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**New Technology Research & Development Program
Grant Contract 582-5-70807-M030**

Final Deliverable Report

The preparation of this report is based on work funded in part
by the State of Texas through a Grant from the
Texas Commission on Environmental Quality.



www.extengine.com

FINAL PROJECT REPORT

Contract No. 582-5-70807-M030
Testing of Extengine LoNOx Biodiesel

SUBMITTED BY

EXTENGINE TRANSPORT SYSTEMS, LLC
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SUBMITTED TO

Texas Commission on Environmental Quality
New Technology Research and Development (NTRD) Program

February 7, 2006

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by the State of Texas
through a Grant from the Texas Commission on Environmental Quality (TCEQ)

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Abstract:

This report presents the results of a demonstration test of Extengine's LoNOx 2% and 20% biodiesel fuels. The effect on emissions of THC, CO, NOx, PM and fuel consumption were measured using the EPA FTP transient test protocol. Tests were performed at Olson-Ecologic Engine Testing Laboratory in Fullerton, California. The LoNOx biodiesel fuels were blends of ultra low sulfur diesel, biodiesel, and a proprietary additive package. LoNOx 2% biodiesel reduced NOx 9% but increased PM 4.5% and HC 16%. LoNOx 20% biodiesel showed an insignificant increase (0.5%) in NOx and decreased PM 16% and HC 27%. Fuel consumption increased 2% with LoNOx 2% biodiesel and 5% with LoNOx biodiesel. These tests were not conducted according to the TxLED protocol and the test engine had substantially higher PM emissions than the original emission standard. Results indicate a high probability of TxLED verification for the LoNox 20% biodiesel.



Objective:

This report presents the results of a demonstration test of Extengine LoNOx 2% and 20% biodiesel fuels. The effect on emissions of THC, CO, NOx, PM and fuel consumption were measured using the EPA FTP Transient test protocol contained in Title 40, Code of Federal Regulations, Part 86, Subpart N. This test was not conducted in full accordance with the Texas procedure for verification of alternative TxLED fuels but are indicative of the results that would be obtained in that program.

Test Fuel:

The reference fuel was an ultra low sulfur diesel fuel meeting EPA specifications for D-2 service accumulation (except for sulfur content). The fuel did not meet the TxLED specification primarily due to high aromatic hydrocarbon content. The reference fuel properties are contained in the test report from Olson-Ecologic Engine Testing Laboratories.

Three candidate fuels were prepared: the reference fuel with the LoNOx additive package (B0), 2% (B2) biodiesel in the reference fuel with the LoNOx additive package, and 20% (B20) biodiesel in the reference fuel with the LoNOx additive package. The neat biodiesel was derived from soy oil and met the ASTM 6751 specification for neat biodiesel (B100). The LoNOx additive package was mixed in the test fuels at 0.1% by volume. The additive package contained components primarily composed of hydrogen and carbon. Oxygen was also present in some of the components and represented approximately 3.5% by weight of the additive package.

Test Laboratory:

Tests were performed by Olson-Ecologic Engine Testing Laboratories, LLC, located in Fullerton, California. Olson-Ecologic is recognized by the California Air Resources Board as qualified for conducting this work and was accepted for this demonstration test by the TCEQ. Olson-Ecologic is also registered to the ISO 9001:2000 management system standard.

Test Protocol:

These tests were conducted on a 1991 Detroit Diesel Series 60 (DDC60) engine and consisted of FTP transient cycle engine dynamometer tests on the reference fuel and the three candidate fuels. One hundred hours were run with the B0 LoNOx fuel using moderate engine loads. Tests were conducted at 100 hours on the three blends. The grant's statement of work required one cold start and 3 hot start tests on the reference fuel and LoNOx B2 using the EPA FTP heavy duty transient engine test cycle. The average of the hot start tests was combined with the cold start test (6/7 and 1/7, respectively) to



calculate the composite result. In addition to those tests, B0 and B20 were also tested, but only using hot starts.

The reference fuel test results showed that the engine met the HC, CO, and NOx emission standard but PM emissions were 3 times higher than the PM standard. Significant effort was expended trying to correct the PM emissions but even with fuel injector replacement and verification of engine control functions, the emissions were not reduced. TCEQ was notified of this problem and accepted the engine for these tests. However, the engine is not typical of engines used for verification testing and better fuel economy and emission results might be obtained with an engine maintained to be in compliance with original emission standards.

The attached Olson-Ecologic test report contains further information regarding the test protocol and engine.

Test Results:

The Olson-Ecologic test report presents the test results, analysis of the reference fuel, and individual test reports. This test demonstrated that the Extengine LoNOx B2 biodiesel blend reduced NOx emissions and the LoNOx B20 biodiesel blends were essentially equivalent in NOx emissions compared to the reference fuel. The emission and fuel consumption changes are shown below.

	----- % Change versus Reference Fuel -----				
	NOx	PM	THC	CO	Fuel Rate
LoNOx B2 (Cold/hot)	- 8.9%	+ 4.5%	+15.8%	+18.0%	+2.5%
LoNOx B0 (3 hot starts)	- 3.7%	+20.4%	+29.4%	+21.8%	+1.6%
LoNOx B2 (3 hot starts)	- 7.1%	+ 2.8%	+22.1%	+19.1%	+2.6%
LoNOx B20 (3 hot starts)	+ 0.4%	-15.5%	- 27.1%	+ 6.7%	+5.3%

Discussion of Test Results:

These results were not as favorable as expected, perhaps due to the condition of the engine. However, compared to the results predicted by the EPA biodiesel emission calculator, LoNOx B20 performed better in terms of NOx, PM, and THC than the reference fuel although fuel consumption increased more than predicted by the EPA biodiesel emission calculator. The EPA biodiesel emission calculator can be downloaded from the EPA website and compares the expected change in emissions and fuel economy versus a "clean fuel" having properties similar to those of the reference fuel used in this test.



	Typical Biodiesel % Change versus "Clean" Fuel				
	NOx	PM	THC	CO	Fuel Rate
B2	+1%	0%	- 1%	0%	0%
B20	+3%	-7%	-13%	-8%	+2%

Conclusions:

- 1) Extengine LoNOx B2 blend reduced NOx but increased other pollutants compared to the reference fuel.
- 2) Extengine LoNOx B20 biodiesel blend was essentially equivalent in NOx emissions and reduced other emissions compared to the reference fuel.
- 3) Extengine LoNOx B20 emissions were lower than predicted by the EPA biodiesel calculator.
- 4) Extengine LoNOx B20 has a high probability of verification as an alternate TxLED fuel.
- 5) LoNOx B2 and B20 did not reduce fuel consumption in this test.

Test Report:

The Olson-Ecologic Engine Test Laboratories, LLC report dated December 16, 2005 is attached herewith.



Olson-EcoLogic
Engine Testing Laboratories, LLC

ISO 9001:2000 Registered

TEST REPORT

Emission and Fuel Consumption Data For Demonstration of Emission and Fuel Economy Effects of Extengine LoNO_x Biodiesel Fuel

Conducted for
Extengine Transport Systems, LLC
1370 South Acacia Avenue
Fullerton, CA 92831

By
Olson-EcoLogic Engine Testing Laboratories
At their CARB and EPA Recognized Engine Testing Facility
1370 South Acacia Avenue
Fullerton, California 92831

December 16, 2005

**The preparation of this report is based on work funded in part by the State of Texas
through a Grant from the Texas Commission on Environmental Quality**

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Executive Summary

This report provides a summary of the data obtained in a demonstration test of Extengine Transport Systems, LLC (Extengine) LoNOx Biodiesel blends. This test was not conducted in accordance with the Texas procedure for verification of TxLED fuels. All emission and fuel consumption testing was accomplished by Olson-EcoLogic Engine Testing Laboratories, at their ISO 9001:2000 registered Lab in Fullerton, California. The Company is CARB/EPA recognized and listed as a qualified emission testing facility for the work reported here.

These tests were conducted on a 1991 Detroit Diesel Series 60 (DDC60) engine and consisted of FTP transient cycle engine dynamometer tests on a reference fuel, the reference fuel with LoNOx blending components, and biodiesel blends containing the LoNOx components with 2% biodiesel (B2) and 20% biodiesel (B20). The fuel blends were prepared at Olson-Ecologic using ultra-low sulfur diesel (ULSD), neat soy-based biodiesel, and Extengine's proprietary LoNOx blending components. A commercially available ULSD without the LoNOx blending components was used as the reference fuel.

Extengine LoNOx B2 biodiesel blend was tested with a cold start and 3 hot start tests. For the composite cold/hot average, emissions of NOx decreased by 9%. However, PM, THC, NMHC, and CO emissions and fuel consumption were increased as shown in the summary table below. The PM increase was less than 5%. The THC and CO emissions increased about 15-18% but emissions remained below applicable emission standards. Fuel consumption increased 2.5%. Results were similar for the hot start test average.

Extengine LoNOx B20 biodiesel blend was tested with 3 hot start tests. Emissions of NOx were increased less than 0.5% compared to the baseline tests. PM emissions were reduced 15.5%. THC emissions were reduced 27%. CO emissions were increased 7%. Fuel consumption increased 5.3%.

