Olson-EcoLogic
Engine Testing Laboratories, LLC

ISO 9001 :2000 Registered

FINAL REPORT

Comparative Exhaust Emission
And
Fuel Economy Data

Using a Caterpillar Diesel Engine Model 3116
Serial No. 5EN02512
With Fuel That Has Passed Through Various Fuel FX Reactors

Testing Conducted for

Fuel FX International
1230 High Bluff Drive, Suite 260
San Diego, California 92130

Testing Conducted By

Olson-EcoLogic Engine Testing Laboratories
An Independent Emission Testing Facility
Recognized and listed by EPA and CARB

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Introduction and Project Description

This comparative testing project was conducted for Fuel FX International to evaluate their proprietary on-board Fuel Reactor. This final summary report contains exhaust emissions data for a Caterpillar Model 3116 diesel engine when operated with and without variations of the Fuel FX Reactor (known only to the client). Baseline exhaust emissions were first measured with special fuel delivered directly to Olson-Ecologic from Haltermann Products in Texas, and then in exactly the same manner with the client installed Fuel FX Reactor installed and operating.

Test Facility and Capability

Olson-EcoLogic as an independent emission test laboratory is an ISO 9001:2000 registered facility. It is officially recognized and listed by EPA and CARB as a capable emission test facility. All engine operation and emission testing for this project was conducted at the Olson-EcoLogic Engine Test Laboratory in Fullerton, California in the SuperFlow 3100 test cell. All test activity was under the direction and responsibility of Donel R. Olson. Mr. Olson is a California registered professional mechanical engineer with 40 years of experience in the measurement and analysis of engine emissions.

Details of the Olson-EcoLogic emission test facility capability can be viewed and obtained on the Olson-EcoLogic website at www.ecologiclabs.com.

Test Device

The proprietary Fuel FX Fuel Reactors are installed in the fuel line and purportedly provide in-line refinement of diesel and gasoline fuels. They are intended for use in trucks, cars and buses. Olson-Ecologic has no knowledge of the internal makeup of the reactors. They are simply described by the client provided identification numbers.

Test Engine

A client supplied six cylinder Caterpillar Model 3116 (serial No. 5EN02512) diesel engine was used for this test project.

Test Fuel

All tests in this project were done with Haltermann provided no. 2 diesel fuel (see Appendix for fuel inspection data).

Testing Protocol

This project involved hot-start steady state testing with a fully warmed up and stabilized engine using test modes specified by the client. The basic protocol involved 10 minute

test sequences of five different operating modes. Subsequently one additional test mode was used and repeated in triplicates for the baseline and for two of the Fuel FX reactors. For each mode emissions and fuel consumption were measured continuously. Gaseous emissions of HC, CO, CO2 and NO plus gravimetric measurements of fuel consumption were recorded. NOx was not measured due to an instrument problem, but NO was continuously recorded and NO normally tracks NOx (at about 90% of the NOx value) as long as the fuel is of constant composition. Fuel measurement was recorded gravimetrically at the five minute interval and again at the end of the ten minute cycle for each test mode.

The five mode test sequences involved baseline measurements with the standard engine (duplicate baseline data are averaged in the results summary). Following the baseline tests four different devices were installed and a single five mode test protocol for each device was conducted exactly as was done for the baseline data.

The five steady-state modes were as follows:

Mode No.	Nominal RPM	Nominal Torque Lb-Ft	Nominal Power
1	2518	84-1 00	40-48
2	2500	124-1 33	58-63
3	2460	230-240	108-112
4	2400	394-395	180
5	2590	343-345	169-170

Note: Because of some small differences in RPM and Torque from test to test it was important to compare data on a mass per BHP basis to obtain comparable results.

After completion of the five mode test sequences the engine was operated over an additional single mode. This single mode was operated at a nominal 1635 to 1655 RPM and a nominal 535 lb-ft of torque to produce a nominal 167-169 BHP. Triplicate baseline data were measured for this single mode followed by triplicate single mode sequences after installation of each test device by the client. Since triplicate data sets were obtained for the baseline and for each device it was possible to conduct some statistical calculations to provide a higher degree of confidence in the results.

Test Results

A summary of the 5-mode test results is provided in Summary Table 1. There is no individual mode weighting. Emissions for each mode are divided by the horsepower for each mode to provide the comparable grams/bhp-hr. The summarized average differences in Table 1 are simply for the 5-mode averages. Differences from the duplicate baseline data for individual modes are tabulated in five tables labeled as

Tables 1A. The individual test reports are in the Appendix for each test showing the measured raw concentrations and the corrected and calculated values in grams per bhp-hr.

Since only single 5-mode tests were conducted for the devices (and only duplicates for baseline data) the 5-mode data cannot be statistically analyzed. Ordinarily this test protocol for single test comparisons can be expected to identify differences of ±5% or more with 95% confidence. Smaller differences would not be significant.

Summary Table 2 provides all of the single mode test comparisons with appropriate statistical analyses.

Discussion of Results

An error was discovered in the quality audit procedure for CO_2 measurements during five mode testing of devices 1 (SAF-FD V.1.0) and 2 (AF-FD V.1.0). After reviewing all of the data an arbitrary correction was made for these two tests using the average CO_2 from the two baseline tests. This correction was justified by conducting a carbon balance calculation comparing the results to the gravimetric fuel consumption measured in each test. Accordingly, the corrected data re considered to be acceptable.

