into the sampling system using a tee connection at the base of the sample probe. The elapsed time for the analyzer to display a reading of 95% of the expected concentration was determined using a stopwatch.

The TEI Model 42c High Level chemiluminescence NO_X analyzer exhibited the longest system response time at 120 seconds. Results of the response time determinations were recorded on field data sheets.

4.5.3 NO_x Converter Test

The NO_2 – NO conversion efficiency of the Model 42c analyzer was verified prior to the testing program. A USEPA Protocol 1 certified concentration of NO_2 was injected directly into the analyzer, following the initial three-point calibration, to verify the analyzer's conversion efficiency. The analyzer's NO_2 – NO converter uses a catalyst at high temperatures to convert the NO_2 to NO for measurement. The conversion efficiency of the analyzer is deemed acceptable if the measured NO_2 concentration is within 90% of the expected value.

The NO_2 – NO conversion efficiency test satisfied the USEPA Method 7E criteria (measured NO_2 concentration was -2.43% of the expected value, i.e., within 90% of the expected value).

4.5.4 Gas Divider Certification (USEPA Method 205)

A STEC Model SGD-710C 10-step gas divider was used to obtain appropriate calibration span gases. The five-step gas divider was NIST certified (on July 3, 2014) with a primary flow standard in accordance with Method 205. When cut with an appropriate zero gas, the ten-step STEC gas divider delivered calibration gas values ranging from 0% to 100% (in 10% step increments) of the USEPA Protocol 1 calibration gas that was introduced into the system. The field evaluation procedures presented in Section 3.2 of Method 205 were followed prior to use of gas divider. The field evaluation yielded no errors greater than 2% of the triplicate measured average and no errors greater than 2% from the expected values.

4.5.5 Instrumental Analyzer Interference Check

The instrumental analyzers used to measure NOx, CO, O_2 and CO_2 have had an interference response test preformed prior to their use in the field (July 26, 2006 and April 3, 2012), pursuant to the interference response test procedures specified in USEPA Method 7E. The appropriate interference test gases (i.e., gases that would be encountered in the exhaust gas stream) were introduced into each analyzer, separately and as a mixture with the analyte that each analyzer is designed to measure. All of analyzers exhibited a composite deviation of less than 3.0% of the span for all measured interferent gases. No major analytical components of the analyzers have been replaced since performing the original interference tests.

4.5.6 Meter Box Calibrations

The Nutech Model 2010 sampling console, which was used to extract a measured amount of exhaust gas from the stack for moisture determinations, was calibrated prior to and after the testing program. This calibration uses the critical orifice calibration technique presented in USEPA Method 5.

Appendix E presents test equipment quality assurance data (NO_2 – NO conversion efficiency test data, stratification test data, instrument calibration and system bias check records, calibration gas and gas divider certifications, interference test results and meter box calibration records).

5.0 TEST RESULTS AND DISCUSSION

5.1 Operating Conditions During the Compliance Test

During the compliance testing program the CI-IC engine in Test Cell No. 9 was operated at an average engine speed of 2,600 revolutions per minute (rpm) and average engine torque of 370 Newton-meters (Nm). The average diesel fuel use rate was 6.78 gallons per hour.

During the compliance testing program the SI-IC engine Test Cell No. 10 was operated at an average engine speed of 4,000 rpm and average engine torque of 253 Nm. The average gasoline fuel use rate was 10.2 gallons per hour.

5.2 Air Pollutant Sampling Results

5.2.1 Diesel Fueled CI-IC Engine Test Results

The gas stream exhausted from the engine operated in Test Cell No. 9 (diesel fueled IC engine) was sampled for three (3) separate 1-hour test periods during the compliance testing performed August 19, 2014. Instrumental analyzers were used to measure concentrations of NO_x, CO, O_2 and CO_2 in the exhaust. Moisture content was determined by gravimetric weight gain in chilled impingers and velocity pressure measurements were performed near the beginning and ending of each sampling period using a Pitot tube for exhaust gas velocity determination.