The emission and fuel consumption changes are shown below:

	<u>% Change versus Baseline</u>				
	<u>NOx</u>	<u>PM</u>	<u>THC</u>	<u>CO</u>	<u>Fuel Rate</u>
LoNOx B2					
Composite (cold + 3 hot starts)	- 8.9%	+ 4.5%	+15.8%	+18.0%	+2.5%
Hot starts	- 7.1%	+ 2.8%	+22.1%	+19.1%	+2.6%
LoNOx B20 (hot starts)	+ 0.4%	-15.5%	- 27.1%	+ 6.7%	+5.3%

This test demonstrated that the Extengine LoNOx B2 blend reduced NOx emissions and the LoNOx B20 biodiesel blend was about equivalent in NOx emissions compared to the reference fuel. Fuel consumption was not reduced by LoNOx biodiesel blends in this test.



Introduction

This report presents the exhaust emission and fuel consumption data and describes the testing protocol used to conduct this demonstration of the Extengine LoNOx biodiesel fuel. Tests were conducted using the EPA transient cycle engine test procedure specified in Title 40 of the Code of Federal Regulations (CFR), Part 86.

Project Objective

The objective of this work was to collect emission data in accordance with the EPA test protocol and statement of work in the TCEQ grant in order to determine the effect of Extengine's LoNOx fuels on exhaust emissions and fuel consumption.

Test Engine

A 1991 Detroit Diesel Series 60 engine was used in this project. The engine had been installed in an International truck and had accumulated approximately 786,000 miles. The engine was set to manufacturer's specification including replacement of the fuel injectors, updating the fuel control system to DDEC4 configuration, reprogramming the computer with the EPA/ARB approved low NOx program, and checking all operating parameters. The engine was found to meet the certification standards for HC, CO, and NOx but was approximately 3 times higher than the standard for PM. These high emissions could not be corrected in spite of the work performed above. The TCEQ agreed with the client that the demonstration test could continue even though the engine did not meet emission standards.

Engine Specification Summary

Serial Number	0R0042360
Engine Family	MDD12.7FZAX
Rated HP	400 hp @ 2100 rpm
Observed HP	400 hp @ 1860 rpm 390 hp @ 2100 rpm
Rated Torque	1300 ft-lbs @ 1200 rpm
Idle Speed	600 rpm
EGR	No
Turbocharged	Yes
Charge Air Cooling	Yes
Fuel Control	DDEC4

Test Fuels

The reference fuel was a D-2 ultra-low sulfur diesel (ULSD) fuel with 8 ppm sulfur and aromatic (21.2%) content that did not meet the TxLED specification but did meet EPA specifications in Table N94-3. An analysis of the reference fuel is included in the Appendix. The reference fuel



was used as the LoNOx base fuel. Soy based neat biodiesel was added to the base fuel to make the B2 and B20 biodiesel blends. The LoNOx components were then added at the recommended concentration in order to prepare the LoNOx fuels.

Emission Test Protocol and Procedures

The Federal Test Procedure (FTP) heavy duty transient engine test for on-road engines was used for all tests. The transient cycle used an engine dynamometer and represents engine operation in a range of duty cycles, traffic conditions, and engine applications.

The test sequence for each fuel consisted of triplicate 20 minute test cycles. The engine was brought to operating temperature prior to testing by running an unmeasured FTP cycle. Each hot start test was preceded by a 20 minute engine-off soak period. Each transient cycle consisted of four phases, the NYNF (New York Non-Freeway) phase typical of light urban traffic with frequent stops and starts, the second is a LANF (Los Angeles Non-Freeway) phase typical of crowded urban traffic with few stops, the third is a LAFY (Los Angeles Freeway) phase simulating crowded expressway traffic in Los Angeles, and the fourth phase repeats the first NYNF phase. Each test cycle included an engine start, followed by idling, acceleration, and deceleration phases and a wide variety of different speeds and loads sequenced to simulate the running of the vehicle that corresponds to the engine being tested. There were few stabilized running conditions, and the average load factor was about 20-25% of the maximum horsepower available at rated speed. A 20 minute cold start test cycle was included for the reference fuel and Extengine LoNOx B2 biodiesel in accordance with grant's scope of work.

The engine was run-in on the transient cell using the reference fuel for approximately 25 hours prior to tests. The operating cycle for accumulating hours was a repetitive series of steady speed modes shown below:

Mode	Time (min.)	RPM	HP
1	15	1300	40
2	15	1300	200
3	60	1800	100
4	20	1800	300
5	10	600	0

After the baseline data were accepted by TCEQ, the engine was run-in on the transient cell for 100 hours on ULSD diesel containing the LoNOx components using the cycle shown above. Preliminary tests were run at 38 hours for comparison to the 100 hour data. The TxLED protocol specifies a maximum of 72 hours for conditioning an engine with an alternate diesel fuel. After completing 100 hours, FTP transient cycle tests were run on LoNOx base fuel without biodiesel, with B2 biodiesel, and with B20 biodiesel.



Olson-EcoLogic Engine Testing Laboratories

Olson-EcoLogic is an independent emission testing facility. The company conducted all of the testing work reported here at their ISO 9001:2000 registered Olson-EcoLogic Engine Testing Lab in Fullerton, California. The laboratory is CARB and EPA recognized and listed as capable of conducting emission testing in accordance with CARB/EPA protocols and requirements as defined in the applicable Federal Register and in the California Code of Regulations – Title 13. All of the work reported here has been conducted by qualified and experienced technicians under the direct supervision and responsibility of Donel R. Olson, a registered professional engineer in the State of California.

Test Cell #1, where all the work was conducted, consisted of an electric dynamometer capable of 450 HP absorption. The exhaust gases were collected by a constant volume sampler (CVS) and diluted with filtered air. The gaseous emissions of total hydrocarbons (HC), methane (MHC), carbon monoxide (CO), oxides of nitrogen (NO_x), nitric oxide (NO), and carbon dioxide (CO₂) were measured continuously and recorded every second during each test cycle and a proportion was captured in a Tedlar sample bag. The exhaust gas emissions were calculated into grams/second on a second-by-second basis using the measured concentrations and exhaust volume/second calculated from the CVS parameters. The second-by-second emissions and power data were integrated to obtain the total per test cycle. Background gaseous emissions collected in the sample bag were subtracted from the integrated emissions and divided by the work performed to obtain g/bhp-hr. Particulates (PM) were collected from the diluted exhaust on a single filter media for each test cycle by use of a Sierra BG-2 sampling system. Filters were weighed before and after collection and combined with the sample and exhaust volumes to obtain the g/bhp-hr of PM emissions. Fuel consumption was measured gravimetrically during the test and reported in lb/bhp-hr.

The instrument calibration functions and collection of data were controlled and performed through a proprietary Windows based LabView software program. This program stored all the raw data and conducted calculations on the gaseous raw data. Calculations of PM emissions were performed separately using a proprietary computer template encompassing the Sierra sampler data, the CVS data, and the engine operation data. The PM data were then manually inserted into the gaseous emission printout. All test numbers were consecutive and if a test was aborted or discontinued the next test number was assigned. For the reference fuel and LoNO_x B2 biodiesel blend, a cold start FTP test cycle was conducted. A composite result was calculated by combining 6/7 of the average of the hot start tests 1/7 of the cold start test.

Test Results

The initial reference fuel tests showed that the engine met the applicable standards for THC, CO, and NO_x but that PM emissions were 3 times higher than the PM standard. The engine was serviced but the emissions could not be brought within the standard. TCEQ was informed of PM emission level by the client and TCEQ approved continuation of the demonstration test.



Emissions during the run-in period with LoNO_x (THC, NMHC, CO, NO_x, and PM) at 100 hours were within 4% of those at 38 hours. This indicated that the TxLED maximum of 72 hours for conditioning engines should be adequate for future tests.

Extengine's LoNO_x B2 biodiesel cold/hot start composite emissions decreased 8.9% for NO_x but increased 4.5% for PM. Emissions of HC and CO were increased 15.8% and 18.0% respectively but remained below the emission standards for the engine. Fuel consumption increased 2.5%.

LoNO_x B20 biodiesel hot start emissions increased 0.4% for NO_x and decreased 15.5% for PM. Emissions of HC decreased 27.1% and CO emissions increased 6.7%. Fuel consumption increased 5.3%.

No tests were rejected as outliers. The statistical test used in the TxLED verification was not used to evaluate the fuels' potential for verification.

