FUEL CONSUMPTION AND NO_X EMISSION TESTS USING NO_X-OUT CATALYST

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FINAL REPORT

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16. Abstract The Pennsylvania Transportation Institute at Penn State was engaged to compare fuel consumption and NO_x emission data before and after using Mass Media Underwriters Inc. "NO_x-OUT" catalyst fuel additive on a medium or heavy-duty diesel vehicle. This report describes the tests performed and the results obtained during chassis dynamometer based fuel consumption and NO_x emission testing on a heavy-duty diesel vehicle with and without the additive.			
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Introduction

Mr. Ian Sturrock, consultant to Mass Media Underwriters Inc., approached the Pennsylvania Transportation Institute at Penn State with a request to compare fuel consumption and NO_x emission data before and after using the firm's "NO_x-OUT" catalyst fuel additive on a medium or heavy-duty diesel vehicle. This report describes the tests performed and the results obtained during chassis dynamometer based fuel consumption and NO_x emission testing on a heavy-duty diesel vehicle with and without the additive.

Test Procedure

The test was conducted using an over-the-road, tandem-axle tractor with the following specifications:

Tractor mileage at the beginning of tests: 48,051 miles
Engine type and power: Diesel, 300 HP at 1,750 rpm
Transmission: Manual 7 speed

The test vehicle was mounted on the large-roll chassis dynamometer, as shown in Figure 1. Tests were performed at constant speeds of 25 mph, 35 mph, 45 mph, 55 mph, and at engine idle. These vehicle operating speeds and load conditions were selected after discussions with Mr. Sturrock. The transmission was in 7^{th} gear for the tests at 45 and 55 mph, 6^{th} gear for the test at 35 mph, and 5^{th} gear for the test at 25 mph. Test speed was maintained within ±0.5 mph. A simulated inertia load of 20 tons (40, 000 lb) was applied by the dynamometer. In addition, a simulated road load was also applied by the dynamometer according to the following equation:

$$\text{Road load (lb)} = 0.01*V^2 + 1*V + 200$$

where V is the speed of the tractor on the dynamometer.

During the dynamometer tests it is necessary to cool the engine using external means to simulate the headwind in actual use. It is also necessary to ensure that the engine's cooling fan

does not operate during the test to avoid parasitic loading of the engine. To achieve the above objectives, the engine's cooling fan was disconnected during the tests. An external heat exchanger was plumbed into the cooling circuit of the engine in such a manner that all of the engine sensors indicated normal operation. The engine coolant was maintained at its operating temperature of approximately 175 $^{\circ}$F.

Figure 1: Tractor mounted on the chassis dynamometer with the external cooling system

Fuel consumption was measured using a Corrsys-Datron Model DFL-3 fuel consumption meter. The fuel line that feeds the engine from the fuel tank and the fuel return line from the engine pass through this fuel meter and the meter calculates the net fuel consumed by the engine. NO_x was measured using a Horiba CLA 220 model chemiluminescent analyzer, which is part of the gas analyzer bench shown in Figure 2. The schematic of the setup for measuring NO_x is shown in Figure 3. The exhaust gas was sampled from the exhaust stack and passed through a

chiller maintained at less than 5 ^{o}C by an ice bath and through a particulate filter before entering the analyzer. This arrangement was used to prevent the heavier condensates, water, and particulate matter from reaching the analyzer.

The tests were conducted in the following sequence:

- Initial fuel consumption and NO_x emissions tests were conducted on the test vehicle without the addition of the catalyst.

- After the initial tests, the catalyst was added in two stages at the following ratios, per the instructions and in the presence of Mr. Sturrock. The first application was 8 g of additive per 15 gal of fuel. The two fuel tanks of the tractor were filled up with diesel and catalyst in the above mixing ratio (270 gal of diesel and 144 g of catalyst). The tractor was run with the treated fuel until both fuel tanks were half empty. At this point, a second dose of catalyst was added to the remaining fuel. The fuel tanks were filled to capacity with a mixing ratio of 4 g of catalyst for 15 gal of fuel (135 gal of fuel and 36 g of catalyst). The tractor was run with this fuel mixture until both fuel tanks were nearly empty.

- The final fuel consumption and NO_x emission tests were conducted with the remaining (treated) fuel in the tanks.

