



## Executive Summary

On behalf of Combustion Technologies LLC, ATDS tested the effect of the "Dipetane" fuel additive on the exhaust emissions and fuel economy of a 1989 Ford F-350 diesel powered truck utilizing California standard diesel fuel. Before and after Hot 505 chassis dynamometer emissions tests were performed to demonstrate the effect of Dipetane on exhaust emissions of a diesel engine. The actual treatment of the vehicle and the mileage accumulation was conducted by Combustion Technologies and was not under the supervision or oversight of ATDS. Combustion Technologies has provided a written statement to ATDS stating that: "No changes were made to the test vehicle other than normal maintenance".

The results of the tests conducted do show a substantial decrease in NOx emissions of about 20% between the initial baseline tests and the tests conducted after mileage accumulation. IIC emissions were reduced by 44% and Particulate Emissions (PM-10) were reduced 25%. There was a 13% increase in test tot est Carbon Monoxide (CO) emissions but this may be in the range of test to test variability. There was also an increase in Fuel economy of approximately 4% as measured by the carbon balance method between the before and after test sequence.

The report below includes an Overview, Project Scope and Tabulated Results. The Proposal for the project is attached.



## Project Overview for Combustion Technologies Dipetane additive testing

This project consisted of Hot 505 emissions testing of a diesel powered truck to determine the effect of the Combustion Technologies Dipetane additive on exhaust emissions of a diesel truck. The truck tested was a 1989 Ford F-350 truck with the 7.3L Diesel Engine, with over 44,377 miles on the odometer. (Due to the age and apparent condition of the truck it is assumed that this is a roll-over to an actual mileage of 144,377). This truck was chosen to represent a typical average-mileage diesel truck in the California market.

A baseline Hot 505 emissions test with standard commercially available California diesel fuel was run at the beginning of the test. Combustion Technologies then took the vehicle away for mileage accumulation with the Dipetane added to standard diesel fuel. After approximately 8,000 miles the vehicle was brought back to the ATDS laboratory for a three Hot 505 test sequence; the fuel used was the tank fuel in the truck upon receipt, presumably California diesel with Dipetane. The test vehicle was run on a chassis dynamometer using the Hot 505 test procedure (third phase of an FTP-74 emissions test) to determine the exhaust emissions during the test cycle. Particulate Matter (PM), Total Hydrocarbons, Oxides of Nitrogen (NOx) and Carbon Monoxide (CO) emissions were measured during the test along with Carbon Dioxide (CO<sub>2</sub>). The test software calculates the fuel economy (MPG) of the vehicle based upon the carbon-balance in the exhaust emissions as compared to the total carbon content of the fuel.

### Project Scope

AIDS provided the following services

- Conducted a baseline test sequence on the chassis dynamometer using the Hot Start 505 second driving cycle using commercially available California diesel fuel.
- Conducted three Hot 505 tests after the completion of 8000 miles mileage accumulation.
- Generated a final report of effects of the test additive on exhaust emissions.



**Test Result Summary**

The tables below tabulate the test results of the vehicle.

Vehicle 1989 Ford F-350				Test Weight (ETW)		8,250					
Engine 7.3L Diesel				Test HP (AHP)		19.2					
Odo 44377 (Probably roll-over to 144,377)											
Test	Test Type	Date	Test/D	ODO	HC g/mi	C) g/mi	NO <sub>x</sub> g/mi	CO <sub>2</sub> g/mi	FE MPG	PM g/mi	
Baseline	Hot 505	1/10/2002	N2000711	44377	0.475	1.085	6,984	810.809	12,501	0.217	
With Dipetane											
#1	Hot 505	8/13/2002	N2000741	52427	0.289	1.251	5.44	784.813	12.918	0.166	
#2	Hot 505	8/13/2002	N2000742	52442	0.280	1.221	5.551	779.475	13.008	0.158	
#3	Hot 505	8/13/2002	N2000743	52446	0.233	1.218	5.77	777.449	13.044	0.166	
Miles Accumulated				8050							
Test Variability											
Max					0.289	1.251	5.770	784.813	13.044	0.166	
Min					0.233	1.218	5.440	777.449	12.918	0.158	
Average					0.267	1.230	5.586	780.579	12.990	0.163	