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Table 1 - Emission Test Results: Extengine LoNOx Biodiesel Demonstration Test

Test No.	Test Date	HC	NMHC	CO	NOx	PM	CO2	Fuel	Work
		----- gm/hp-hr -----							
Baseline Diesel Fuel tests									
EXTDDC20-Cold	7/11/2005	0.217	0.166	4.021	5.867	0.624	651.4	0.431	29.12
EXTDDC20A	7/11/2005	0.183	0.136	3.301	4.872	0.862	639.9	0.417	28.76
EXTDDC21	7/11/2005	0.123	0.080	3.821	4.993	0.774	648.8	0.420	28.68
EXTDDC22	7/12/2005	0.156	0.111	3.519	4.677	0.681	647.7	0.416	28.69
Average hot tests		0.154	0.109	3.547	4.847	0.772	645.5	0.418	28.71
Standard deviation hot tests		0.030	0.028	0.261	0.159	0.091	4.9	0.002	0.04
Composite (1/7 cold + 6/7hot)		0.163	0.117	3.615	4.993	0.751	646.3	0.420	28.77
LoNOx Fuel tests									
38hrs LoNOx Basefuel									
EXTDDC24	8/24/2005	0.214	0.163	4.236	4.627	void	653.1	0.427	28.34
EXTDDC25	8/24/2005	0.170	0.111	4.263	4.695	0.900	647.7	0.426	28.39
Average hot tests		0.192	0.137	4.250	4.661	0.900	650.4	0.427	28.37
Standard deviation hot tests		0.031	0.037	0.019	0.048	--	3.8	0.001	0.04
100hrs LoNOx Basefuel									
EXTDDC26	8/27/2005	0.269	0.163	4.177	4.435	0.948	641.9	0.421	28.39
EXTDDC27	8/27/2005	0.184	0.111	4.360	4.719	0.919	649.8	0.425	28.41
EXTDDC28	8/27/2005	0.145	0.072	4.423	4.844	0.922	653.6	0.427	28.36
Average hot tests		0.199	0.115	4.320	4.666	0.930	648.4	0.424	28.39
Standard deviation hot tests		0.063	0.046	0.128	0.210	0.016	6.0	0.003	0.03
100 hrs LoNOx B2 Biodiesel									
EXTDDC29	8/28/2005	0.214	0.175	4.210	4.407	0.756	647.8	0.429	28.42
EXTDDC30	8/28/2005	0.172	0.133	4.248	4.620	0.782	644.6	0.428	28.41
EXTDDC31	8/28/2005	0.178	0.137	4.212	4.487	0.845	657.0	0.429	28.37
Average hot tests		0.188	0.148	4.223	4.505	0.794	649.8	0.429	28.40
Standard deviation hot tests		0.023	0.023	0.021	0.108	0.046	6.4	0.001	0.03
EXTDDC32-Cold	8/29/2005	0.193	0.150	4.511	4.819	0.728	652.8	0.437	28.56
Composite (1/7cold + 6/7hot)		0.189	0.149	4.264	4.550	0.785	650.2	0.430	28.42
100hrs LoNOx B20 Biodiesel									
EXTDDC33	8/29/2005	0.101	0.062	3.784	4.815	0.640	643.9	0.436	28.39
EXTDDC34	8/29/2005	0.119	0.081	3.636	4.911	0.705	649.8	0.444	28.38
EXTDDC35	8/29/2005	0.117	0.080	3.932	4.878	0.614	652.8	0.440	28.39
Average hot tests		0.112	0.074	3.784	4.868	0.653	648.8	0.440	28.39
Standard deviation hot tests		0.010	0.011	0.148	0.049	0.047	4.5	0.004	0.01

*PM sample flow rate was too high and filter plugged before the end of the test.



Table 2 – Emission Reduction Effectiveness: Extengine LoNOx Biodiesel Demonstration Test

	HC	NMHC	CO	NOx	PM	CO2	Fuel	Work
	----- Percent Change -----							
Composite vs. Composite Baseline								
LoNOx B2 @ 100 hrs	15.8%	26.8%	18.0%	-8.9%	4.5%	0.6%	2.5%	-1.2%
Hot Start vs. Hot Start Baseline								
LoNOx Base fuel @ 38 hrs	24.7%	25.7%	19.8%	-3.8%	16.5%	0.8%	2.1%	-1.2%
LoNOx Base fuel @ 100 hrs	29.4%	5.8%	21.8%	-3.7%	20.4%	0.5%	1.6%	-1.1%
LoNOx B2 @ 100 hrs	22.1%	36.1%	19.1%	-7.1%	2.8%	0.7%	2.6%	-1.1%
LoNOx B20 @ 100 hrs	-27.1%	-31.8%	6.7%	0.4%	-15.5%	0.5%	5.3%	-1.1%



APPENDIX

- TEST PRINTOUTS
- BASE DIESEL FUEL ANALYSIS

Olson-Ecologic Engine Testing Laboratories, LLC

Heavy Duty Transient Test Results

EXTDDC20

Test Information

Test ID EXTDDC20
 Date Mon, Jul 11, 2005
 Time 8:23 AM
 Fuel Specification DIESEL
 Test Comments: COLD START; REFERENCE FUEL

Engine Information

Engine Manufacturer DETRIOT
 Engine Model SERIES 60
 Engine Serial Number 42360

Bag Emissions Concentrations

HC Bag Conc 4.282052 ppm
 NOx Bag Conc 44.128448 ppm
 NO Bag Conc 37.621742 ppm
 CO2 Bag Conc 0.571576 percent
 CO Bag Conc 66.083091 ppm
 Methane Bag Conc 6.261418 ppm

Bag Background Concentrations

HC Bag Ambient 2.057568 ppm
 NOx Bag Ambient 0.111484 ppm
 NO Bag Ambient -0.133845 ppm
 CO2 Bag Ambient 0.048762 percent
 CO Bag Ambient 10.731642 ppm
 Methane Bag Ambient 5.130626 ppm

Integrated Concentrations Corrected for Background

HC Conc 5.499228 ppm
 NOx Conc 45.884158 ppm
 NO Conc 46.249921 ppm
 CO2 Conc 0.515153 percent
 CO Conc 50.113250 ppm

Dilution/Engine Air Data

Barometric Pressure 30.024732 inHg
 Relative Humidity 52.025550 percent
 Engine Inlet Air Temp 71.920101 deg F
 Absoute Humidity 60.163908 gr/lb

Mass Emissions

HC Mass 6.311953 grams
 NOx Mass 170.845744 grams
 NO Mass 172.238669 grams
 CO2 Mass 18971.630963 grams
 CO Mass 117.094563 grams
 NMHC Mass 4.822632 grams

Brake Specific Emissions

HC 0.216740 g/bhp-hr
 NOx 5.866515 g/bhp-hr
 NO 5.914345 g/bhp-hr
 CO2 651.449408 g/bhp-hr
 CO 4.020803 g/bhp-hr
 NMHC 0.165600 g/bhp-hr

Sample Flow Data

Total Volume (Vmix) 71465.516228 scf
 Dilution Flow 62958.586359 scf
 Exhaust Flow 8506.929870 scf
 Dilution (Total/Exhaust) 8.400859 ratio

Correction Factors

NOx Humidity CF 0.963545 Kh
 Dry to Wet CF 0.987192 Kw
 Dilution Factor 96.940376 df

Test Cycle Data

Hot-Cold Test 1.000000 1=Cold, 2=Hot
 Test Time 1213.000000 sec
 Total Work 29.122186 bhp-hr
 Reference Work 31.920809 bhp-hr

Fuel Data

Fuel Usage 5687.000000 grams
 BSFC 0.430520 lb/bhp-hr

Particulate 0.624 g/bhp-hr

Olson-Ecologic Engine Testing Laboratories, LLC

Heavy Duty Transient Test Results

EXTDDC20A

Test Information

Test ID: EXTDDC20A
 Date: Mon, Jul 11, 2005
 Time: 8:23 AM
 Fuel Specification: DIESEL
 Test Comments: COLD START; 20MIN SOAK; HOT START; ULS FUEL

Engine Information

Engine Manufacturer: DETRIOT
 Engine Model: SERIES 60
 Engine Serial Number: 42360

Bag Emissions Concentrations

HC Bag Conc: 3.766522 ppm
 NOx Bag Conc: 36.634335 ppm
 NO Bag Conc: 35.116245 ppm
 CO2 Bag Conc: 0.542462 percent
 CO Bag Conc: 57.914158 ppm
 Methane Bag Conc: 5.906998 ppm

Bag Background Concentrations

HC Bag Ambient: 1.819381 ppm
 NOx Bag Ambient: -0.015873 ppm
 NO Bag Ambient: -0.029487 ppm
 CO2 Bag Ambient: 0.048160 percent
 CO Bag Ambient: 12.086596 ppm
 Methane Bag Ambient: 4.880221 ppm

Integrated Concentrations Corrected for Background

HC Conc: 4.576951 ppm
 NOx Conc: 37.489715 ppm
 NO Conc: 42.137910 ppm
 CO2 Conc: 0.498700 percent
 CO Conc: 40.670642 ppm

Dilution/Engine Air Data

Barometric Pressure: 30.014679 inHg
 Relative Humidity: 50.700852 percent
 Engine Inlet Air Temp: 73.013969 deg F
 Absoute Humidity: 60.928408 gr/lb

Mass Emissions

HC Mass: 5.260587 grams
 NOx Mass: 140.097541 grams
 NO Mass: 157.468553 grams
 CO2 Mass: 18401.901262 grams
 CO Mass: 94.927336 grams
 NMHC Mass: 3.902904 grams

