Executive Summary – Fuel Additive

EPA based fuel economy testing was completed at the Ohio State University Center of Automotive Research.   The purpose of the testing was to take a commercial Fedex truck and have 3rd party fuel economy and emissions testing completed before and after HSS Diesel Extreme was added to the tank.   The test truck was a 2006 P500 Freightliner with 247631 miles.   The fleet owner has never used oil or fuel additives in the past.   Two standard EPA fuel economy tests were performed to simulate driving conditions in the city and highway driving.   Fuel economy measured on a dyno is viewed as having a +/- 2% repeatability.   We have taken the following steps to increase the repeatability for this test.   A professional driver was used to conduct the tests, baseline and product testing were conducted on the same day with the same weather conditions and fuel consumed was measured gravimetrically with 4 significant digits. The baseline and test runs were completed 3 times to ensure repeatability. The product was tested at the standard 1 quart of Diesel Extreme per 75 gallons of diesel fuel as directed on the bottle.

UDDS (City Driving test Results)

# of tests	Condition	Total Hydro Carbon g/mile	±	Carbon Monoxide g/mile	±	Nox g/mile	±	Fuel Economy (miles/gal)	±
3	Baseline	0.43	0.01	2	0.07	4.43	0.03	14.25	0.16
3	w/ Diesel Extreme	0.44	0.02	1.86	0.12	4.82	0.02	14.55	0.13

Impact of Diesel Extreme on emissions and fuel economy USDS results:

	THC	CO	Nox	Fuel Economy Increase
Fuel Additive vs. Baseline	0.60%	-6.80%	8.90%	**2.10%**

55 mph (Steady state Highway Driving Test)

# of tests	Condition	Total Hydro Carbon g/mile	±	Carbon Monoxide g/mile	±	Nox g/mile	±	Fuel Economy (miles/gal)	±
3	Baseline	0.105	0.01	0.57	0.01	2.09	0.02	23.65	0.2
3	w/ Diesel Extreme	0.09	0	0.49	0	2.21	0.02	24.86	0.46

Impact of Diesel Extreme on emissions and fuel economy SteadyState Test results:

	THC	CO	Nox	Fuel Economy Increase
Fuel Additive vs. Baseline	-14.40%	-15.10%	5.90%	**5.10%**

Conclusion: The results showed a notable increase in fuel economy of 2.1% in the city driving test and 5.1 % in the highway driving.   Regained fuel economy is likely due to a combination of cleaning of internal diesel injector deposits that were preventing optimum combustion along with the improvement of fuel quality due to the cetane improver contained in the test product.

Executive Summary Completed by: Kevin Adams – Chemical Engineer – LSI Labs, December 15, 2016

OSU-CAR ES TEST REPORT – LUBRICATION SPECIALTIES FUEL PRODUCT

DECEMBER 8, 2016

Walt Dudek

Introduction

The Ohio State University Center for Automotive Research was retained by Lubrication Specialties to complete an independent evaluation of a product for emissions and fuel economy improvements. The fuel product was labeled Hot Shot's Secret Diesel Extreme Diesel Fuel Additive. The Engineering Services group (CAR-ES) was fully responsible for the design of the test plan and completion of the test program. The additive product was delivered directly to CAR-ES by the customer. The test vehicle was provided by the customer.

Test Plan

The approach to testing was to generate baseline data for the test vehicle using standard commercial diesel fuel over a series of tests. The test sequence was then repeated using the customer's fuel additive product. The baseline data was directly compared to data generated over the same test cycles using the customer's fuel product. Both tests sequences were conducted using the same test vehicle with the same test driver provided by CAR-ES. The vehicle dynamometer loading conditions and base fuel supply were consistent throughout the program.

Two test cycles were used for this program. The EPA Heavy-Duty Urban Dynamometer Driving Schedule (UDDS) and a five minute steady-state 55 mph cruise. The UDDS was developed for the chassis dynamometer testing of heavy-duty vehicles (40 CFR 86 App. I). The 55 mph steady-state cruise test was used to provide a test cycle which had no driver/throttle interaction.

