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AUTOMOTIVE PRODUCTS AND EMISSIONS RESEARCH DIVISION

SAE J1321 FUEL CONSUMPTION TEST EVALUATION OF A DIESEL FUEL ADDITIVE PRODUCT

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FINAL REPORT
SwRI Project 08 10587

Prepared for

CleanBoost™ and
CleanBoost HFO™

May 21, 2004

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I. EXECUTIVE SUMMARY

At the request of CleanBoost™ and CleanBoost HFO™, the Southwest Research Institute (SwRI) Fleet and Field Evaluations Section conducted fuel consumption tests utilizing three class-8 diesel trucks. Fuel consumption was measured during a baseline segment with commercially available #2 diesel fuel. The purpose of the program was to determine possible fuel savings benefits of a diesel fuel additive product, CleanBoost™, added to the diesel fuel compared to the baseline condition.

The procedure chosen for this evaluation was the SAE J1321 *"Joint TMC/SAE Fuel Consumption Test Procedure Type II"*. This recommended practice provides a standard test procedure for comparing the in-service fuel consumption of one or more vehicles operating under two conditions. An unchanging control vehicle is run in tandem with the test vehicle(s) to provide reference fuel consumption data. The result of a test using this procedure is the percentage difference in fuel consumption of one vehicle in two different test conditions.

The result of the average percent improvement in fuel economy for the test segment with CleanBoost™ added to the diesel fuel compared to the baseline segment is given in Table 1.

Table 1 – Percent Improvement in Fuel Economy Compared to the Baseline

		% Improvement in Fuel Economy		
	Diesel Fuel	Test Truck 415568	Test Truck 415572	Avg. of 2 Test Trucks
Baseline Segment	Commercially available #2 diesel			
Test Segment	Commercially available #2 diesel fuel with CleanBoost™*	3.63%	2.49%	3.06%

* CleanBoost™ was added to the diesel fuel as specified by the test sponsor in the test trucks and 1,500 miles were accumulated on each of the test trucks for conditioning prior to conducting the test segment.

II. PROCEDURE

SwRI conducted the SAE J1321 procedure using one control truck and two test trucks operated simultaneously on an interstate highway to simulate a long-haul route. The trucks were equipped with weigh tanks, which were used to measure fuel consumption. Refer to the photograph in Appendix B. The truck and trailer equipment was rented specifically for the test program.

A. Description of Test Vehicles

The trucks were identical 2003 model year Freightliner tractors. The trailers were 48-foot flat beds with concrete ballast. The trucks had the following driveline components:

1. The engines were Detroit Diesel 60 Series with exhaust gas recirculation (EGR).
2. The transmissions were Eaton Fuller FRO-15210C
3. The tractor axles were manufactured by Dana Spicer and had an axle ratio of 3.70.
   a) E- 1200I front axle
   b) DS404 R-SRS rear axle

One weigh tank with quick disconnect hose couplings was mounted on each truck. The fuel supply lines and return lines had been modified with quick-disconnect couplings to facilitate switching from the truck tank to the weigh tank. The trailers were ballasted with concrete blocks to provide a total truck and trailer rig weight of approximately 76,000 pounds. Table 2 provides the vehicle weight data.

Table 2 – Truck and Trailer Rig Weights

	Test Truck 1 Unit 415568	Control Truck Unit 415570	Test Truck 2 Unit 415572
Odometer at the start of the program	34,103	41,652	24,883
Trailer Number	381923	393961	381894
Front Axle (lbs.)	10,960	11,260	11,160
Truck Drive Axles (lbs.)	31,600	31,400	30,980
Trailer Axles (lbs.)	33,580	33,100	33,920
Total Rig Weight (lbs.)	76,140	75,760	76,060

B. Test Route (Long-Haul Cycle)

The test route chosen represented typical long-haul interstate highway operations. A low-density traffic portion of IH 35 was used between mile markers 124 and 144. Each lap was started by traveling south from mile marker 144 past 124 to the Devine, Texas exit. The trucks then crossed under the interstate to begin the second half of the route northbound from mile marker 124 to 144. The road surface was asphalt and generally flat with a few rolling hills. The drivers practiced laps until each driver became proficient with the driving procedure. Target times were established for the driver of each of the three trucks for both the southbound and northbound legs.