Brake Specific Emissions

HC: 0.182944 g/bhp-hr
 NOx: 4.872071 g/bhp-hr
 NO: 5.476170 g/bhp-hr
 CO2: 639.949665 g/bhp-hr
 CO: 3.301220 g/bhp-hr
 NMHC: 0.135728 g/bhp-hr

Sample Flow Data

Total Volume (Vmix): 71588.773318 scf
 Dilution Flow: 63327.061684 scf
 Exhaust Flow: 8261.711635 scf
 Dilution (Total/Exhaust): 8.665126 ratio

Correction Factors

NOx Humidity CF: 0.965413 Kh
 Dry to Wet CF: 0.987021 Kw
 Dilution Factor: 99.448323 df

Test Cycle Data

Hot-Cold Test: 2.000000 1=Cold, 2=Hot
 Test Time: 1214.000000 sec
 Total Work: 28.755232 bhp-hr
 Reference Work: 31.820989 bhp-hr

Fuel Data

Fuel Usage: 5433.500000 grams
 BSFC: 0.416579 lb/bhp-hr

Particulate: 0.862 g/bhp-hr

Olson-Ecologic Engine Testing Laboratories, LLC

Heavy Duty Transient Test Results

EXTDDC21

Test Information

Test ID EXTDDC21
 Date Mon, Jul 11, 2005
 Time 3:01 PM
 Fuel Specification DIESEL
 Test Comments: W/UJSF

Engine Information

Engine Manufacturer DETRIOT
 Engine Model SERIES 60
 Engine Serial Number 42360

Bag Emissions Concentrations

HC Bag Conc 4.174384 ppm
 NOx Bag Conc 36.908833 ppm
 NO Bag Conc 31.771374 ppm
 CO2 Bag Conc 0.547712 percent
 CO Bag Conc 60.069472 ppm
 Methane Bag Conc 5.356920 ppm

Bag Background Concentrations

HC Bag Ambient 2.225805 ppm
 NOx Bag Ambient 0.098838 ppm
 NO Bag Ambient 0.188272 ppm
 CO2 Bag Ambient 0.046004 percent
 CO Bag Ambient 10.872420 ppm
 Methane Bag Ambient 4.392588 ppm

Integrated Concentrations Corrected for Background

HC Conc 3.106812 ppm
 NOx Conc 37.695878 ppm
 NO Conc 37.114551 ppm
 CO2 Conc 0.504533 percent
 CO Conc 46.916344 ppm

Dilution/Engine Air Data

Barometric Pressure 30.024732 inHg
 Relative Humidity 43.328493 percent
 Engine Inlet Air Temp 80.839928 deg F
 Absoute Humidity 67.606202 gr/lb

Mass Emissions

HC Mass 3.529703 grams
 NOx Mass 143.198723 grams
 NO Mass 140.974482 grams
 CO2 Mass 18607.544768 grams
 CO Mass 109.593025 grams
 NMHC Mass 2.281235 grams

Brake Specific Emissions

HC 0.123076 g/bhp-hr
 NOx 4.993126 g/bhp-hr
 NO 4.915571 g/bhp-hr
 CO2 648.817410 g/bhp-hr
 CO 3.821346 g/bhp-hr
 NMHC 0.079543 g/bhp-hr

Sample Flow Data

Total Volume (Vmix) 71497.095941 scf
 Dilution Flow 63127.321844 scf
 Exhaust Flow 8369.774097 scf
 Dilution (Total/Exhaust) 8.542297 ratio

Correction Factors

NOx Humidity CF 0.981915 Kh
 Dry to Wet CF 0.985532 Kw
 Dilution Factor 100.244412 df

Test Cycle Data

Hot-Cold Test 2.000000 1=Cold, 2=Hot
 Test Time 1213.000000 sec
 Total Work 28.679170 bhp-hr
 Reference Work 31.886511 bhp-hr

Fuel Data

Fuel Usage 5461.500000 grams
 BSFC 0.419836 lb/bhp-hr

Particulate 0.774 g/bhp-hr

Olson-Ecologic Engine Testing Laboratories, LLC

Heavy Duty Transient Test Results

EXTDDC22

Test Information

Test ID EXTDDC22
 Date Tue, Jul 12, 2005
 Time 9:38 AM
 Fuel Specification DIESEL
 Test Comments: H.S. HDT; Reference Fuel

Engine Information

Engine Manufacturer DETRIOT
 Engine Model SERIES 60
 Engine Serial Number 42360

Bag Emissions Concentrations

HC Bag Conc 3.593874 ppm
 NOx Bag Conc 35.502399 ppm
 NO Bag Conc 27.663044 ppm
 CO2 Bag Conc 0.547695 percent
 CO Bag Conc 57.932460 ppm
 Methane Bag Conc 5.593279 ppm

Bag Background Concentrations

HC Bag Ambient 1.569850 ppm
 NOx Bag Ambient 0.375278 ppm
 NO Bag Ambient 0.280116 ppm
 CO2 Bag Ambient 0.048008 percent
 CO Bag Ambient 9.437766 ppm
 Methane Bag Ambient 4.642920 ppm

Integrated Concentrations Corrected for Background

HC Conc 3.862305 ppm
 NOx Conc 35.374153 ppm
 NO Conc 31.596868 ppm
 CO2 Conc 0.501250 percent
 CO Conc 42.823125 ppm

Dilution/Engine Air Data

Barometric Pressure 30.024732 inHg
 Relative Humidity 45.682231 percent
 Engine Inlet Air Temp 78.023138 deg F
 Absoute Humidity 64.881538 gr/lb

Mass Emissions

HC Mass 4.465675 grams
 NOx Mass 134.171219 grams
 NO Mass 119.871886 grams
 CO2 Mass 18581.167362 grams
 CO Mass 100.958201 grams
 NMHC Mass 3.194529 grams

Brake Specific Emissions

HC 0.155663 g/bhp-hr
 NOx 4.676905 g/bhp-hr
 NO 4.178463 g/bhp-hr
 CO2 647.697499 g/bhp-hr
 CO 3.519175 g/bhp-hr
 NMHC 0.111354 g/bhp-hr

Sample Flow Data

Total Volume (Vmix) 72172.655457 scf
 Dilution Flow 63785.923968 scf
 Exhaust Flow 8386.731489 scf
 Dilution (Total/Exhaust) 8.605576 ratio

Correction Factors

NOx Humidity CF 0.975048 Kh
 Dry to Wet CF 0.986139 Kw
 Dilution Factor 99.848786 df

Test Cycle Data

Hot-Cold Test 2.000000 1=Cold, 2=Hot
 Test Time 1213.000000 sec
 Total Work 28.688033 bhp-hr
 Reference Work 31.910659 bhp-hr

Fuel Data

Fuel Usage 5408.000000 grams
 BSFC 0.415595 lb/bhp-hr

Particulate 0.681 g/bhp-hr

Olson-Ecologic Engine Testing Laboratories, LLC

Heavy Duty Transient Test Results

EXTDDC24

Test Information

Test ID EXTDDC24
 Date Wed, Aug 24, 2005
 Time 12:11 PM
 Fuel Specification DIESEL
 Test Comments: 38 HOURS; LONOX FUEL; PM DATA VOID

Engine Information

Engine Manufacturer DETRIOT
 Engine Model SERIES 60
 Engine Serial Number 42360

Bag Emissions Concentrations

HC Bag Conc 2.675642 ppm
 NOx Bag Conc 35.025745 ppm
 NO Bag Conc 27.704824 ppm
 CO2 Bag Conc 0.551073 percent
 CO Bag Conc 67.247596 ppm
 Methane Bag Conc 4.926659 ppm

Bag Background Concentrations

HC Bag Ambient 0.331987 ppm
 NOx Bag Ambient 0.997211 ppm
 NO Bag Ambient 0.496593 ppm
 CO2 Bag Ambient 0.044519 percent
 CO Bag Ambient 11.532570 ppm
 Methane Bag Ambient 3.817680 ppm

Integrated Concentrations Corrected for Background

HC Conc 5.242433 ppm
 NOx Conc 35.006784 ppm
 NO Conc 30.826929 ppm
 CO2 Conc 0.502824 percent
 CO Conc 51.449970 ppm

Dilution/Engine Air Data

Barometric Pressure 29.924649 inHg
 Relative Humidity 50.043171 percent
 Engine Inlet Air Temp 74.286827 deg F
 Absoute Humidity 62.969371 gr/lb

Mass Emissions

HC Mass 6.072161 grams
 NOx Mass 131.109658 grams
 NO Mass 115.496160 grams
 CO2 Mass 18506.376159 grams
 CO Mass 120.038250 grams
 NMHC Mass 4.619554 grams

Brake Specific Emissions

HC 0.214281 g/bhp-hr
 NOx 4.626731 g/bhp-hr
 NO 4.075746 g/bhp-hr
 CO2 653.071827 g/bhp-hr
 CO 4.236032 g/bhp-hr
 NMHC 0.163020 g/bhp-hr