**Product Evaluation**

As can be seen from the above table, the results for the gaseous emissions a significant improvement in HC, NO<sub>x</sub> and PM for the 1989 Ford F-350 diesel vehicle between the baseline test and the test after mileage accumulation. The slight increase in CO may be test to test variability unrelated to changes in the test vehicle. The increase in fuel economy is significant for a vehicle of this age and type.

Linwood E. Farmer Jr  
Division Vice-President



## Executive Summary

On behalf of Combustion Technologies LLC, ATDS tested the effect of "Dipetane" on the exhaust emissions and fuel economy of a diesel powered truck utilizing Bio-diesel (B-20) fuel. Three Hot 505 chassis dynamometer emissions tests were performed to demonstrate the effect of Dipetane on Nitrous Oxides (NOx) formation by a diesel engine using Bio-diesel fuel. While Bio-diesel fuel has many positive attributes in comparison to regular, petroleum-based diesel fuel, the use of Bio-diesel frequently results in an increase in the formation of NOx. Dipetane, formulated to help reduce NOx in diesel engines, was tested in conjunction with the Bio-diesel to determine if the combination would yield the positive results of Bio-diesel without the negative increase in NOx.

The results of the three tests did not show any substantial increase nor decrease in NOx emissions over the test cycle used for this testing. Upon review of the test results, Combustion Technologies advised ATDS that the Dipetane can have minimal effect on emissions when first introduced to the vehicle and their customers are advised to run a minimum of 5000 miles before the full effect may be felt. As a result it was decided to run the vehicle on the Bio-Diesel with Dipetane for a period of time and then conduct another test to see what impact continued usage of the product would have on emissions.

The report below includes an Overview, Project Scope and Tabulated Results. The Proposal for the project is attached.

## Project Overview for Bio-Diesel with Dipetane Testing

This project consisted of Hot 505 emissions testing of a diesel powered truck to determine the effect of the Combustion Technologies Dipetane additive on NOx emissions of a diesel truck using B-20 diesel fuel. The truck tested was a 1996 Dodge RAM 2500 pick-up truck with the 5.9L Cummins Turbo-charged Diesel engine, with over 125,000 miles on the odometer. This truck was chosen to represent a typical high-mileage diesel truck in the California market.



Four tests were run on the test vehicle: A baseline test with standard commercially available California diesel fuel; a second test with a 20% mixture of Bio-diesel with standard diesel, (B-20), a third test with B-20 with Dipetane and a final test after accumulating approximately 5,000 miles on B-20 with Dipetane. The test vehicle, a 1996 Dodge RAM 2500 pick-up truck, was run on a chassis dynamometer using the Hot 505 test procedure (third bag of an FTP-75 emissions test) to determine the NOx emissions during the test cycle. Particulate Matter (PM), Total Hydrocarbons and Carbon Monoxide emissions were also measured during the test.

Between the baseline test on standard diesel fuel and the test on the B-20 fuel the truck was driven over 350 miles on B-20 using a representative driving cycle. Between the first test with B-20 and the test with B-20 treated with Dipetane the truck was driven over 570 miles using the treated B-20. Finally, the truck was driven over 4500 miles using the B-20 with Dipetane mixture before the final test. Again, the driving cycle was representative of real-world driving in Southern California.