C. Long-Haul Cycle Operation

Prior to each day of operation, tire inflation pressures were checked and adjusted to the proper level. A pre-weighed fuel tank had been installed on each truck. The trucks were driven approximately 14 miles from SwRI to the beginning of the test route. One lap was run as a warm-up lap each day prior to measuring fuel consumption. The trucks started each lap with approximately five minutes separation between trucks.

Total fuel consumption was measured over a distance of 20 miles southbound and 20 miles northbound. To begin the southbound leg, the engine was stopped, and the fuel supply and return lines were switched from the truck tank to the weigh tank. The engine was restarted and the truck was accelerated to a cruising speed of 60 mph. The cruising speed was maintained for approximately 20 miles. After 20 miles, the truck was decelerated with brake application and stopped on the highway shoulder at a specified landmark. The engine was allowed to idle for approximately 60 seconds and then stopped to switch fuel lines from the weigh tank to the truck tank. The truck exited IH 35 to turn around for the northbound leg.

The northbound leg began on the shoulder of IH 35 at a designated landmark where the fuel lines were switched from the truck tank to the weigh tank. After starting the engine, the truck was accelerated to a cruising speed of 60 mph and stopped after completing approximately 20 miles. When the 60-second idle was complete, the fuel lines were switched and the truck was driven back to SwRI to determine the weight of fuel consumption.

To maintain consistent operation during the test phases, the trucks were operated with the headlights on, the air conditioning off, and the blower fan in low position. An observer in each truck recorded driving times for both the southbound and northbound legs. The time for each leg had to match the appropriate target times within 0.5% for that lap to be considered operationally valid. The laps were driven in this manner until at least enough valid laps were completed in each segment to meet the requirements of the standard J1321 procedure.

D. Installation of the Clean Boost™

CleanBoost™ and CleanBoost HFO™ supplied the CleanBoost™ diesel fuel additive for the test segment. Another company had sponsored an SAE J1321 segment prior to the test segment with the CleanBoost™ diesel fuel additive. That company had agreed in writing to allow CleanBoost™ and CleanBoost HFO™ to use the data from that segment as the baseline for the CleanBoost™ J1321 program.

SwRI had performed J1321 programs using these trucks since November 2003. None of the J1321 evaluations involved fuel additive products. During all the SAE J1321 segments only commercially available #2 diesel fuel was used. For the CleanBoost™ program only #2 diesel fuel from one batch at SwRI was used to fill the truck weigh tanks.

CleanBoost™ and CleanBoost HFO™ provided the instructions for mixing CleanBoost™ into the fuel. For the first fuel tank usage of CleanBoost™, the instructions recommend a ratio of 1 fluid ounce of CleanBoost™ to 15 gallons of diesel fuel. The right truck saddle tank of all three trucks had been removed for the gravimetric weigh tank used to measure fuel consumption. The left truck saddle tank had a capacity of 120 gallons of fuel. The left saddle tank in each test truck was filled with #2 diesel fuel. Eight fluid ounces of CleanBoost™ were added to the left saddle tank of each test truck. The technician, who added the CleanBoost™, shook the bottle of CleanBoost™ for 30 seconds each time prior to pouring it into the measuring jar.

The two test trucks were each driven for 1,500 miles at primarily highway speeds for conditioning. The weigh tanks were removed for the conditioning mileage. When #2 diesel fuel was added to the saddle tank, the amount was recorded. The amount of CleanBoost™, which was added to the saddle tank, was determined from a chart supplied by CleanBoost™ and CleanBoost HFO™ based on a regular addition ratio (after the first tank) of 1 fluid ounce to 23 gallons of diesel fuel. The operator shook the container of CleanBoost™ prior to measuring the amount as stated in the instructions. Only diesel fuel from one batch in an underground tank at SwRI was ever mixed with CleanBoost™ for this program.

The fuel for the weigh tanks of the test trucks was prepared in four 55-gallon drums as follows. Fifty gallons of #2 diesel fuel from the single batch was installed into a 55-gallon drum. The drum was either a new drum or had been used for previous J1321 programs with the single batch of fuel. The technician shook the bottle of CleanBoost™ for 30 seconds and then added CleanBoost™ at the regular ratio as noted in chart supplied by CleanBoost™ and CleanBoost HFO™. The four drums were clearly labeled “Diesel fuel with CleanBoost™ for test trucks 415568 and 415572 only”. The weigh tanks for the test trucks were drained and only the fuel from the labeled drums was used for the test truck weigh tanks. The control truck continued to be fueled with #2 diesel fuel from the single batch with no CleanBoost™ added. A complete SAE J1321 test segment was conducted.