Sample Flow Data

Total Volume (Vmix) 71426.442916 scf
 Dilution Flow 63219.260681 scf
 Exhaust Flow 8207.182235 scf
 Dilution (Total/Exhaust) 8.702919 ratio

Correction Factors

NOx Humidity CF 0.970367 Kh
 Dry to Wet CF 0.986566 Kw
 Dilution Factor 108.573850 df

Test Cycle Data

Hot-Cold Test 2.000000 1=Cold, 2=Hot
 Test Time 1213.000000 sec
 Total Work 28.337428 bhp-hr
 Reference Work 31.900639 bhp-hr

Fuel Data

Fuel Usage 5487.000000 grams
 BSFC 0.426883 lb/bhp-hr

Particulate _____ g/bhp-hr

Olson-Ecologic Engine Testing Laboratories, LLC

Heavy Duty Transient Test Results

EXTDDC25

Test Information

Test ID EXTDDC25
 Date Wed, Aug 24, 2005
 Time 2:09 PM
 Fuel Specification DIESEL
 Test Comments: 38 HOURS; LONOX FUEL

Engine Information

Engine Manufacturer DETRIOT
 Engine Model SERIES 60
 Engine Serial Number 42360

Bag Emissions Concentrations

HC Bag Conc 3.484801 ppm
 NOx Bag Conc 35.889675 ppm
 NO Bag Conc 27.774090 ppm
 CO2 Bag Conc 0.550576 percent
 CO Bag Conc 66.242338 ppm
 Methane Bag Conc 4.889974 ppm

Bag Background Concentrations

HC Bag Ambient 0.940155 ppm
 NOx Bag Ambient 0.991691 ppm
 NO Bag Ambient 0.158071 ppm
 CO2 Bag Ambient 0.046094 percent
 CO Bag Ambient 9.543489 ppm
 Methane Bag Ambient 3.555433 ppm

Integrated Concentrations Corrected for Background

HC Conc 4.199412 ppm
 NOx Conc 36.036262 ppm
 NO Conc 32.428375 ppm
 CO2 Conc 0.499712 percent
 CO Conc 51.828927 ppm

Dilution/Engine Air Data

Barometric Pressure 29.924649 inHg
 Relative Humidity 44.575789 percent
 Engine Inlet Air Temp 75.345407 deg F
 Absoute Humidity 58.038919 gr/lb

Mass Emissions

HC Mass 4.837463 grams
 NOx Mass 133.263457 grams
 NO Mass 120.007851 grams
 CO2 Mass 18385.027718 grams
 CO Mass 121.005928 grams
 NMHC Mass 3.157188 grams

Brake Specific Emissions

HC 0.170432 g/bhp-hr
 NOx 4.695087 g/bhp-hr
 NO 4.228071 g/bhp-hr
 CO2 647.734277 g/bhp-hr
 CO 4.263235 g/bhp-hr
 NMHC 0.111233 g/bhp-hr

Sample Flow Data

Total Volume (Vmix) 71409.556879 scf
 Dilution Flow 63202.538609 scf
 Exhaust Flow 8207.018270 scf
 Dilution (Total/Exhaust) 8.701035 ratio

Correction Factors

NOx Humidity CF 0.958452 Kh
 Dry to Wet CF 0.987667 Kw
 Dilution Factor 110.530385 df

Test Cycle Data

Hot-Cold Test 2.000000 1=Cold, 2=Hot
 Test Time 1213.000000 sec
 Total Work 28.383596 bhp-hr
 Reference Work 31.915818 bhp-hr

Fuel Data

Fuel Usage 5483.500000 grams
 BSFC 0.425917 lb/bhp-hr

Particulate 0.900 g/bhp-hr

Olson-Ecologic Engine Testing Laboratories, LLC

Heavy Duty Transient Test Results

EXTDDC26

Test Information

Test ID EXTDDC26
 Date Sat, Aug 27, 2005
 Time 3:06 PM
 Fuel Specification DIESEL
 Test Comments: EXT. LONOX 100HRS.

Engine Information

Engine Manufacturer DETRIOT
 Engine Model SERIES 60
 Engine Serial Number 42360

Bag Emissions Concentrations

HC Bag Conc 1.893057 ppm
 NOx Bag Conc 34.456005 ppm
 NO Bag Conc 27.090120 ppm
 CO2 Bag Conc 0.542059 percent
 CO Bag Conc 65.801486 ppm
 Methane Bag Conc 6.109828 ppm

Bag Background Concentrations

HC Bag Ambient -0.609157 ppm
 NOx Bag Ambient 0.975272 ppm
 NO Bag Ambient 0.417785 ppm
 CO2 Bag Ambient 0.044575 percent
 CO Bag Ambient 10.337232 ppm
 Methane Bag Ambient 3.698645 ppm

Integrated Concentrations Corrected for Background

HC Conc 6.552222 ppm
 NOx Conc 33.811774 ppm
 NO Conc 30.135051 ppm
 CO2 Conc 0.495327 percent
 CO Conc 50.822098 ppm

Dilution/Engine Air Data

Barometric Pressure 29.924649 inHg
 Relative Humidity 43.178992 percent
 Engine Inlet Air Temp 77.835822 deg F
 Absoute Humidity 60.830578 gr/lb

Mass Emissions

HC Mass 7.627063 grams
 NOx Mass 125.941446 grams
 NO Mass 112.293503 grams
 CO2 Mass 18226.585411 grams
 CO Mass 118.612544 grams
 NMHC Mass 4.636601 grams

Brake Specific Emissions

HC 0.268615 g/bhp-hr
 NOx 4.435492 g/bhp-hr
 NO 3.954829 g/bhp-hr
 CO2 641.916307 g/bhp-hr
 CO 4.177377 g/bhp-hr
 NMHC 0.163295 g/bhp-hr

Sample Flow Data

Total Volume (Vmix) 71418.424543 scf
 Dilution Flow 63163.146988 scf
 Exhaust Flow 8255.277555 scf
 Dilution (Total/Exhaust) 8.651245 ratio

Correction Factors

NOx Humidity CF 0.965290 Kh
 Dry to Wet CF 0.987044 Kw
 Dilution Factor 112.585659 df

Test Cycle Data

Hot-Cold Test 2.000000 1=Cold, 2=Hot
 Test Time 1213.000000 sec
 Total Work 28.394021 bhp-hr
 Reference Work 31.905982 bhp-hr

Fuel Data

Fuel Usage 5425.500000 grams
 BSFC 0.421257 lb/bhp-hr

Particulate 0.948 g/bhp-hr

Olson-Ecologic Engine Testing Laboratories, LLC

Heavy Duty Transient Test Results

EXTDDC27

Test Information

Test ID EXTDDC27
 Date Sat, Aug 27, 2005
 Time 3:58 PM
 Fuel Specification DIESEL
 Test Comments: EXT. LONOX ULSD

Engine Information

Engine Manufacturer DETRIOT
 Engine Model SERIES 60
 Engine Serial Number 42360

Bag Emissions Concentrations

HC Bag Conc 1.589076 ppm
 NOx Bag Conc 34.860924 ppm
 NO Bag Conc 27.198675 ppm
 CO2 Bag Conc 0.552161 percent
 CO Bag Conc 67.161035 ppm
 Methane Bag Conc 5.226845 ppm

Bag Background Concentrations

HC Bag Ambient -0.159130 ppm
 NOx Bag Ambient 0.731444 ppm
 NO Bag Ambient 0.450432 ppm
 CO2 Bag Ambient 0.045914 percent
 CO Bag Ambient 10.262161 ppm
 Methane Bag Ambient 3.587407 ppm

Integrated Concentrations Corrected for Background

HC Conc 4.503097 ppm
 NOx Conc 35.563727 ppm
 NO Conc 31.270551 ppm
 CO2 Conc 0.501918 percent
 CO Conc 53.080597 ppm

Dilution/Engine Air Data

Barometric Pressure 29.924649 inHg
 Relative Humidity 49.176594 percent
 Engine Inlet Air Temp 76.091619 deg F
 Absoute Humidity 65.747648 gr/lb

Mass Emissions

HC Mass 5.231438 grams
 NOx Mass 134.096514 grams
 NO Mass 117.932545 grams
 CO2 Mass 18463.450794 grams
 CO Mass 123.878376 grams
 NMHC Mass 3.153537 grams

Brake Specific Emissions

HC 0.184114 g/bhp-hr
 NOx 4.719350 g/bhp-hr
 NO 4.150481 g/bhp-hr
 CO2 649.796821 g/bhp-hr
 CO 4.359736 g/bhp-hr
 NMHC 0.110985 g/bhp-hr

Sample Flow Data

Total Volume (Vmix) 71406.127431 scf
 Dilution Flow 63210.210636 scf
 Exhaust Flow 8195.916795 scf
 Dilution (Total/Exhaust) 8.712403 ratio

Correction Factors

NOx Humidity CF 0.977193 Kh
 Dry to Wet CF 0.985946 Kw
 Dilution Factor 107.348691 df