The average measured NO_X and CO concentrations in the exhaust gas were 279 and 0.10 parts per million by volume, dry basis (ppmvd), respectively. This results in calculated emission rates of 72.8 pounds of NO_x per 1,000 gallons of fuel combusted (lb/1,000 gal) and 0.02 lb CO/1,000 gal based on the measured average exhaust gas volumetric flowrate of 247 dry standard cubic feet per minute (dscfm) and average diesel fuel use rate of 6.78 gal/hr. The average moisture content of the exhaust gas was 7.90% and the average O_2 and CO_2 concentrations of the exhaust gas were 8.05 and 9.69%, respectively.

Tables 5.1 presents measured exhaust gas conditions and pollutant emission rates for the diesel fueled CI-IC engine operated in Test Cell No. 9.

5.2.2 Gasoline Fueled SI-IC Engine Test Results

The gas stream exhausted from the engine operated in Test Cell No. 10 (gasoline fueled IC engine) was sampled for three (3) separate 1-hour test periods during the compliance testing performed August 20, 2014. Instrumental analyzers were used to measure concentrations of NO_x, CO, O_2 and CO_2 in the exhaust. Moisture content was determined by gravimetric weight gain in chilled impingers and velocity pressure measurements were performed near the beginning and ending of each sampling period using a Pitot tube for exhaust gas velocity determination.

The average measured NO_X and CO concentrations in the exhaust gas were 270 ppmvd and 0.156% (by volume), respectively. This results in calculated emission rates of 37.0 lb NO_x/1,000 gal and 130 lb CO/1,000 gal based on the measured average exhaust gas volumetric flowrate of 194 dscfm and average gasoline fuel use rate of 10.2 gal/hr. The average moisture content of the exhaust gas was 13.9% and the average O_2 and CO_2 concentrations of the exhaust gas were 0.22% and 15.0%, respectively.

Tables 5.2 presents measured exhaust gas conditions and pollutant emission rates for the gasoline fueled SI-IC engine operated in Test Cell No. 10.

Appendix F provides field data and calculations for the diesel fueled CI-IC and gasoline fueled SI-IC engine exhaust gas streams.

Appendix G provides raw instrumental analyzer response data for each test period.

5.3 Emission Compliance Determination

For CI fuels, PTI No. 370-08B specifies NO_x and CO emission factors of 53.8 and 94.0 lb/1,000 gal, respectively. For SI fuels, PTI No. 370-08B specifies NO_x and CO emission factors of 279 and 641 lb/1,000 gal, respectively. The permit indicates that Ricardo shall use the permitted emission factors until test-derived emission factors are available.

PTI No. 370-08B specifies annual NO_x and CO emission limits of 34.5 and 74.6 tons per year, respectively. Ricardo will use the emission factors determined during this emissions test program to determine compliance with the permitted annual emission limits.

5.4 Variations from Normal Sampling Procedures or Operating Conditions

Both the diesel fueled CI-IC engine operated in Test Cell No. 9 and the gasoline fueled SI-IC engine operated in Test Cell No. 10 were operated with catalysts during all test periods. Ricardo uses catalysts on the majority of engine scenarios tested at its facility in Van Buren Township, MI and requested the testing be performed under these conditions as to achieve representative NO_x, CO, CO_2, and O_2 concentrations of normal operating conditions.

Test No. 1 for the diesel fueled CI-IC engine operated in Test Cell No. 9 was performed for an additional five (5) minutes beyond the normal sixty (60) minute test time due to an additional NO_x instrument and system bias calibration prior to the test since NO_x concentrations in the exhaust stack were higher than the TEI Model 42c High Level chemiluminescence NO_X analyzer had been initially instrument and system bias calibrated for. The additional five (5) minutes of test data was requested by Mr. Tom Maza, MDEQ-AQD.