Figure 2: Exhaust gas analyzer bench

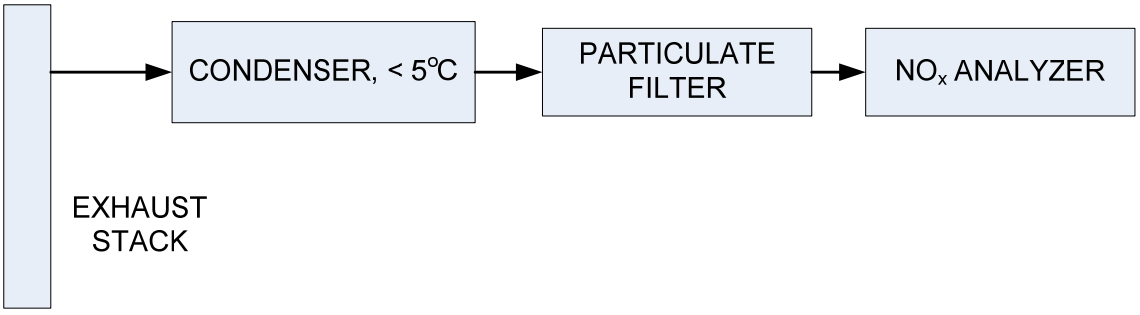

Figure 3: Schematic layout for NO_x measurement

Results and Conclusions

The results of the NO_x emission tests before and after treatment of the fuel with the catalyst are shown in Table 1 and also in Figure 4. Figure 4 shows the comparative NO_x emission data in parts per million at engine idle and at the different vehicle speeds tested. The results of the fuel consumption tests are also shown in Table 1, and Figure 5 shows the comparative data in miles per gallon at different vehicle speeds. The fuel consumption data at engine idle in gallons per minute can be compared in Table 1.

The above results indicate that there is little change in the emission of NO_x at the different vehicle speeds tested, and the differences appear to be within the limits of the experiment (Figure 4). However, the NO_x emission at engine idle showed an increase of 13.4% after treatment, as seen in Table 1, which is also compared in Figure 4.

The fuel mileage appears to have improved slightly after the treatment at the different vehicle speeds, as can be seen from Table 1 and as compared in Figure 1. The differences appear to be within the limits of the experiment at 25 mph and 45 mph. At 35 mph and 55 mph, improvements of approximately 3.3% and 4.5% were observed. At engine idle, however, fuel consumption increased by approximately 4%.

Table 1: Fuel consumption and NO_x measurements

Before Treatment - 3/23/07							
Gear	Speed	NOx ppm	Fuel Consumed				
			Time min	Gallon	gal/min	mpg	
Driver 1							
	Idle	174.9	2	0.0146	0.0073	-	
5	25	360.8	4	0.169	0.04225	9.861933	
6	35	583.2	5	0.325	0.065	8.974359	
7	45	886.7	2	0.196	0.098	7.653061	
7	55	983.2	2	0.295	0.1475	6.214689	
Driver 2							
	Idle	168.2	4	0.0293	0.007325	-	
5	25	343.6	5	0.202	0.0404	10.31353	
6	35	556.8	5	0.336	0.0672	8.680556	
7	45	853.2	5	0.471	0.0942	7.961783	
7	55	985.4	5	0.753	0.1506	6.086764	
Average Values Before Treatment							
	Idle	171.55			0.007313	-	
5	25	352.2			0.041325	10.08773	
6	35	570			0.0661	8.827457	
7	45	869.95			0.0961	7.807422	
7	55	984.3			0.14905	6.150727	
After Treatment - 4/27/07							
Driver 1							
	Idle	186	4	0.0305	0.007625		
5	25	360	4	0.1615	0.040375	10.31992	
6	35	562	4	0.2511	0.062775	9.292447	
7	45	878	4	0.3748	0.0937	8.004269	
7	55	976	4.0166	0.565	0.140666	6.516608	
Driver 2							
	Idle	203	4	0.0314	0.00785		
5	25	383	5	0.206	0.0412	10.11327	
6	35	587	4	0.261	0.06525	8.939974	
7	45	910	5	0.48	0.096	7.8125	
7	55	984	4	0.578	0.1445	6.343714	
Average Values After Treatment							
0	Idle	194.5			0.007738	-	

5	25	371.5			0.040788	10.21659
6	35	574.5			0.064013	9.116211
7	45	894			0.09485	7.908384
7	55	980			0.142583	6.430161

