Program for Advanced Vehicle Evaluation

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Report on

SAE J1321 (TMC RP-1102) Type II Fuel Consumption Test

Conducted for

Evans Cooling Systems, Inc.
255 Gay Street
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ABSTRACT

The purpose of the testing program described herein was to evaluate the impact on fuel economy resulting from two different engine cooling system configurations. The first evaluation (Test # 09-1A) the standard ethylene glycol engine coolant was replaced in the Test vehicle with the Evans NPG + waterless coolant (1% water in system after fill of NPG +). In the second evaluation (Test # 09-1B) the Evans NPG + waterless coolant remained and the two standard cooling thermostats (part # 23537137) were replaced with two 215°F thermostats, supplied by Evans Cooling System personnel in the Test vehicle. Standard water based ethylene glycol engine coolant and the standard cooling thermostats (190°F) were used in the Control Vehicle, throughout both tests. The cooling system fans were locked in the "ON" position, on both the Test and Control Vehicles, during the Baseline and Test segments of both tests to eliminate the fan as a variable.

Testing was conducted by the PAVE Research Institute between the dates of January 12 and January 16, 2009 on a 42-mile test loop on Interstate I-85 between exit 70 (the stop and start point) and exit 51 (the turnaround point where test vehicles reversed direction). The SAE J1321 (TMC RP-1102) Type II test procedure was used, incorporating the SAE 40 mile minimum test run. The TMC/SAE Type II test results showed the following:

- Test # 09-1A - 0.26% improvement in fuel economy
- Test # 09-1B +3.04% improvement in fuel economy

SAE J1321 (TMC RP-1102) states that based on experience overall test accuracy for this procedure is expected to be within 1 percent. The addition of Evans NPG + waterless coolant alone (Test # 09-1A) showed no change or impact on fuel economy. The addition of Evans NPG + Waterless coolant and operation at a higher temperature (Test # 09-1B) would be expected to produce an actual improvement in fuel economy of between +2.04 and +4.04 percent.

Two 2004 Freightliner Columbia Series Model C120 tractors (Units 1 and 3), powered with Detroit Diesel 14L Series 60 engines were used in this evaluation. These tractors are part of The National Center for Asphalt Technology's (NCAT) Pavement Research Test Fleet. The tractors are in the 500,000 mile to 600,000 mile range of service life and in good mechanical condition. The tractor/trailers were loaded to approximately 76,000 GCW, using 48 foot van trailers that are equally loaded with concrete barriers. In consideration of the posted 70 mph speed limit on I-85, the target testing speed was set at 67 mph in order to minimize traffic disruptions. The average rolling trip speed was approx. 54.7 mph. Trip rolling times were acceptable on valid runs.

During testing, fuel consumption was measured in 18-gallon portable weigh tanks that only accommodated a single test run when filled to capacity. The weight of fuel consumed after each test run was measured using an Ohaus Champ II Model CH300R digital scale with a 650 pound capacity. Scale calibration was checked before and after each stage of testing. The measured specific gravity of the #2 diesel used during testing was 0.851 at 60°F. The same drivers remained with the Control vehicle and the Test vehicle for the duration of testing.

The Control vehicle was not altered in any way between the Baseline and Test segments. There were no operational issues during either test. The yellow "check engine" light came on 15 times during Test # 09-1B, giving a code indicating a higher than normal coolant operating temperature, but observation of DDEC data showed no coolant temperature above 215deg.F on a 40 mile run of test route. There is no reduction in engine power or power back with this code. The red engine light for power back or engine shut down did not come on during entire evaluation.

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INTRODUCTION

Recent historical increases in the cost of diesel fuel have resulted in an unprecedented interest in products that have the potential to improve fuel economy. At the request of Evans Cooling Systems, Inc., the PAVE Research Institute at Auburn University recently conducted a fuel economy test utilizing class 8 diesel trucks. The purpose of the testing was to quantify any benefits derived from the addition of Evans NPG + waterless coolant alone and the addition of Evans NPG + waterless coolant plus higher operating temperatures on a legally loaded test truck at highway speeds.

The procedure chosen for this evaluation was the *Joint TMC/SAE Fuel Consumption Test Procedure – Type II*, also known as SAE's J1321 and TMC's RP 1102. This procedure was developed specifically to meet the needs of the trucking industry, and it is an integral part of TMC's *Guidelines for Qualifying Products Claiming a Fuel Economy Benefit* (RP 1115).