Test Cycle Data

Hot-Cold Test 2.000000 1=Cold, 2=Hot
 Test Time 1213.000000 sec
 Total Work 28.414191 bhp-hr
 Reference Work 31.905407 bhp-hr

Fuel Data

Fuel Usage 5476.000000 grams
 BSFC 0.424876 lb/bhp-hr

Particulate 0.919 g/bhp-hr

Olson-Ecologic Engine Testing Laboratories, LLC

Heavy Duty Transient Test Results

EXTDDC28

Test Information

Test ID EXTDDC28
 Date Sat, Aug 27, 2005
 Time 5:04 PM
 Fuel Specification DIESEL
 Test Comments: EXT. LONOX ULSD

Engine Information

Engine Manufacturer DETROIT
 Engine Model SERIES 60
 Engine Serial Number 42360

Bag Emissions Concentrations

HC Bag Conc 1.794068 ppm
 NOx Bag Conc 35.933079 ppm
 NO Bag Conc 27.569036 ppm
 CO2 Bag Conc 0.552853 percent
 CO Bag Conc 69.012712 ppm
 Methane Bag Conc 5.304163 ppm

Bag Background Concentrations

HC Bag Ambient 0.052318 ppm
 NOx Bag Ambient 1.365731 ppm
 NO Bag Ambient 0.043101 ppm
 CO2 Bag Ambient 0.044225 percent
 CO Bag Ambient 10.796881 ppm
 Methane Bag Ambient 3.663424 ppm

Integrated Concentrations Corrected for Background

HC Conc 3.567709 ppm
 NOx Conc 36.526220 ppm
 NO Conc 32.571925 ppm
 CO2 Conc 0.504128 percent
 CO Conc 53.879585 ppm

Dilution/Engine Air Data

Barometric Pressure 29.924649 inHg
 Relative Humidity 49.472587 percent
 Engine Inlet Air Temp 75.617289 deg F
 Absoute Humidity 65.099330 gr/lb

Mass Emissions

HC Mass 4.102899 grams
 NOx Mass 137.383159 grams
 NO Mass 122.594308 grams
 CO2 Mass 18538.187375 grams
 CO Mass 125.436785 grams
 NMHC Mass 2.037832 grams

Brake Specific Emissions

HC 0.144664 g/bhp-hr
 NOx 4.844005 g/bhp-hr
 NO 4.322563 g/bhp-hr
 CO2 653.639577 g/bhp-hr
 CO 4.422787 g/bhp-hr
 NMHC 0.071852 g/bhp-hr

Sample Flow Data

Total Volume (Vmix) 70601.215951 scf
 Dilution Flow 62409.857068 scf
 Exhaust Flow 8191.358883 scf
 Dilution (Total/Exhaust) 8.618987 ratio

Correction Factors

NOx Humidity CF 0.975588 Kh
 Dry to Wet CF 0.986090 Kw
 Dilution Factor 109.137161 df

Test Cycle Data

Hot-Cold Test 2.000000 1=Cold, 2=Hot
 Test Time 1213.000000 sec
 Total Work 28.361482 bhp-hr
 Reference Work 31.906814 bhp-hr

Fuel Data

Fuel Usage 5499.500000 grams
 BSFC 0.427493 lb/bhp-hr

Particulate 0.922 g/bhp-hr

Olson-Ecologic Engine Testing Laboratories, LLC

Heavy Duty Transient Test Results

EXTDDC29

Test Information

Test ID EXTDDC29
 Date Sun, Aug 28, 2005
 Time 2:56 PM
 Fuel Specification DIESEL
 Test Comments: EXT. B2 LONOX biodiesel

Engine Information

Engine Manufacturer DETROIT
 Engine Model SERIES 60
 Engine Serial Number 42360

Bag Emissions Concentrations

HC Bag Conc	0.915802	ppm
NOx Bag Conc	35.654705	ppm
NO Bag Conc	27.299694	ppm
CO2 Bag Conc	0.550107	percent
CO Bag Conc	66.212511	ppm
Methane Bag Conc	3.818760	ppm

Bag Background Concentrations

HC Bag Ambient	-0.934782	ppm
NOx Bag Ambient	1.704419	ppm
NO Bag Ambient	0.234073	ppm
CO2 Bag Ambient	0.043361	percent
CO Bag Ambient	8.866321	ppm
Methane Bag Ambient	3.017867	ppm

Integrated Concentrations Corrected for Background

HC Conc	5.201906	ppm
NOx Conc	33.746486	ppm
NO Conc	31.276271	ppm
CO2 Conc	0.500269	percent
CO Conc	51.216645	ppm

Dilution/Engine Air Data

Barometric Pressure	29.924649	inHg
Relative Humidity	45.375657	percent
Engine Inlet Air Temp	75.697257	deg F
Absoute Humidity	59.780567	gr/lb

Mass Emissions

HC Mass	6.073075	grams
NOx Mass	125.253930	grams
NO Mass	116.247536	grams
CO2 Mass	18410.724800	grams
CO Mass	119.650180	grams
NMHC Mass	4.969022	grams

Brake Specific Emissions

HC	0.213679	g/bhp-hr
NOx	4.407013	g/bhp-hr
NO	4.090126	g/bhp-hr
CO2	647.774507	g/bhp-hr
CO	4.209847	g/bhp-hr
NMHC	0.174833	g/bhp-hr

Sample Flow Data

Total Volume (Vmix)	71416.789344	scf
Dilution Flow	63201.896350	scf
Exhaust Flow	8214.892993	scf
Dilution (Total/Exhaust)	8.693575	ratio

Correction Factors

NOx Humidity CF	0.962622	Kh
Dry to Wet CF	0.987278	Kw
Dilution Factor	116.510604	df

Test Cycle Data

Hot-Cold Test	2.000000	1=Cold, 2=Hot
Test Time	1213.000000	sec
Total Work	28.421503	bhp-hr
Reference Work	31.877780	bhp-hr

Fuel Data

Fuel Usage	5527.000000	grams
BSFC	0.428723	lb/bhp-hr

Particulate	0.756	g/bhp-hr
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Olson-Ecologic Engine Testing Laboratories, LLC

Heavy Duty Transient Test Results

EXTDDC30

Test Information

Test ID EXTDDC30
 Date Sun, Aug 28, 2005
 Time 4:05 PM
 Fuel Specification DIESEL
 Test Comments: EXT. B2 LONOX biodiesel; FuelFix

Engine Information

Engine Manufacturer DETRIOT
 Engine Model SERIES 60
 Engine Serial Number 42360

Bag Emissions Concentrations

HC Bag Conc 0.537143 ppm
 NOx Bag Conc 35.957279 ppm
 NO Bag Conc 27.494698 ppm
 CO2 Bag Conc 0.553475 percent
 CO Bag Conc 67.573807 ppm
 Methane Bag Conc 3.855184 ppm

Bag Background Concentrations

HC Bag Ambient -1.202996 ppm
 NOx Bag Ambient 0.826552 ppm
 NO Bag Ambient 0.415097 ppm
 CO2 Bag Ambient 0.044623 percent
 CO Bag Ambient 9.347653 ppm
 Methane Bag Ambient 3.050759 ppm

Integrated Concentrations Corrected for Background

HC Conc 4.176973 ppm
 NOx Conc 35.187650 ppm
 NO Conc 31.252401 ppm
 CO2 Conc 0.497773 percent
 CO Conc 51.688135 ppm

Dilution/Engine Air Data

Barometric Pressure 29.924649 inHg
 Relative Humidity 47.516535 percent
 Engine Inlet Air Temp 75.157685 deg F
 Absoute Humidity 61.506379 gr/lb

Mass Emissions

HC Mass 4.892407 grams
 NOx Mass 131.242649 grams
 NO Mass 116.599845 grams
 CO2 Mass 18311.229239 grams
 CO Mass 120.668255 grams
 NMHC Mass 3.770523 grams

Brake Specific Emissions

HC 0.172217 g/bhp-hr
 NOx 4.619861 g/bhp-hr
 NO 4.104421 g/bhp-hr
 CO2 644.571958 g/bhp-hr
 CO 4.247633 g/bhp-hr
 NMHC 0.132726 g/bhp-hr

Sample Flow Data

Total Volume (Vmix) 71404.350822 scf
 Dilution Flow 63240.206130 scf
 Exhaust Flow 8164.144692 scf
 Dilution (Total/Exhaust) 8.746091 ratio

Correction Factors

NOx Humidity CF 0.966787 Kh
 Dry to Wet CF 0.986892 Kw
 Dilution Factor 121.388353 df

Test Cycle Data

Hot-Cold Test 2.000000 1=Cold, 2=Hot
 Test Time 1213.000000 sec
 Total Work 28.408355 bhp-hr
 Reference Work 31.884830 bhp-hr

Fuel Data

Fuel Usage 5511.000000 grams
 BSFC 0.427680 lb/bhp-hr

Particulate 0.782 g/bhp-hr

Olson-Ecologic Engine Testing Laboratories, LLC

Heavy Duty Transient Test Results

EXTDDC31

Test Information

Test ID EXTDDC31
 Date Sun, Aug 28, 2005
 Time 5:10 PM
 Fuel Specification DIESEL
 Test Comments: EXT. B2 LONOX biodiesel