III. RESULTS

A. Calculation of Fuel Economy Results

The fuel consumed in each test lap, which was operationally valid, is given in the table on page 1 of Appendix A. A set number was designated each time the control truck and test truck(s) attempted to make simultaneous test laps. The quantity (weight) of fuel consumed by each test truck (415568 and 415572) was compared to the quantity of fuel consumed in the control truck (415570). The weight of fuel used by a given test truck was divided by the weight of fuel used by the control truck in the simultaneous lap. The SAE J1321 procedure identifies this number as the T/C ratio.

The percent improvement in fuel economy, which can be either positive or negative, is calculated using the equation shown below. The table on page 1 in Appendix A lists the T/C ratios from all the operationally valid test laps. The T/C ratios, which passed the J1321 2.0% test criteria and were used to calculate the average T/C ratios, are noted with an asterisk.

Percent Improvement in Fuel Economy:
= [(Average Baseline T/C – Average Test T/C) / Average Test T/C] x 100

B. Percent Improvement in Fuel Economy Results

The average percent improvement in fuel economy for each individual test truck and the average of the two test trucks is shown in the graph on page 2 of Appendix A. As stated in Section 1, entitled SCOPE of the SAE J1321 procedure, the accuracy based on test experience will be within ±1.0%. The average percent improvement in fuel economy (+3.06%) for the #2 diesel fuel is considered significant compared to the baseline.