TEST PROCEDURE

Vehicle Identification

The control and treatment tractors used in the experiment were sequential serial number 2004 Freightliner Columbia series Model C120 day cabs with no aerodynamic modifications. Both units were equipped with Detroit Diesel 60 Series DDEC-IV (EGR) engines rated at 435 hp at 2,100 rpms, the tractors are in the 500,000 mile to 600,000 mile range of service life and in good mechanical condition. Both tractors were equipped with Eaton Fuller 9 speed manual transmissions and cruise control, which produced approximately 1500 rpm at cruise speeds. Detailed information about the tractors (shown in Figure 1) is provided in the Appendix.

Figure 1 – Truck Configuration Used During the Testing Process

All fuel used was ultra low sulfur #2 diesel, verified by specific gravity at the time of testing. Any accessories that would have pulled auxiliary power were used in an identical manner in both tractors during all stages of Type II testing. Mirrors and windows were maintained in the same position for all stages of operation. Tire pressures were adjusted as necessary prior to the first test run on each day to ensure that all tires were within 5 psi of the manufacturers' recommended cold inflation temperatures. The tractor/trailers were loaded to approximately 76,000 GCW, using 48 foot van trailers that are equally loaded with concrete barriers.

Test Route

As seen in Figure 2, the test route consisted of a 41.5 mile round trip loop along interstate 85 between milepost 70 and milepost 51, with a parking lot that was located at exit 70 used to stage the testing operation. A loop extension located near exit 51 was used as a turn around point. The extension, which is located at the National Center for Asphalt Technology's main lab, was used to get the full SAE 40 mile run. It was determined during the planning process that traffic along this section of interstate 85 would facilitate reliable testing without significant traffic disruptions.

Figure 2 – Section of I-85 Used for Round Trip Type II Test Route

Each Type II test run consisted of at least 40 miles of continuous operation on the chosen test route, with vehicles spaced out in order to prevent aerodynamic interaction. The travel speed of the test vehicles was maintained at approximately 67 mph using cruise control, while running in overdrive (9^{th}) gear to produce rpm levels and vehicle dynamics representative of real world duty cycles.

Research Methodology

A work plan was developed based upon the *Joint TMC/SAE Fuel Consumption Test Procedure – Type II* methodology. In this procedure, fuel consumption measurements in a test vehicle (T) are compared to measurements from a control vehicle (C) before and after treatment. The difference between the before and after T/C ratios are used to calculate a fuel savings percentage presumably resulting from the treatment. For the purpose of this study, a test run was defined as at least 40 miles of continuous driving on the interstate-based test route.

Vehicle operation was synchronized using handheld radios and digital stopwatches to ensure precisely identical duty cycles. Both trucks were outfitted with 18-gallon portable weigh tanks that accommodated 1 test run on a single fill (shown in Figure 3). During testing, fuel consumption was calculated by measuring the weight of fuel consumed after each 41.5-mile run An Ohaus Champ II Model CH300R digital scale with a 650 pound capacity was used. Scale calibration was checked before and after each stage of testing. The same drivers remained with both the control vehicle and the treatment vehicle for the duration of testing. The weighing process is shown in Figure 4. The T/C ratios for all test runs were calculated, and the first 3 ratios that fell within the prescribed 2 percent filtering band were used to compute an average value representing each segment of testing.

Figure 3 –Portable Weigh Tank

Figure 4 – Weighing Portable Tank to Within a Tenth of a Pound

Test Data

All raw experimental data collected in the field during the testing process are provided in Table 1. Baseline testing was completed on January 12, 2009. In the first evaluation (Test # 09-1A) the standard water based ethylene glycol engine coolant was replaced in the Test vehicle with the Evans NPG + waterless coolant (1% water in system after fill of NPG +). The coolant was replaced on the evening of January 12, 2009 after baseline testing was completed. The first evaluation was completed on January 14, 2008. In the second evaluation (Test # 09-1B) the Evans NPG + waterless coolant remained and the two standard cooling 190°F thermostats (part # 23537137) were replaced with two prototype 215°F thermostats that were supplied by Evans Cooling System personnel. The thermostats were replaced on January 14, 2009 after the first evaluation was finished. The second evaluation was finished on January 15, 2009.