### Project Scope

ATDS provided the following services:

- Procured a test vehicle: a 1996 Dodge RAM 2500 pickup and inspected the vehicle upon arrival at ATDS to verify the condition of the vehicle.
- Conducted a baseline test sequence on the chassis dynamometer using the Hot Start 505 second driving cycle using commercially available California diesel fuel.
- Drained all of the standard diesel fuel from the vehicle and refilled the vehicle with a 20% mixture of Bio-diesel fuel with standard diesel fuel (B-20).
- Drove the vehicle over 350 miles on B-20.
- Repeated the Hot Start 505 test protocol on the chassis dynamometer.
- Added sufficient Dipetane to the B-20 to make a 0.5% (one-half percent) mixture of Dipetane and B-20.
- Drove the vehicle over 570 miles on the Dipetane-treated B-20.
- Repeated the Hot Start 505 test protocol on the chassis dynamometer.
- Drove 4500 miles using the B-20 with Dipetane mixture.
- Repeated the Hot Start 505 test protocol on the chassis dynamometer.
- Generated a final report of effects of the test additive on NOx emissions.

Combustion Technologies provided the following:

- Sufficient B-20 with Dipetane for 4500 miles of mileage accumulation.



## Test Result Summary

The test results for the Dodge RAM 2500 with 5.9L Cummins Turbo Diesel

Test	Fuel	Date	THC g/mi	NOX g/mi	CO g/mi	PM g/mi
Baseline	CA Diesel	* 6/7/2002	0.218	7.036	0.846	0.094
Bio-diesel	B-20	6/10/2002	0.224	6.895	0.907	0.085
Change in Emissions (%)			3%	-2%	7%	-10%
Treated Bio-Diesel	B-20 w/Dipetane	6/11/2002	0.220	6.904	0.885	0.098
Change in Emissions from B-20 (%)			-2%	0%	-2%	15%
After Mileage Accumulation	B-2- w/Dipetane	8/28/2002	0.306	6.756	0.796	0.061
Change in Emissions rom B-20 (%)			37%	-2%	-12%	-28%
Change in Emissions from Baseline (%)			40%	-4%	-6%	-35%

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## Product Evaluation

As can be seen from the above table, the impact of either Bio-diesel (B-20) alone, or Bio-diesel (B-20) treated with Dipetane is minimal in the test sequence. The results for the gaseous emissions are well within the expected test to test variability for a single test on a vehicle of this type. While there was more variability in the PM measurements for the vehicle, again this is not uncommon for a vehicle of this age and mileage. Valves and rings can cause significant fluctuations in these emissions components on a test to test basis.

During post-test discussions with Combustion Technologies ATDS was advised that previous testing had shown that some vehicles required over 5,000 miles on Dipetane treated fuel before results were noted. As a result, Combustion Technologies provided sufficient B-20 with Dipetane to allow for an extension of the mileage accumulation on the vehicle until the 5,000 miles had been accumulated. The results for NOx are again within the nominal test to test variability for this type of vehicle however the CO and PM readings show significant reductions from the baseline. The increase in HC cannot be explained at this time and appears to be an anomalous result, particularly in light of the reduction in emissions of CO and PM which normally tend to track that of HC. Additional tests on the vehicle are planned to determine if the HC readings are related to the use of B-2- with Dipetane, a vehicle related issued or an artifact of the test process.



The reduction in PM emissions is significantly particularly in view of this reduction being achieved without a corresponding increase in NOx emissions. In most diesel applications there is an inverse relationship between PM and NOx; ie. any action which reduces PM tends to increase NOx and vice versa. A typical example is the use of Exhaust Gas Recirculation (EGR) to decrease NOx; the more EGR an engine uses the lower the NOx but PM can rise rapidly as NOx falls. Inversely, an increase in combustion chamber pressure and temperatures, through changes in the fuel injection pulse width and timing will decrease PM but cause a corresponding rise in NOx.

The State of California and the EPA have recently determined that Diesel exhaust emissions, and in particular PM, have a statistical link to increased rates of respiratory illness including Emphysema, Asthma and Lung Cancer. As a result there is an increased emphasis on reducing Diesel emissions as quickly as possible. New technology engines will reduce emissions but only in the future; diesel vehicles tend to have very long service lives and therefore the penetration of new technology is slow. Alternatively, changes in fuel will affect all existing vehicles as well as the new ones and therefore can provide the quick impact desired by the regulatory community.

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