FIELD STUDY

AMSOIL
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Diesel Fleet Fuel Economy in Stop-and-Go City Driving Conditions

In two scenarios, AMSOIL synthetic lubricants increased fuel economy compared to conventional lubricants.

Engine oil alone: 2.38%

Engine oil, transmission oil and differential lube: 3.15%

Overview

Few types of operating conditions decrease fuel economy in traditional engines more dramatically than stop-and-go city driving. It takes much more energy to move a vehicle from a standstill. All-day city driving in diesel delivery vehicles, road maintenance equipment, construction vehicles and similar equipment erodes the profitability and cost effectiveness of businesses and municipalities of all sizes.

Given the high cost of diesel fuel, even slight increases in fuel economy result in significant cost savings. Synthetic lubricants are increasingly being recognized for their ability to increase fuel economy and reduce costs compared to conventional lubricants.

Objective

Determine, using the SAE J1376 Fuel Economy Measurement Test (Engineering Type) for Buses and Trucks, whether AMSOIL synthetic diesel oil, transmission oil and gear lube collectively; or AMSOIL synthetic diesel oil alone, provide increased fuel economy compared to conventional lubricants in trucks operating in stop-and-go city conditions.

Method

At the request of AMSOIL INC., personnel from Auburn University's Program for Advanced Vehicle Evaluation (PAVE) compared fuel consumption in two class 8 diesel trucks in accordance with the SAE J1376 Fuel Economy Measurement Test (Engineering Type) for Buses and Trucks. Testing was done at Auburn University's National Center for Asphalt Technology (NCAT) Pavement Test Track and was designed to closely replicate real-world driving on city streets. The SAE J1376 test's primary goal is to eliminate all operating and environmental variables that may influence fuel economy. One truck, designated the control vehicle, operated using Chevron® conventional lubricants throughout the procedure. The other truck, designated the test vehicle, operated using AMSOIL synthetic lubricants.

Note: *The Chevron conventional lubricants and AMSOIL synthetic lubricants used in this study, obtained in March 2012, were available to consumers at the time of testing. Testing was completed in March 2012. Results do not reflect future formulation changes. Chevron conventional lubricants were chosen due to their widespread use in the trucking industry.*

SAE J1376 includes a baseline segment and a test segment. The baseline segment consisted of three test runs. Following each run, the total fuel consumed in the test vehicle was divided by the total fuel consumed in the control vehicle to produce a test/control (T/C) ratio. The average of the three T/C ratios was used in calculating the final fuel economy results. The baseline segment's main purpose is to determine the baseline rate of fuel consumption in both the test and control vehicles while operating with conventional lubricants.

The first test segment was conducted according to the same procedures, with the lone difference being installation of AMSOIL Premium 5W-40 Synthetic Diesel Oil in the test vehicle's engine. Three test runs were again conducted and their T/C ratios averaged. The average baseline and test segment T/C ratios were computed to determine the percentage of fuel economy improvement. For the second test segment, the test vehicle operated using AMSOIL synthetic drivetrain lubricants in the transmission and differentials, in addition to AMSOIL synthetic diesel oil in the engine.

Study Vehicles

In a study of this kind, it's critical the control and test vehicles exhibit specifications as close to identical as possible. The Auburn University Pavement Test Track provided two vehicles that demonstrated the following specifications:

	Control & Test Vehicles
Year	2004
Make	Freightliner®
Model	Columbia (day cab)
Engine	Detroit™ Diesel Series 60
Base Horsepower	435
Mileage, Control Vehicle	760,000
Mileage, Test Vehicle	895,000
Transmission	Eaton Fuller 10-Speed
Model#	RTOC-16909A
Differentials	Dana Spicer®
Model#	DSH40
Gross Vehicle Weight Rating (GVWR)	76,000 lbs.