			Test Vehicle				Control Vehicle			
Run	**Test Segment**	**41.5-mileTest Run**	**Begin Tank Wt. (lbs)**	**End Tank Wt. (lbs)**	**Fuel (lbs)**	**Run Trip Time**	**Begin Tank Wt. (lbs)**	**End Tank Wt. (lbs)**	**Fuel (lbs)**	**Run Trip Time**
1/12/2009	Baseline	1	201.7	138.3	63.4	44:45	198.7	135.9	62.8	44:57
		2	195.7	131.6	64.1	47:42	206.2	141.7	64.5	46:07
		3	191.8	129.5	62.3	45:35	204.0	141.6	62.4	45:16
		4	186.2	124.1	62.1	45:21	184.9	122.3	62.6	45:15
1/13/2009	1st Treatment Set	1	188.6	126.3	62.3	44:39	195.4	134.0	61.4	44:58
		2	197.3	135.2	62.1	45:15	203.4	141.4	62.0	45:00
		3	190.9	128.5	62.4	45:24	203.0	140.2	62.8	44:11
		4	183.2	120.6	62.6	46:14	195.7	131.0	64.7	47:01
		5	189.7	127.3	62.4	45:35	197.4	133.3	64.1	44:02
1/14/2009	1st Treatment Set	6	184.8	123.7	61.1	45:11	192.4	128.3	64.1	45:29
		7	203.2	141.1	62.1	46:59	197.8	136.2	61.6	45:20
1/15/2009	2nd Treatment Set	1	188.6	124.4	64.2	45:03	203.7	137.7	66.0	44:58
		2	196.4	132.8	63.6	45:21	204.4	138.9	65.5	45:00
		3	194.6	130.5	64.1	44:55	203.8	139.6	64.2	44:11
		4	179.1	116.0	63.1	45:08	175.8	110.3	65.5	47:01

Table 1 – Type II Test Raw Data (T=Treatment Vehicle, C=Control Vehicle)

Calculations

The first three runs of the baseline and test segments that passed through the statistical filter and met the requirements of the test procedure were used to compute fuel savings (in accordance with the testing specifications). The first, third, fourth and fifth Test segments from the 1st Treatment set as well as the third segment of the 2nd Treatment Set did not meet the requirement that T/C values fall within 2% (Table 2). Using the first three valid runs, it was determined that the addition of Evans NPG + waterless coolant alone (Test # 09-1A) showed no change or impact on fuel economy. While the addition of Evans NPG + Waterless coolant and operation at a higher temperature (Test # 09-1B) would be expected to produce an actual improvement in fuel economy of between +2.04 and +4.04 percent.

Run	Test Segment	40-mile Test Run	Fuel Vehicle Test (lbs)	Fuel Vehicle Control (lbs)	T/C (All)	T/C (Band)	T/C (Filter)	T/C (Avg)	% Improved
1/12/2009	Baseline	1	63.4	62.8	1.0096	101.6%	1.0096		
		2	64.1	64.5	0.9938	100.0%	0.9938		
		3	62.3	62.4	0.9984	100.5%	0.9984		
		4	62.1	62.6	0.9920	99.8%	0.9920	0.9985	
1/13/2009	1st Treatment Set	1	62.3	61.4	1.0147 [1]				
		2	62.1	62.0	1.0016	102.9%	1.0016		
		3	62.4	62.8	0.9936	102.1%	0.9936		
		4	62.6	64.7	0.9675 [1]				
		5	62.4	64.1	0.9735 [1]				
1/14/2009	1st Treatment Set	6	61.1	64.1	0.9532 [1]				
		7	62.1	61.6	1.0081	103.6%	1.0081	1.0011	-0.26%
1/15/2009	2nd Treatment Set	1	64.2	66.0	0.9727	99.9%	0.9727		
		2	63.6	65.5	0.9710	99.7%	0.9710		
		3	64.1	64.2	0.9984 [1]				
		4	63.1	65.5	0.9634	99.0%	0.9634	0.9690	3.04%

[1] Excluded from consideration because the requirement that valid T/C ratios be within 2% for each Test Segment was not met for this data point.

Table 2 – Type II Fuel Economy Test Calculations

DISCUSSION OF RESULTS

During Test #09-1B, the oil and coolant temperatures were recorded after both the Test and Control vehicles were powered down and began refueling. This was done on each of the first three runs and warm up. These recorded values indicate on a 42°F ambient temperature day, the coolant temperatures were 12 to 22 Fahrenheit degrees higher and the oil temperatures were 19 to 27 Fahrenheit degrees higher in Test vehicle which had the high temperature thermostats.

In a brief 40 mile over the route basic operating temperature observation the oil temperature was typically warmer than the coolant temperature, and the coolant temperature bumped 215 °F seven times, triggering a FMI I1 PID: 110 FMI: 14 code, which is a higher than normal coolant temperature warning. There is no reduction in engine power with this code or power back. This is a parameter that would be reprogrammed if the higher opening temperature thermostats were used full time.