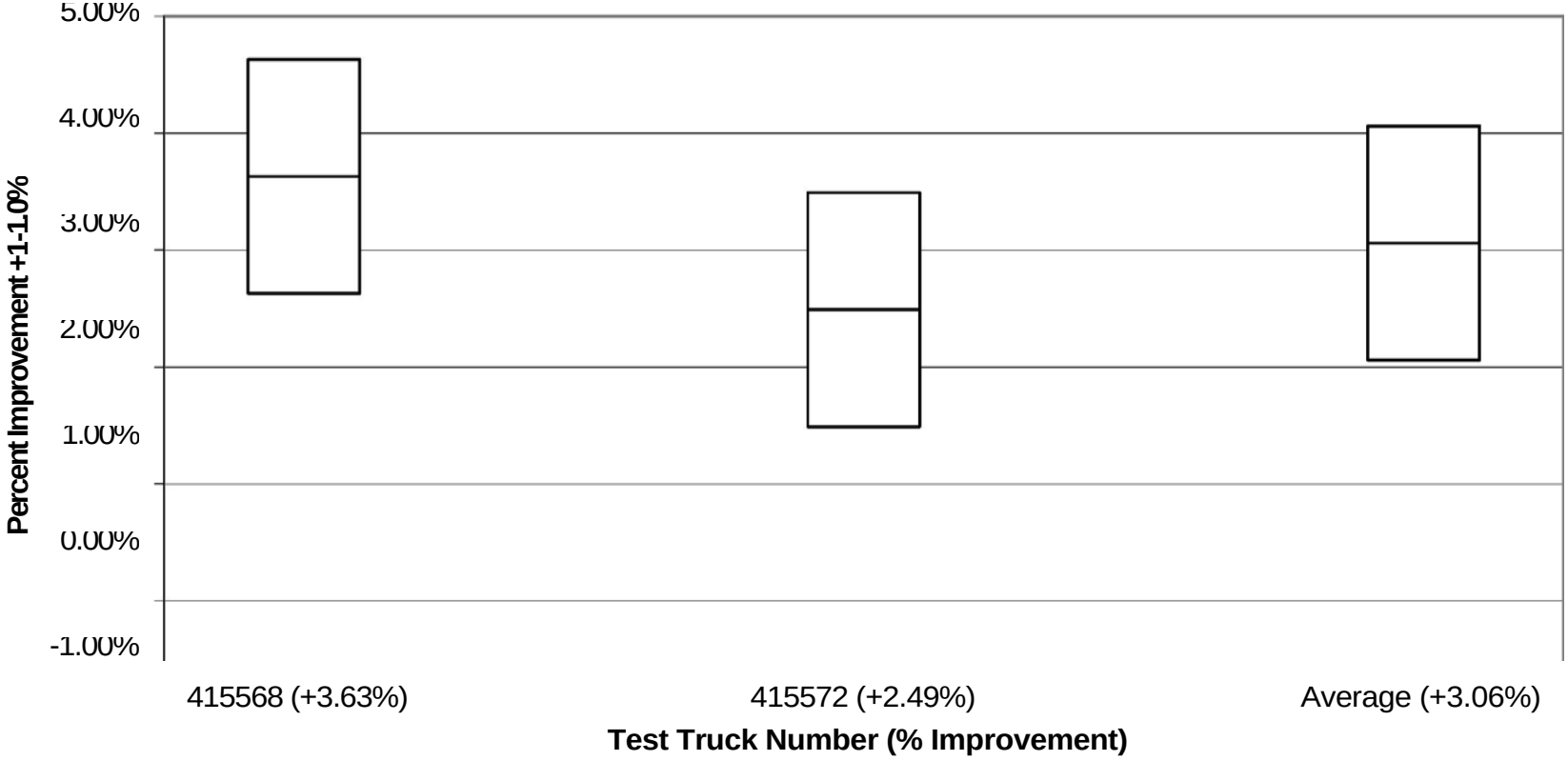
APPENDIX A
Test Results

CleanBoost™ and CleanBoost HFO™ - SAE J1321 - CleanBoost™ Diesel Fuel Additive Evaluation

Set #	Date	Weather Data						Segment	Fuel Consumed			T/C Ratios		Remarks
		Southbound			Northbound				Test Truck 415568 (Lbs.)	Test Truck 415572 (Lbs.)	Control Truck 415570 (Lbs.)	Test Truck 415568	Test Truck 415572	
		Temp (F)	Wind (MPH)	Wind Dir.	Temp (F)	Wind (MPH)	Wind Dir.							
Baseline Segment								**Driver**	Mario Espinosa	Thomas Smith	David Feise			
								Fuel	#2 Diesel					
6	5/3/2004	62.1	0.8	N	64.6	1.0	S	Baseline	54.9	55.2	54.5	1.0073	1.0128	
7	5/3/2004	74.2	6.3	S	77.1	1.1	S	Baseline	56.2	55.2	57.0	0.9860	0.9684 *	
8	5/3/2004	80.6	1.0	N	79.9	3.8	S	Baseline	54.9	54.8	57.1	0.9615	0.9597	
9	5/4/2004	63.2	0.0	-	64.6	1.9	S	Baseline	54.7	53.7	54.7	1.0000	0.9817 *	
10	5/4/2004	73.6	3.5	S	73.6	7.7	S	Baseline	57.8	57.0	57.9	0.9983	0.9845 *	
11	5/4/2004	77.9	3.4	S	77.9	7.2	S	Baseline	58.4	57.9	59.6	0.9799	0.9715	
J1321 Avg. T/C Ratios												1.0019	0.9782	
Test Segment								**Driver**	Mario Espinosa	Thomas Smith	Larry Eckhardt			
								Fuel	#2 Diesel & Clean Boost		#2 Diesel			
12	5/19/2004	76.7	2.0	SE	75.2	6.8	SE	Test	57.1	56.9	59.6	0.9581	0.9547 *	
13	5/19/2004	79.5	4.0	SE	81.3	4.5	S	Test	56.8	56.0	58.7	0.9676	0.9540 *	
14	5/19/2004	86.0	3.1	SE	89.4	4.8	S	Test	57.8	56.6	59.3	0.9747	0.9545 *	
J1321 Avg. T/C Ratios												0.9668	0.9544	
J1321 Percent Fuel Economy Improvement												3.63%	2.49%	
Average Fuel Economy Improvement - Two Trucks													3.06%	

* T/C ratios selected to calculate an average T/C ratio as specified in Appendix I of the SAE J1321, Joint TMC/SAE Fuel Consumption Test Procedure - Type II.

SAE J1321 Percent Fuel Economy Improvement
#2 Diesel Fuel plus Clean Boost™ and 1,500 Miles for Conditioning
Versus
Baseline with #2 Diesel Fuel



APPENDIX B
Truck and Trailer Photograph

Truck and Loaded Trailer