Each vehicle pulled a 48' box trailer loaded with bulk concrete dead weights totaling a gross combined weight (GCW) of 76,000 pounds. Final GCW was representative of real-world trucking operations and was determined using a truck-and-trailer scale. To limit variables that may have affected fuel economy, skilled personnel from the Pavement Test Track experienced in fuel economy testing performed the following maintenance to each vehicle:

- Installation of new air filter
- Installation of new fuel filter
- Inspection and replacement (if necessary) of steering and drive tires
- Greasing of all chassis and driveshaft fittings
- Inspection and adjustment (if necessary) of truck and trailer brakes
- Inspection of trucks and trailers for overall cleanliness and mechanical integrity

Baseline Lubricant Selection

Prior to initiating the baseline segment, both the control and test vehicles underwent a thorough lubricant flush procedure to remove the engine oil, transmission oil and front and rear differential gear lube. After completely removing the old fluids, the following conventional lubricants were installed:

Engine: Chevron Delo® 400 LE SAE 15W-40

Transmission: Chevron Delo Trans Fluid ESI®

Front and Rear Differentials: Chevron Delo Gear Lube ESI SAE 80W-90

With both vehicles suitably prepared, the baseline segment was initiated.

Driving Conditions

To ensure consistency, the control and test vehicles followed identical procedures throughout the test, beginning with a one-hour warm-up time prior to each segment to stabilize operating temperatures. Each driver became familiar with the route and demonstrated methodical driving habits. An onboard observer accompanied both the control and test vehicles during all test runs to monitor driving conditions, record driving times and synchronize driver actions.

During each run, both drivers achieved similar engine rpm prior to shifting and similar throttle positioning during acceleration. Each traveled within 2 mph of the target speed limit at all times, braked appropriately and maintained an appropriate following distance to eliminate aerodynamic draft effects. Vehicle operation was synchronized using handheld radios and digital stopwatches to ensure identical duty cycles. Each driver and observer noted any differences between test runs that may have had an effect on test results. No vehicle or operational issues were encountered during any phase of testing. The trucks repeated test runs until compiling the required data.

Test Route & Ambient Conditions

Testing was conducted on Auburn University's NCAT Pavement Test Track located in Opelika, Ala. It is a 1.7-mile closed-loop track used to simulate local driving cycles on city streets. Each individual run totalled 3 miles at a maximum speed of 35 mph with approximately 2 stops per mile. The track's parking area served as the starting and stopping points for each run as well as the refueling point. The trucks repeated test runs until compiling the required data.

When cued, both trucks immediately departed the starting area and navigated the track. Upon completion, each trucks' 18-gallon portable fuel tanks were removed and weighed to the nearest 0.1 gallon using a calibrated digital scale. Each truck then refueled from the same pump and readied for the following test run. Off-road, ultra-low-sulfur #2 diesel fuel was used throughout. All fueling equipment was stationed at the Auburn University NCAT Pavement Test Track and operated by Track personnel.

The weather conditions (e.g. temperature, humidity, barometric pressure, wind direction, wind speed) were recorded as well as fuel temperature, odometer mileage, road and traffic conditions, load shifting in the trailer and possible fluid leaks.

18-gallon portable fuel tanks

Aerial view of test track

Test Segment Lubricant Selection

Upon completion of the baseline segment, the engine in the test vehicle alone was flushed using the same guidelines followed prior to the baseline segment. The lone difference, however, was installation of AMSOIL Premium 5W-40 Synthetic Diesel Oil. The first test segment, designed to isolate motor oil selection as the lone variable affecting fuel economy, was conducted following the same route and procedures used during the baseline segment. Consecutive runs were completed until compiling the required data. Afterward, the test vehicle again underwent the flushing procedure. The following AMSOIL synthetic lubricants were installed throughout the drivetrain in preparation for the second test segment:

Engine: Premium 5W-40 Synthetic Diesel Oil

Transmission: SAE 50 Long-Life Synthetic Transmission Oil

Front and Rear Differentials: 75W-90 Long Life Synthetic Gear Lube

The second test segment was conducted to isolate motor oil, transmission oil and gear lubricant selection as the lone variables affecting fuel economy.