SAE J1321 (TMC RP-1102) states that based on experience overall test accuracy for this procedure is expected to be within 1 percent. The addition of Evans NPG + waterless coolant alone (Test # 09-1A) showed no change or impact on fuel economy. The addition of Evans NPG + Waterless coolant and operation at a higher temperature (Test # 09-1B) would be expected to produce an actual improvement in fuel economy of between +2.04 and +4.04 percent.

APPENDIX – TRACTOR SPECIFICATIONS

- Model Year – 2004
- GVW – 52,000
- Engine – Minimum 14.0 Liter 435HP @ 2100 RPM 1650 LB/FT Torque
- Batteries – (3) 12V with 2280 CCA
- Positive Post for jump starting the truck
- Compressor – Minimum of 15.9 CFM
- Clutch – Eaton Fuller 15-1/2" Adjust Free
- Exhaust – Right hand mounted vertical exhaust with 13' 06" curved vertical chrome tailpipe.
- Coolant filter – Fleetguard or approved equivalent
- Radiator – Minimum 1350 SQ-IN
- Antifreeze – Minimum rating of –34F
- Transmission – Eaton Fuller RTOC-16909A
- Transmission – Convert transmission to 13-speed at 500,000 miles (Provide total price for parts and labor as a separate line item)
- Transmission oil cooler – Air to oil
- Front Axle – Dana Spicer E-1200I 3.5" Drop Front Axle rated at 12,000 LB
- Front Brakes – Dana Spicer 15 x 4L ES LMS Extended Lube front brakes
- Front Suspension – 12,000 LB Taper-Leaf
- Front Slack adjusters – Dana Spicer LMS Extended Lube automatic front slack adjusters
- Front shock absorbers
- Rear Axle – Dana Spicer DSH40 rated at 40,000 LB
- Rear Axle Ratio – 3.70
- Main Driveline – Dana Spicer SPL250HD
- Interaxle Driveline – Dana Spicer SPL170 XL
- Interaxle Lockout – To include indicator light
- Synthetic Oil – 50W Transmission / 75W – 90W all axles
- Rear Brakes – Dana Spicer 16.5x7L LMS extended lube
- Rear Slack Adjusters – Dana Spicer LMS extended lube automatic rear slack adjusters
- Rear Suspension – Airliner 40,000 LB extra duty
- Air Suspension Dump Valve – Manual with indicator light and warning buzzer
- Rear Shock Absorbers – Both axles
- Trailer Air Hose – 15' coiled
- Trailer Electrical Cable – 15' Coiled
- Wheelbase – 187"
- Frame – 7/16" x 3-11/16" x 11-1/8" steel frame with a ¼" full C-Channel frame reinforcement with a minimum RBM rating 3,432,000 lbf-in per rail
- Frame Overhang – Minimum of 57 inches
- Front Tow Hooks – Frame mounted

- Clear Frame Rails 30” back of cab for cab guard mounting
- Air Slide 5th Wheel – 24” with a vertical load capacity of 70,000 lbs and a trailing load capacity of 200,000 lbs
- Fuel Tank – 100 - gallon aluminum right hand mounted fuel tank
- Front Tires – 275/80R 22.5 14 PLY Michelin XZA2
- Front Wheels – Aluminum 10-Hub Pilot
- Rear Tires – 275/80R 22.5 14 PLY Michelin XDA H/T
- Rear Wheels – 10-Hub Pilot 5-hand steel wheels
- Cab – Minimum of 120” conventional cab
- Cab Mounts – Air ride
- Air Horn
- Utility Light – Flush mounted back of cab
- Mirrors – Dual West Coast heated mirrors with right hand remote 102” wide
- Convex Mirrors – 8” convex mirrors mounted under primary mirrors on driver and passenger sides
- Factory tinted windshield and glass
- Vent Windows
- Ash Tray and Lighter – Dash mounted
- Fire Extinguisher – Mounted left hand of drivers seat
- Heater and Defroster
- Air Conditioning
- Driver Seat – High back air ride driver seat with adjustable lumbar support and dual armrest
- Passenger Seat – High back non-suspension
- Seat Covers – Heavy duty vinyl
- Gauges – To include all standard gauges plus tachometer, trip meter, hour meter, voltmeter, air restriction indicator, low air pressure light and buzzer, primary and secondary air pressure gauges, engine coolant temperature, and engine oil pressure
- Radio – AM/FM/WB Cassette
- Trailer Brake – Hand Controlled
- Park Brake System – Two valve system with warning indicator