Engine Information

Engine Manufacturer DETRIOT
 Engine Model SERIES 60
 Engine Serial Number 42360

Bag Emissions Concentrations

HC Bag Conc 0.997244 ppm
 NOx Bag Conc 35.578060 ppm
 NO Bag Conc 27.307407 ppm
 CO2 Bag Conc 0.547699 percent
 CO Bag Conc 68.853938 ppm
 Methane Bag Conc 3.919011 ppm

Bag Background Concentrations

HC Bag Ambient -0.722557 ppm
 NOx Bag Ambient 1.153925 ppm
 NO Bag Ambient 0.411755 ppm
 CO2 Bag Ambient 0.043071 percent
 CO Bag Ambient 10.880101 ppm
 Methane Bag Ambient 3.055260 ppm

Integrated Concentrations Corrected for Background

HC Conc 4.325741 ppm
 NOx Conc 33.921723 ppm
 NO Conc 30.861076 ppm
 CO2 Conc 0.506468 percent
 CO Conc 51.225699 ppm

Dilution/Engine Air Data

Barometric Pressure 29.924649 inHg
 Relative Humidity 50.307192 percent
 Engine Inlet Air Temp 74.545041 deg F
 Absoute Humidity 63.864018 gr/lb

Mass Emissions

HC Mass 5.047935 grams
 NOx Mass 127.287443 grams
 NO Mass 115.877107 grams
 CO2 Mass 18637.098109 grams
 CO Mass 119.502371 grams
 NMHC Mass 3.876941 grams

Brake Specific Emissions

HC 0.177940 g/bhp-hr
 NOx 4.486882 g/bhp-hr
 NO 4.084667 g/bhp-hr
 CO2 656.957595 g/bhp-hr
 CO 4.212458 g/bhp-hr
 NMHC 0.136662 g/bhp-hr

Sample Flow Data

Total Volume (Vmix) 71427.361823 scf
 Dilution Flow 63269.959029 scf
 Exhaust Flow 8157.402793 scf
 Dilution (Total/Exhaust) 8.756140 ratio

Correction Factors

NOx Humidity CF 0.972556 Kh
 Dry to Wet CF 0.986366 Kw
 Dilution Factor 108.789053 df

Test Cycle Data

Hot-Cold Test 2.000000 1=Cold, 2=Hot
 Test Time 1213.000000 sec
 Total Work 28.368799 bhp-hr
 Reference Work 31.894293 bhp-hr

Fuel Data

Fuel Usage 5516.500000 grams
 BSFC 0.428703 lb/bhp-hr

Particulate 0.845 g/bhp-hr

Olson-Ecologic Engine Testing Laboratories, LLC

Heavy Duty Transient Test Results

EXTDDC32

Test Information

Test ID EXTDDC32
 Date Mon, Aug 29, 2005
 Time 9:47 AM
 Fuel Specification DIESEL
 Test Comments: EXTENGINE B2 LONOX BOIDIESEL

Engine Information

Engine Manufacturer DETRIOT
 Engine Model SERIES 60
 Engine Serial Number 42360

Bag Emissions Concentrations

HC Bag Conc 2.685305 ppm
 NOx Bag Conc 36.999603 ppm
 NO Bag Conc 27.483732 ppm
 CO2 Bag Conc 0.569874 percent
 CO Bag Conc 72.491790 ppm
 Methane Bag Conc 4.606029 ppm

Bag Background Concentrations

HC Bag Ambient 0.752247 ppm
 NOx Bag Ambient 1.046643 ppm
 NO Bag Ambient -0.197758 ppm
 CO2 Bag Ambient 0.048401 percent
 CO Bag Ambient 11.383676 ppm
 Methane Bag Ambient 3.659540 ppm

Integrated Concentrations Corrected for Background

HC Conc 4.782354 ppm
 NOx Conc 36.717599 ppm
 NO Conc 33.472420 ppm
 CO2 Conc 0.525616 percent
 CO Conc 55.201894 ppm

Dilution/Engine Air Data

Barometric Pressure 29.401299 inHg
 Relative Humidity 53.435240 percent
 Engine Inlet Air Temp 71.833637 deg F
 Absoute Humidity 63.239810 gr/lb

Mass Emissions

HC Mass 5.522424 grams
 NOx Mass 137.627271 grams
 NO Mass 125.595107 grams
 CO2 Mass 19340.549274 grams
 CO Mass 128.819652 grams
 NMHC Mass 4.273938 grams

Brake Specific Emissions

HC 0.193364 g/bhp-hr
 NOx 4.818918 g/bhp-hr
 NO 4.397620 g/bhp-hr
 CO2 677.195089 g/bhp-hr
 CO 4.510525 g/bhp-hr
 NMHC 0.149649 g/bhp-hr

Sample Flow Data

Total Volume (Vmix) 71405.715715 scf
 Dilution Flow 63068.918336 scf
 Exhaust Flow 8336.797379 scf
 Dilution (Total/Exhaust) 8.565125 ratio

Correction Factors

NOx Humidity CF 0.971453 Kh
 Dry to Wet CF 0.986508 Kw
 Dilution Factor 88.373227 df

Test Cycle Data

Hot-Cold Test 1.000000 1=Cold, 2=Hot
 Test Time 1213.000000 sec
 Total Work 28.559790 bhp-hr
 Reference Work 31.906614 bhp-hr

Fuel Data

Fuel Usage 5663.000000 grams
 BSFC 0.437145 lb/bhp-hr

Particulate 0.728 g/bhp-hr

Olson-Ecologic Engine Testing Laboratories, LLC

Heavy Duty Transient Test Results

EXTDDC33

Test Information

Test ID EXTDDC33
 Date Mon, Aug 29, 2005
 Time 11:19 AM
 Fuel Specification DIESEL
 Test Comments: EXTENGINE B20; LONOX; biodiesel

Engine Information

Engine Manufacturer DETRIOT
 Engine Model SERIES 60
 Engine Serial Number 42360

Bag Emissions Concentrations

HC Bag Conc 3.215272 ppm
 NOx Bag Conc 36.603848 ppm
 NO Bag Conc 28.227184 ppm
 CO2 Bag Conc 0.551482 percent
 CO Bag Conc 62.981377 ppm
 Methane Bag Conc 4.594658 ppm

Bag Background Concentrations

HC Bag Ambient 1.523783 ppm
 NOx Bag Ambient 1.262521 ppm
 NO Bag Ambient 0.396624 ppm
 CO2 Bag Ambient 0.047824 percent
 CO Bag Ambient 12.095862 ppm
 Methane Bag Ambient 3.754987 ppm

Integrated Concentrations Corrected for Background

HC Conc 2.513563 ppm
 NOx Conc 36.640070 ppm
 NO Conc 32.692154 ppm
 CO2 Conc 0.496977 percent
 CO Conc 46.129298 ppm

Dilution/Engine Air Data

Barometric Pressure 29.924649 inHg
 Relative Humidity 51.756656 percent
 Engine Inlet Air Temp 72.646536 deg F
 Absoute Humidity 61.600417 gr/lb

Mass Emissions

HC Mass 2.860801 grams
 NOx Mass 136.712756 grams
 NO Mass 122.063222 grams
 CO2 Mass 18282.959879 grams
 CO Mass 107.429462 grams
 NMHC Mass 1.763429 grams

Brake Specific Emissions

HC 0.100755 g/bhp-hr
 NOx 4.814886 g/bhp-hr
 NO 4.298944 g/bhp-hr
 CO2 643.907461 g/bhp-hr
 CO 3.783558 g/bhp-hr
 NMHC 0.062106 g/bhp-hr

Sample Flow Data

Total Volume (Vmix) 71418.568632 scf
 Dilution Flow 63197.430799 scf
 Exhaust Flow 8221.137834 scf
 Dilution (Total/Exhaust) 8.687188 ratio

Correction Factors

NOx Humidity CF 0.967026 Kh
 Dry to Wet CF 0.986871 Kw
 Dilution Factor 107.862245 df

Test Cycle Data

Hot-Cold Test 2.000000 1=Cold, 2=Hot
 Test Time 1213.000000 sec
 Total Work 28.393769 bhp-hr
 Reference Work 31.918576 bhp-hr

Fuel Data

Fuel Usage 5619.000000 grams
 BSFC 0.436285 lb/bhp-hr

Particulate 0.640 g/bhp-hr

Olson-Ecologic Engine Testing Laboratories, LLC

Heavy Duty Transient Test Results

EXTDDC34

Test Information

Test ID EXTDDC34
 Date Mon, Aug 29, 2005
 Time 3:09 PM
 Fuel Specification DIESEL
 Test Comments: EXTENGINE B20; LONOX; biodiesel

Engine Information

Engine Manufacturer DETRIOT
 Engine Model SERIES 60
 Engine Serial Number 42360

Bag Emissions Concentrations

HC Bag Conc 2.257228 ppm
 NOx Bag Conc 35.898678 ppm
 NO Bag Conc 27.533695 ppm
 CO2 Bag Conc 0.549505 percent
 CO Bag Conc 62.916913 ppm
 Methane Bag Conc 3.717803 ppm