Results

Baseline Segment

Fuel economy results are calculated using the SAE J1376 Fuel Economy Measurement Test (Engineering Type) for Buses and Trucks and require an understanding of how T/C ratios are calculated. Using Run 1 from Table 1 as an example, dividing 27.90 (pounds of fuel consumed in the test vehicle) by 29.10 (pounds of fuel consumed in the control vehicle) produces the T/C ratio (0.9588). The ratio indicates for every 1.00 pound of fuel consumed by the control vehicle (using conventional lubricants), the test vehicle (also using conventional lubricants) consumed 0.9588 pounds of fuel. It is evident the control vehicle displayed reduced fuel economy compared to the test vehicle despite both using the same conventional lubricants under identical operating procedures. This portion of the test identifies the natural differences between identically equipped vehicles.

SAE J1376 requires conducting runs until three T/C ratios within a 2 percent range are achieved. This requirement helps eliminate statistical anomalies that skew final results. Three runs were required to obtain three acceptable T/C ratios, which were averaged to calculate the Average Baseline T/C Ratio (0.9542).

Table 1 Baseline Segment Results

	Run 1	Run 2	Run 3
Control Vehicle (lbs. fuel consumed)	29.10	29.20	29.00
Test Vehicle (lbs. fuel consumed)	27.90	27.70	27.70
T/C Ratio	0.9588	0.9486	0.9552

Avg. Baseline
T/C Ratio
0.9542

Test Segment (Engine Only)

Following the baseline segment, the test vehicle alone underwent the previously described flushing procedure prior to the installation of AMSOIL Premium 5W-40 Synthetic Diesel Oil. The control vehicle continued to operate with Chevron conventional lubricants.

Test segment results are calculated in identical fashion. Three test runs were needed to achieve the three required T/C ratios falling within a 2 percent range. Table 2 displays the results. Averaging the three T/C ratios produces an Average Test T/C Ratio of 0.9315. This ratio initially indicates that for every 1.00 pound of fuel consumed by the control vehicle (using conventional diesel oil), the test vehicle (using AMSOIL Premium 5W-40 Synthetic Diesel Oil) consumed 0.9315 pounds of fuel. Applying the natural differences identified in the baseline segment between the control and test vehicles, the switch to AMSOIL synthetic lubricants resulted in increased fuel economy. Determining the exact percentage requires completing the equation shown below.

Table 2 Test Segment Results (Engine Only)

	Run 1	Run 2	Run 3
Control Vehicle (lbs. fuel consumed)	29.40	28.80	29.40
Test Vehicle (lbs. fuel consumed)	27.20	26.90	27.50
T/C Ratio	0.9252	0.9340	0.9354

Avg. Test T/C Ratio **0.9315**

***(0.9542 – 0.9315) / 0.9542 x 100% =** **2.38% Improved Fuel Economy**
using AMSOIL Premium 5W-40 Synthetic Diesel Oil

** (Avg. Baseline T/C Ratio) – (Avg. Test T/C Ratio) / (Avg. Baseline T/C Ratio) x 100%*

Test Segment (Engine, Transmission & Differentials)

Testing was performed to determine if installing AMSOIL synthetic transmission and gear lubricants, in addition to AMSOIL synthetic diesel oil, would result in improved fuel economy compared to conventional lubricants. Three test runs were needed to achieve the required T/C ratios falling within a 2 percent range. Table 3 displays the results. Averaging the three T/C ratios produces an Average Test T/C Ratio of 0.9241. This ratio initially indicates that for every 1.00 pound of fuel consumed by the control vehicle (using conventional lubricants), the test vehicle (using AMSOIL Premium 5W-40 Synthetic Diesel Oil, SAE 50 Long-Life Synthetic Transmission Oil and 75W-90 Long Life Synthetic Gear Lube) consumed 0.9241 pounds of fuel. Applying the natural differences identified in the baseline segment between the control and test vehicles, the switch to AMSOIL synthetic lubricants resulted in increased fuel economy. Determining the exact percentage requires completing the equation shown below.