The vehicle was tested in the following sequence for the evaluation program:

1. The vehicle was installed on the chassis dynamometer and secured
2. An external fuel tank was installed to allow gravimetric measurement of fuel consumed during testing
3. The external fuel tank was filled with commercial low sulfur diesel fuel
4. The vehicle was warmed up and Coastdown tests were completed to determine appropriate dynamometer simulation settings per Petrushov (SAE 970408)

Baseline Testing
5. Vehicle warmup for 20 minutes
6. UDDS Test Cycle #1
7. UDDS Test Cycle #2
8. UDDS Test Cycle #3
9. UDDS Test Cycle #4
10. Steady-State Test Cycle #1

11. Steady-State Test Cycle #2
12. Steady-State Test Cycle #3

Product Testing – Fuel Additive

13. Add fuel additive product to external fuel tank following bottle instructions
     - Product was added to commercial fuel remaining in the external tank at the completion of baseline testing. The external tank was then filled completely from the original fuel source. The total volume of treated fuel was 15.0 gallons.
14. 60-Minutes of vehicle operation in alternating 10-minute intervals of 55 and 45 mph to ensure full vehicle exposure to the fuel product.
15. UDDS Test Cycle #1
16. UDDS Test Cycle #2
17. UDDS Test Cycle #3
18. UDDS Test Cycle #4
19. Steady-State Test Cycle #1
20. Steady-State Test Cycle #2
21. Steady-State Test Cycle #3

End of Test Program

Test Vehicle

The test vehicle was provided by the customer; a 2006 Freightliner P500. This vehicle was a representative "in-use" vehicle which fulfilled the customer's target vehicle type. The vehicle was checked for road and dyno worthiness prior to starting the test program. All fluids were verified to be at manufacturer specified levels and the tires and exhaust system were found to be in good condition and leak free. There were no mechanical problems or check engine lights present during the program.

During testing the vehicle simulation was set for a vehicle mass of 11,000 lbs. which represents a partial cargo load for this model.

| Make	Freightliner
Model	P500
Model Year	2006
VIN #	4UZAANBW16CV95203
Odometer Mileage (prior to testing)	247,631

Test Procedures

Description of Testing:

UDDS Test. Each UDDS test completed during this program was performed with the vehicle warmed up and running in idle at the start of the test. Engine crank emissions were not collected during this program. The UDDS simulates typical city driving and raw emissions were continuously sampled to calculate a grams/mile emissions result for total hydrocarbons (THC), carbon monoxide (CO), and oxides of nitrogen (NO_x). Fuel economy, in miles per gallon, is determined via gravimetric measurement of the auxiliary external fuel tank.

Steady-State Test. The steady-state test included five minutes of vehicle operation at 55 mph using the vehicle cruise control. Prior to sample collection the vehicle was operated at the test condition for five minutes. The sampled portion of the cycle was repeated three times and all emissions measurements are taken as described for UDDS Testing. Fuel economy, in miles per gallon, is again determined via gravimetric measurement of the auxiliary external fuel tank.

Accuracy of Repeat Measurements. Fuel economy measured on a chassis dynamometer using an external gravimetric tank are viewed as repeatable within ±2%. Any variation within ±2% can be influenced by test-to-test measurement scatter. Emissions measurements do not have an established industry test-to-test variance. The "±" listed for each result in this report is based on a 95% confidence interval.
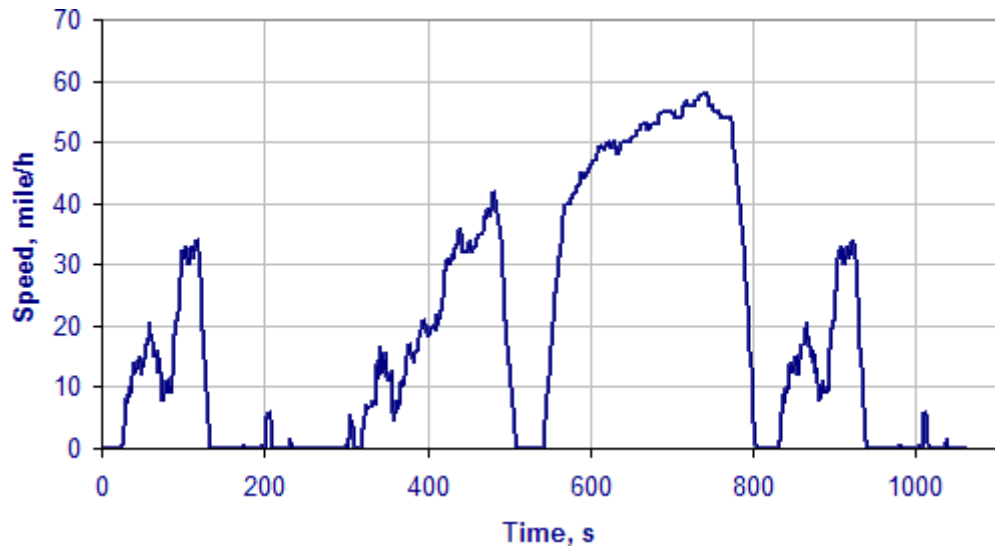
The UDDS Driving Cycle