Bag Background Concentrations

HC Bag Ambient 0.620302 ppm
 NOx Bag Ambient 0.564821 ppm
 NO Bag Ambient 0.103984 ppm
 CO2 Bag Ambient 0.043129 percent
 CO Bag Ambient 11.725304 ppm
 Methane Bag Ambient 2.889524 ppm

Integrated Concentrations Corrected for Background

HC Conc 2.936090 ppm
 NOx Conc 37.287583 ppm
 NO Conc 33.352892 ppm
 CO2 Conc 0.501275 percent
 CO Conc 44.323092 ppm

Dilution/Engine Air Data

Barometric Pressure 29.924649 inHg
 Relative Humidity 53.569122 percent
 Engine Inlet Air Temp 71.890146 deg F
 Absoute Humidity 62.165074 gr/lb

Mass Emissions

HC Mass 3.383986 grams
 NOx Mass 139.375400 grams
 NO Mass 124.710624 grams
 CO2 Mass 18443.674841 grams
 CO Mass 103.188014 grams
 NMHC Mass 2.310195 grams

Brake Specific Emissions

HC 0.119230 g/bhp-hr
 NOx 4.910676 g/bhp-hr
 NO 4.393986 g/bhp-hr
 CO2 649.834301 g/bhp-hr
 CO 3.635670 g/bhp-hr
 NMHC 0.081396 g/bhp-hr

Sample Flow Data

Total Volume (Vmix) 71417.705558 scf
 Dilution Flow 63222.683210 scf
 Exhaust Flow 8195.022348 scf
 Dilution (Total/Exhaust) 8.714766 ratio

Correction Factors

NOx Humidity CF 0.968401 Kh
 Dry to Wet CF 0.986745 Kw
 Dilution Factor 113.540814 df

Test Cycle Data

Hot-Cold Test 2.000000 1=Cold, 2=Hot
 Test Time 1213.000000 sec
 Total Work 28.382120 bhp-hr
 Reference Work 31.902139 bhp-hr

Fuel Data

Fuel Usage 5713.000000 grams
 BSFC 0.443766 lb/bhp-hr

Particulate 0.705 g/bhp-hr

Olson-Ecologic Engine Testing Laboratories, LLC

Heavy Duty Transient Test Results

EXTDDC35

Test Information

Test ID: EXTDDC35
 Date: Mon, Aug 29, 2005
 Time: 4:02 PM
 Fuel Specification: DIESEL
 Test Comments: EXTENGINE B20; LONOX; biodiesel; FuelFix; ULSD

Engine Information

Engine Manufacturer: DETRIOT
 Engine Model: SERIES 60
 Engine Serial Number: 42360

Bag Emissions Concentrations

HC Bag Conc	1.873194	ppm
NOx Bag Conc	36.588127	ppm
NO Bag Conc	28.094009	ppm
CO2 Bag Conc	0.550163	percent
CO Bag Conc	63.791364	ppm
Methane Bag Conc	3.707662	ppm

Bag Background Concentrations

HC Bag Ambient	0.278304	ppm
NOx Bag Ambient	1.028491	ppm
NO Bag Ambient	0.186808	ppm
CO2 Bag Ambient	0.044368	percent
CO Bag Ambient	10.271915	ppm
Methane Bag Ambient	2.905491	ppm

Integrated Concentrations Corrected for Background

HC Conc	2.868871	ppm
NOx Conc	36.743579	ppm
NO Conc	32.512364	ppm
CO2 Conc	0.503483	percent
CO Conc	47.830617	ppm

Dilution/Engine Air Data

Barometric Pressure	29.924649	inHg
Relative Humidity	54.098673	percent
Engine Inlet Air Temp	73.149346	deg F
Absoute Humidity	65.547377	gr/lb

Mass Emissions

HC Mass	3.319102	grams
NOx Mass	138.492948	grams
NO Mass	122.621594	grams
CO2 Mass	18532.461740	grams
CO Mass	111.616186	grams
NMHC Mass	2.261616	grams

Brake Specific Emissions

HC	0.116916	g/bhp-hr
NOx	4.878443	g/bhp-hr
NO	4.319371	g/bhp-hr
CO2	652.809801	g/bhp-hr
CO	3.931703	g/bhp-hr
NMHC	0.079666	g/bhp-hr

Sample Flow Data

Total Volume (Vmix)	71421.638781	scf
Dilution Flow	63279.592383	scf
Exhaust Flow	8142.046398	scf
Dilution (Total/Exhaust)	8.771952	ratio

Correction Factors

NOx Humidity CF	0.976699	Kh
Dry to Wet CF	0.985991	Kw
Dilution Factor	109.355168	df

Test Cycle Data

Hot-Cold Test	2.000000	1=Cold, 2=Hot
Test Time	1213.000000	sec
Total Work	28.388762	bhp-hr
Reference Work	31.904776	bhp-hr

Fuel Data

Fuel Usage	5667.000000	grams
BSFC	0.440089	lb/bhp-hr

Particulate	0.614	g/bhp-hr
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ANALYSTS INCORPORATED

P.O. BOX 23200 2910 FORD ST.
 OAKLAND, CA 94623 OAKLAND, CA 94601
 800-424-0099 510-536-5914
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EXTENGINE TRANSPORT SYSTEMS
 RICHARD CARLSON
 1370 S. ACACIA AVENUE
 FULLERTON CA 92831

Lab Number : 9703
 Logged Date : 08-MAR-05
 Sample Drawn : 02-MAR-05
 Report Date : 11-APR-05
 Record Ref.# : 514617
 Reprinted : 11-APR-05

Unit ID : ARCO ECD RED Mfg. : -
 Sample ID : SAMPLE 6 - PART 1 Model : -
 worksite : PO No.: 75
 Time On Fluid : Time On System :

Requirements for:
 D.F.O. #2 (Low Sulfur) ASTM D975

TESTING PERFORMED:	MEASURED	MIN	MAX
Cerium, ppm (ICP)	<0.1		
Chromium by ICP - ppm	<.06		
Copper, ppm - ICP	<0.2		
Iron, ppm - (ICP)	2		
Nickel by ICP - ppm	<0.7		
Phosphorus, ppm	2		
Lead, ppm - ICP	1		
Distillation, Deg F - D86			
- Init. Boiling Pt. temp	356		
- Recovered - 5 % temp	395		
- 10 % temp	405		
- 20 % temp	426		
- 30 % temp	444		
- 40 % temp	463		
- Recovered - 50 % temp	484		
- 60 % temp	507		
- 70 % temp	535		
- 80 % temp	567		
- Recovered - 90 % temp	609	540	640
- 95 % temp	649		
- End Point - FBP temp	662		
- Recovery - % vol	97.7		
- Residue - % vol	1.5		
- Loss - % vol	0.8		
Viscosity @ 40'C, cSt - D445	2.3	1.9	4.1
Ash Content, % WT. - D482	<.001		.01
Sulfur Content by EDXRF, mass% - D4294	<.01		.05
API Gravity, Deg API - D287/D1298	39.7		
Cetane Index (Calc.) - D976	51.6	40	
Cloud Point, 'F - D2500	14		
Carbon Residue (Rmsbtm-10%btm)%wt - D524	0.06		.35
Copper Strip Corrosion - No. - D130	1A		
Flash Point PMCC, Deg. F - D93	162	125	
Water & Sediment, %vol - D1796	0		.05

Continued...

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EXTENGINE TRANSPORT SYSTEMS

Lab Number : 9702

RICHARD CARLSON

Logged Date : 08-MAR-05

1370 S. ACACIA AVENUE

Sample Drawn : 02-MAR-05

FULLERTON CA 92831

Report Date : 11-APR-05

Record Ref.# : 514622

Reprinted : 11-APR-05

Unit ID : ARCO ECD RED

Mfg. : -

Sample ID : SAMPLE 6 - PART 2

Model : -

Worksite :

PO No.: 75

Time On Fluid :

Time On System :

Requirements for:

D.F.O. #2 (Low Sulfur) ASTM D975

TESTING PERFORMED:

	MEASURED	MIN	MAX
Total Chlorine in Oil, ppm - D2622	<10.0		
Sulfur content by UV, ppm - D5453	9		15
AROMATICS IN DIESEL FUEL - D5186			
Mono-Aromatics - wt%	19.4		
Poly-cyclic Aromatics, wt% - D5186	2.4		
Total Aromatics - wt%	21.8		
.	.		
Cetane Number - D613	54	40	
Nitrogen, Chemiluminescence, ppm - D4629	7.6		
LUBRICITY OF DSL FUELS BY HFFR - D6079			
Wear Scar Diameter - microns	0.43		520
Fuel Temperature - Deg C	60		

RECOMMENDATIONS / COMMENTS:

Condition / Evaluation statements not applicable to this sample.
 Report issued to provide test results only. All tests were outsourced.

Respectfully submitted,

 Analysts, Inc.