Table 3 Test Segment Results (Engine, Transmission & Differentials)

	Run 1	Run 2	Run 3
Control Vehicle (lbs. fuel consumed)	29.50	29.30	29.50
Test Vehicle (lbs. fuel consumed)	27.50	27.00	27.10
T/C Ratio	0.9322	0.9215	0.9186

Avg. Test T/C Ratio **0.9241**

***(0.9542 – 0.9241) / 0.9542 x 100% =** **3.15% Improved Fuel Economy**
using AMSOIL synthetic lubricants in the engine, transmission and differentials

** (Avg. Baseline T/C Ratio) – (Avg. Test T/C Ratio) / (Avg. Baseline T/C Ratio) x 100%*

Reduced Emissions

A reduction in fuel consumption directly correlates to a reduction in exhaust emissions. The Environmental Protection Agency (EPA) established limits for diesel exhaust emissions, and the calculations below are derived from the 2010 limits that apply to model-year 2010 and newer vehicles. Many state and local governments have adopted these standards for older engines as well, which often require aftermarket exhaust treatment devices, such as diesel particulate filters, to meet the standards. Table 4 compares emissions levels from a single truck operating with conventional lubricants and the same truck realizing 2.38 percent and 3.15 percent reductions in emissions operating with AMSOIL synthetic diesel oil and AMSOIL synthetic drivetrain lubricants, respectively.

Table 4 Emissions Reductions

	2010 EPA Limits	Annual Emissions Operating with Conventional Lubricants*		Annual Emissions Reductions by Improving Fuel Economy with AMSOIL Synthetic Lubricants			
				2.38% (Engine only)		3.15% (Engine, transmission & differentials)	
Nitrogen Oxides (NO_x)	0.2 g/bhp-hr	228.8 kg/yr**	503.4 lb/yr	5.4 kg/yr†	11.9 lb/yr	7.2 kg/yr	15.9 lb/yr
Particulate Matter (PM)	0.01 g/bhp-hr	11.4 kg/yr	25.1 lb/yr	0.3 kg/yr	0.6 lb/yr	0.4 kg/yr	0.8 lb/yr
Carbon Dioxide (CO_2)	10.1 kg/gal	202,000.0 kg/yr	444,400.0 lb/yr	4,807.6 kg/yr	10,576.7 lb/yr	6,363.0 kg/yr	13,998.6 lb/yr
Carbon Monoxide (CO)	15.5 g/bhp-hr	17,732.0 kg/yr	39,010.4 lb/yr	422.0 kg/yr	928.4 lb/yr	558.6 kg/yr	1,228.8 lb/yr

* *Based on 400-hp truck averaging 120,000 annual miles; achieving 6 mpg; and operating 11 hours/day, 5 days/week, 52 weeks/year*

** *Sample Calculation: NO_x = 0.2g/bhp-hr x 400hp = 80g/hr x 11hr x 5 days x 52 weeks = 228.8kg/yr*

† *AMSOIL Reduction: NO_x = 228.8kg/yr x 0.0238 = 5.4kg/yr (reduction)*

Conclusion

Testing completed by Auburn University's Program for Advanced Vehicle Evaluation, in compliance with the industry-standard SAE J1376 Fuel Economy Measurement Test (Engineering Type) for Buses and Trucks, demonstrates use of AMSOIL Premium 5W-40 Synthetic Diesel Oil in trucks operating in stop-and-go city conditions can increase fuel economy and, in this case, did by 2.38 percent. Additional testing demonstrates AMSOIL synthetic drivetrain lubricants installed in the engine, transmission and differentials can increase fuel economy and, in this case, did by 3.15 percent.

The study was designed to eliminate environmental and operating variables by using two nearly identical trucks and operating them in a consistent and methodical fashion throughout the same controlled test track. Data indicates installing AMSOIL synthetic lubricants in the test vehicle's engine, transmission and front and rear differentials resulted in increased fuel economy, which correlates to reduced fuel costs and exhaust emissions.

Although this study was completed using full-sized class 8 trucks and 48' box trailers, these results should extend to other types of class 8 diesel applications used in stop-and-go conditions as well. The fuel economy benefits provided can reduce costs for vehicles operating in a variety of scenarios, including relatively few daily miles or significantly more.

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