The Fuel product was added to the auxiliary external fuel tank following the packaging directions.

Test Results

The UDDS and Steady-State emissions and fuel economy results are summarized in the following tables.

UDDS Test Results:

# of Tests	Condition	THC (g/mile)	±	CO (g/mile)	±	NOx (g/mile)	±	Fuel Economy (miles/gal)	±
4	Baseline	0.43	0.01	2.00	0.07	4.43	0.03	14.25	0.16
4	Fuel Additive	0.44	0.02	1.86	0.12	4.82	0.02	14.55	0.13

Impact of Product on emissions and fuel economy UDDS Test results:

	THC	CO	NOx	FE
Fuel Additive vs Baseline	0.6%	-6.8%	8.9%	2.1%

UDDS Results Discussion

The use of the fuel additive product resulted in slight changes in THC emissions, CO emissions, and measured fuel economy during the UDDS tests completed as compared to the baseline results. The emissions results are within the 95% data confidence and can be viewed as standard test-to-test variance. The fuel economy slightly exceeded the ±2% band which is considered standard test-to-test variance. NOx emissions were increased with the use of the fuel additive product.

Steady-State Test Results:

# of Tests	Condition	THC (g/mile)	±	CO (g/mile)	±	NOx (g/mile)	±	Fuel Economy (miles/gal)	±
3	Baseline	0.105	0.01	0.57	0.01	2.09	0.02	23.65	0.20
3	Fuel Additive	0.090	0.00	0.49	0.00	2.21	0.02	24.86	0.46

Impact of Product on emissions and fuel economy Steady-State Test results:

	THC	CO	NOx	FE
Fuel Additive vs Baseline	-14.4%	-15.1%	5.9%	5.1%

Steady-State Results Discussion

The use of the fuel additive product had a positive impact on THC and CO emissions and a negative impact on NOx emissions during the Steady-State tests completed as compared to the baseline results. There was a measured fuel economy improvement which exceeded the ±2% range of test-to-test variance for this test set.

Summary

The Ohio State University Center for Automotive Research has observed no significant measureable decrease in vehicle emissions or increase in fuel economy during testing of the customer's fuel additive product over the UDDS test cycle.

During steady-state testing a measurable increase in fuel economy was coupled both increases (NOx) and decreases (THC and CO) in emissions during testing of the customer's fuel additive product.

The duration of the test program was short by design and did not include extensive mileage accumulation or operation after the product was introduced into the vehicle fuel. No observations on the possible effects of extended product use can be drawn from this data set.