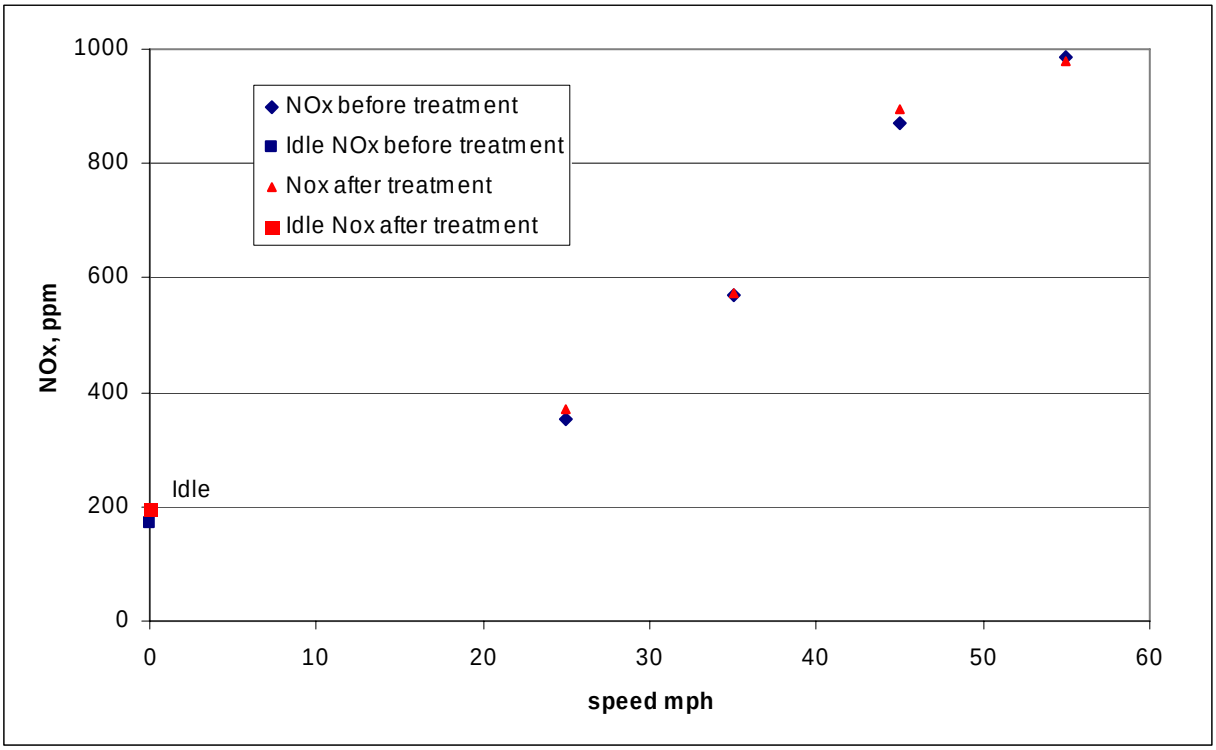

Figure 4: NO_x emission before and after treatment (ppm)

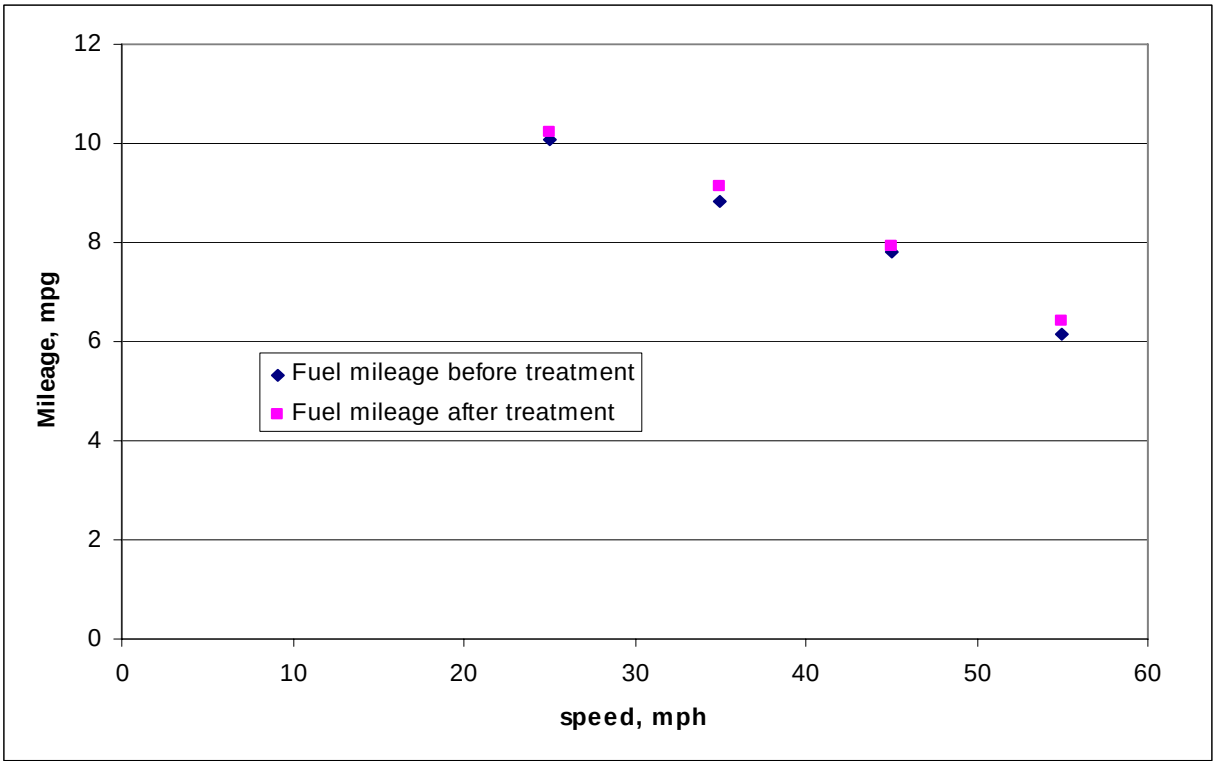

Figure 5: Fuel consumption before and after treatment (mpg)