Summary Table 1 provides comparisons of the four devices for the five mode average results to the five mode average baseline data with each mode weighted the same. The independent mode data comparisons are provided in Summary Tables 1A (five independent tables). Summary Table 2 provides comparison of Devices 2 and 3 to the baseline data for the triplicate single mode test in each case. Significant differences exist for different modes of operation and for the various devices. There are significant improvements in fuel economy during five mode testing for Devices 1, 2 and 3. For essentially all of the tests, both five modes and single modes, there was a significant reduction in nitrous oxide (NO) ranging from 14% to 52% when operating with the Fuels FX reactors installed.

Of particular interest is the fuel economy gain for all four devices during the first mode of the five mode test. This improvement ranged from 1.4% for Device 4 to 10.5% for Device 3.

Weighted Averages for Test Modes 1-5
CAT 3116 Test Engine - Haltermann Certified Test Fuel
Testing Performed at the Olson-EcoLogic Facility on June 13-14, 2005

LIGHT SERVICE WEIGHTED AVERAGE - GRAMS PER BRAKE HORSEPOWER HOUR
Weighting for Service Type - Hypothetical Light Load & Traffic Service (City Bus) Mode 1 - 40% / Mode 2 - 30% / Mode 3 - 20% / Mode 4 - 5% / Mode 5 - 5%

Test	Mode	BHP	HC	CO	KNO	FUEL
BL3	1-5	74.06	0.55	0.77	3.95	220.74
BL4	1-5	73.01	0.46	0.67	3.65	221.92
BL Average		73.54	0.50	0.72	3.80	221.33
D1	1-5	76.58	0.46	0.72	3.58	213.75
Change from BL Average		4.13%	-8.21%	0.39%	-5.69%	-3.43%
D2	1-5	74.33	0.43	0.79	1.85	216.26
Change from BL Average		1.08%	-14.55%	9.79%	-51.21%	-2.29%
D3	1-5	77.29	0.79	1.23	2.77	209.94
Change from BL Average		5.10%	56.93%	70.94%	-27.04%	-5.15%
D4	1-5	73.89	0.57	0.77	2.91	222.39
Change from BL Average		0.49%	13.47%	7.26%	-23.48%	0.48%

Test Order for Mode 1-5 Test Session - Baselines & Devices

1st	Baseline 1*	BL1	5-10 min Tests
2nd	Baseline 2*	BL2	5-10 min Tests
3rd	Baseline 3	BL3	5-10 min Tests
4th	Baseline 4	BL4	5-10 min Tests
5th	SAF-FD V.1.0	D1	5-10 min Tests
6th	AF-FD V.1.0	D2	5-10 min Tests
7th	R.2.d.lh	D3	5-10 min Tests
8th	R.1.d.xp	D4	5-10 min Tests

*Data not used due to the incorrect test group was loaded for the test engine & caused dyno control problems for baselines 1 & 2

HEAVY SERVICE WEIGHTED AVERAGE - GRAMS PER BRAKE HORSEPOWER HOUR
Weighting for Service Type - Hypothetical Heavy Service Mode 1 - 10% / Mode 2 - 10% / Mode 3 - 10% / Mode 4 - 35% / Mode 5 - 35%

Test	Mode	BHP	HC	CO	KNO	FUEL
BL3	1-5	143.42	0.18	0.47	3.47	177.26
BL4	1-5	142.94	0.16	0.43	3.33	177.37
BL Average		143.18	0.17	0.45	3.40	177.32
D1	1-5	144.21	0.16	0.46	2.69	175.68
Change from BL Average		0.72%	-6.62%	2.69%	-21.05%	-0.92%
D2	1-5	143.76	0.15	0.50	1.63	175.57
Change from BL Average		0.41%	-12.29%	10.67%	-51.98%	-0.98%
D3	1-5	144.38	0.26	0.64	1.80	175.05
Change from BL Average		0.84%	51.48%	42.33%	-46.93%	-1.28%
D4	1-5	143.23	0.19	0.46	1.91	178.24
Change from BL Average		0.04%	11.69%	1.17%	-43.89%	0.52%

EQUAL WEIGHTED AVERAGE - GRAMS PER BRAKE HORSEPOWER HOUR
Weighting for Service Type - Equal Mode 1 - 20% / Mode 2 - 20% / Mode 3 - 20% / Mode 4 - 20% / Mode 5 - 20%

Test	Mode	BHP	HC	CO	KNO	FUEL
BL3	1-5	112.13	0.32	0.57	3.66	194.13
BL4	1-5	111.42	0.28	0.52	3.47	194.78
BL Average		111.77	0.30	0.55	3.57	194.45
D1	1-5	113.80	0.28	0.56	3.06	190.62
Change from BL Average		1.82%	-7.49%	2.06%	-14.19%	-1.97%
D2	1-5	112.34	0.26	0.61	1.72	191.76
Change from BL Average		0.51%	-13.68%	10.78%	-51.84%	-1.39%
D3	1-5	113.97	0.47	0.88	2.23	189.02
Change from BL Average		1.97%	57.06%	60.61%	-37.45%	-2.80%
D4	1-5	111.92	0.34	0.57	2.30	195.64
Change from BL Average		0.13%	12.74%	4.25%	-35.45%	0.61%

Summary Prepared October 9, 2005