Individual Test Results Summary

Test	#	Condition	Time	Distance	THC	CO	Nox	Fuel	Exhaust Volume	Exhaust Volume	Exhaust Volume	THC	THC	CO	CO	Nox	Nox	FE	FE
			mm:ss	miles	ppm	ppm	ppm	grams	m3/min	m3	ft3	g	g/mile	g	g/mile	g	g/mile	gallons	mpg
UDDS	1	Baseline	17:55	5.54	87.42	228.87	287.17	1281	2.54	45.48	1606.28	2.29	0.41	12.12	2.19	24.98	4.51	0.40	14.02
UDDS	2	Baseline	17:55	5.56	101.98	202.66	282.42	1236	2.51	45.03	1590.17	2.65	0.48	10.62	1.91	24.32	4.37	0.38	14.58
UDDS	3	Baseline	17:55	5.54	92.84	210.63	282.06	1287	2.52	45.23	1597.18	2.42	0.44	11.09	2.00	24.40	4.41	0.40	13.94
UDDS	4	Baseline	17:55	5.55	89.17	204.19	289.53	1244	2.48	44.44	1569.22	2.29	0.41	10.56	1.90	24.61	4.43	0.38	14.46
			Average	5.55	92.85	211.59	285.30	1262	2.51	45.04	1590.71	2.41	0.43	11.10	2.00	24.58	4.43	0.39	14.25
			Stdev	0.01	6.49	12.03	3.66	25.73					0.03		0.13		0.06		0.32
			+/-	0.01	3.24	6.01	1.83	12.86					0.01		0.07		0.03		0.16
UDDS	1	Fuel Add	17:55	5.56	85.99	195.93	320.02	1205	2.43	43.55	1538.11	2.16	0.39	9.94	1.79	26.66	4.80	0.37	14.94
UDDS	2	Fuel Add	17:55	5.50	89.29	168.01	314.67	1228	2.45	43.83	1547.75	2.26	0.41	8.57	1.56	26.38	4.80	0.38	14.51
UDDS	3	Fuel Add	17:55	5.52	106.29	216.62	314.68	1247	2.51	44.88	1585.03	2.75	0.50	11.32	2.05	27.01	4.89	0.38	14.35
UDDS	4	Fuel Add	17:55	5.56	95.77	216.77	307.53	1249	2.53	45.38	1602.41	2.51	0.45	11.45	2.06	26.69	4.80	0.39	14.41
			Average	5.53	94.34	199.33	314.23	1232.25	2.48	44.41	1568.32	2.42	0.44	10.32	1.86	26.69	4.82	0.38	14.55
			Stdev	0.03	8.95	23.06	5.12	20.48					0.05		0.24		0.05		0.27
			+/-	0.01	4.47	11.53	2.56	10.24					0.02		0.12		0.02		0.13

Test	#	Condition	mm:ss Time	miles Distance	ppm THC	ppm CO	ppm Nox	grams Fuel	m3/min Exhaust Volume	m3 Exhaust Volume	ft3 Exhaust Volume	THC g	THC g/mile	CO g	CO g/mile	Nox g	Nox g/mile	FE gallons	FE mpg
SS	1	Baseline	5:01	4.67	54.55	130.60	277.28	637	3.60	18.07	638.27	0.57	0.12	2.75	0.59	9.59	2.05	0.20	23.75
SS	2	Baseline	5:05	4.73	44.13	126.62	284.71	658	3.58	18.20	642.89	0.46	0.10	2.68	0.57	9.91	2.10	0.20	23.28
SS	3	Baseline	5:01	4.68	42.89	125.53	290.21	633	3.56	17.83	629.82	0.44	0.09	2.61	0.56	9.90	2.12	0.20	23.94
		Average		4.69	47.19	127.58	284.07	642.67	3.58	18.04	636.99	0.49	0.10	2.68	0.57	9.80	2.09	0.20	23.65
		Stdev		0.03	6.41	2.67	6.49	13.43				0.01	0.01	0.02	0.02	0.03	0.03		0.34
		+/-		0.02	3.70	1.54	3.75	7.75					0.01		0.01		0.02		0.20
SS	1	Fuel Add	5:05	4.68	43.61	113.93	308.27	633	3.41	17.35	612.71	0.44	0.09	2.30	0.49	10.23	2.18	0.20	23.97
SS	2	Fuel Add	5:11	4.77	41.05	111.25	319.05	606	3.40	17.60	621.67	0.42	0.09	2.28	0.48	10.74	2.25	0.19	25.50
SS	3	Fuel Add	5:12	4.79	41.58	113.07	311.39	617	3.40	17.67	623.87	0.42	0.09	2.33	0.49	10.52	2.20	0.19	25.15
		Average		4.75	42.08	112.75	312.90	618.67	3.40	17.54	619.42	0.43	0.09	2.30	0.49	10.50	2.21	0.19	24.86
		Stdev		0.06	1.35	1.37	5.55	13.58				0.00	0.00	0.01	0.01	0.04	0.04		0.80
		+/-		0.03	0.78	0.79	3.20	7.84					0.00		0.00		0.02		0.46