Following Test No. 2 and prior to Test No. 3 for the diesel fueled CI-IC engine operated in Test Cell No. 9, Mr. Tom Maza, MDEQ-AQD requested that Ricardo inject urea to the engine catalyst during Test No. 3 due to higher than expected NO_x concentrations observed during Test No. 1 and Test No. 2.

Test No. 3 for the diesel fueled CI-IC engine operated in Test Cell No. 9 was paused twice, from 1403-1425 and from 1432-1507, due to the Universal Analyzers, Inc. gas cooler overheating. Mr. Tom Maza, MDEQ-AQD approved the pauses to allow the gas cooler to return to normal operating temperatures.

Report Prepared By:

Tyler J. Wilson
Environmental Consultant

Reviewed By:

Andy Rusnak, QSTI
Senior Environmental Engineer

Table 5.1. Measured exhaust gas conditions and air pollutant emission rates for the diesel fueled compression-ignited IC engine operated in EU-TestCell-09

Test No. Test date Test period (24-hr clock)	1 8/19/2014 1005 - 1110	2 8/19/2014 1140 - 1240	3 8/19/2014 1330 - 1525	 Three-Test Average
Diesel fuel use rate (gal/hr)	6.78	6.78	6.78	6.78
Engine speed (rpm)	2,600	2,600	2,600	2,600
Engine torque (Nm)	370	370	370	370
Exhaust gas composition				
CO_2 content (% vol)	9.70	9.68	9.70	9.69
O_2 content (% vol)	8.09	8.08	8.00	8.05
Moisture (% vol)	6.40	9.13	8.18	7.90
Exhaust gas flowrate (scfm)	268	268	271	269
Exhaust gas flowrate (dscfm)	247	245	249	247
Carbon monoxide emission rates				
CO conc. (ppmvd)	0.07	0.14	0.09	0.10
CO emissions (lb/hr)	0.00	0.00	0.00	0.00
CO emissions (lb/1,000 gal) †	0.01	0.02	0.01	0.02
Nitrogen Oxides emission rates				
NO_x conc. (ppmvd)	402	400	37.3	279
NO_x emissions (lb/hr)	0.71	0.70	0.07	0.49
NO_x emissions (lb/1,000 gal) †	105	104	9.81	72.8

† The current permitted CO and NO_x emission factors specified for the combustion of CI fuel are 94.0 lb CO/1,000 gal and 53.8 lb NO_x/1,000 gal, respectively.

Table 5.2. Measured exhaust gas conditions and air pollutant emission rates for the gasoline fueled spark-ignited IC engine operated in EU-TestCell-10

Test No. Test date Test period (24-hr clock)	1 8/20/2014 1045 - 1145	2 8/20/2014 1220 - 1320	3 8/20/2014 1345 - 1445	Three-Test Average
Gasoline fuel use rate (gal/hr)	10.2	10.2	10.2	10.2
Engine speed (rpm)	4,000	4,000	4,000	4,000
Engine torque (Nm)	252	253	253	253
Exhaust gas composition				
CO_2 content (% vol)	15.0	15.0	14.9	15.0
O_2 content (% vol)	0.24	0.22	0.20	0.22
Moisture (% vol)	13.9	14.1	13.8	13.9
Exhaust gas flowrate (scfm)	222	228	228	226
Exhaust gas flowrate (dscfm)	190	196	196	194
Carbon monoxide emission rates				
CO conc. (% vol)	0.135	0.156	0.178	0.156
CO emissions (lb/hr)	1.12	1.33	1.52	1.32
CO emissions (lb/1,000 gal) †	110	131	149	130
Nitrogen Oxides emission rates				
NO_x conc. (ppmvd)	270	282	259	270
NO_x emissions (lb/hr)	0.37	0.40	0.36	0.38
NO_x emissions (lb/1,000 gal) †	36.3	38.9	35.8	37.0

† The current permitted CO and NO_x emission factors specified for the combustion of SI fuel are 641 lb CO/1,000 gal and 279 lb NO_x/1,000 gal, respectively.

APPENDIX A

TEST PLAN APPROVAL LETTER