

An Alternative Fuel Diesel Injection Study by AltGas Technologies, LLC - (Oct. 2013)

Adding a small percentage of propane to the combustion process of a diesel engine improves diesel fuel combustion efficiency. This benefit has been known for many years. Farmers in the 1930's found that by adding some propane gas into the engine air charge, their tractors would realize tremendous power gains. In the early 2000's a wave began to commercialize the Propane Diesel Injection (PDI) concept for over-the-road vehicles. Early inventions focused primarily on performance and horsepower enhancement for smaller, non-commercial vehicles. The fuel efficiency aspect of the product then, was not of much importance. It is today.

Background:

The AltGas Technologies, LLC group (AGT) founders have a 30+ year history of environmental regulatory consulting and management. Fueling system and regulatory agency compliance was and is their areas of expertise. Most of their clients have been in either the automotive or trucking industries.

AltGas took an interest in PDI in 2007. AGT had developed the first clean-burning propane powered Auxiliary Power Unit (APU) for long-haul trucks. They were introduced to PDI through one of their trucking clients. At that time, there were few PDI devices that had much success at commercialization. AGT's interest in PDI was; **its potential ability to reduce diesel engine fuel consumption and emissions** on larger, commercial diesel vehicles.

AGT launched their PDI study with three goals:

- 1) Find out if a suitable technology already existed;**
- 2) If not, find a technology that could be adapted;**
- 3) Perfect, commercialize and bring it to market.**

AGT's intention was not to manufacture a PDI system, but rather to find and partner with the best system manufacturer who already had one.

Highlights of the Study:

AGT studied, tested, and worked intimately with the most prominent inventors and manufacturers of PDI in the US, Canada and Europe over a 5 year period.

AGT participated directly and extensively in non-biased, in-field testing and evaluation of PDI systems – gaining first-hand, direct knowledge of how they worked, their strengths, and their weaknesses. Tests

were performed under a number of standards and conditions including ASTM, as well as long-term over-the-road, and driver-logged. Dynamometer testing was included. AltGas has a library of test results performed on numerous makes and models of truck and tractor engines using the best PDI technologies available.

AGT consulted with some of the world's most prominent engine specialists, including Steve Dinan of Dinan Engineering on resolving injection and fuel delivery problems that proved to be inherent with almost every PDI system studied.

US and Foreign Patents (if applicable) were studied, evaluated, and cross-referenced.

Systems and Brands Included in the Study:

Group A):

- **Technocarb** - EcoDiesel System
- **PRINS** - Dieselblend
- **American Diesel Systems** - Diesel Magnum II
- **ICOM** - Dual Fuel JTG
- **Engine Control Technology** - 2-Fuel System
- **CCAT** - Dual Fuel System

Group B):

- **Diesel Performance** - Powershot 2000
- **RMR ProDiesel** – The Enhancer
- **Impco/ Nash Fuel** – Diesel Injection Kit
- **Superchips** - DPI
- **Red Rooster** - Diesel Economizer

Results Highlights:

The **Group B)** injection systems do not have the ability to protect the engines they are installed on from being inadvertently damaged by the injection system. None of them monitor the critical conditions taking place in the engine that can lead to engine damage or mechanical failure. This could never pass the scrutiny of either regulatory agencies, or commercial corporate consumers. None of them, therefore, are good candidates for successful commercialization.

With the exception of the Technocarb EcoDiesel System, all of the **Group A)** systems are integrated - in one fashion or another, with the engine ECU. This makes it possible to monitor for unsafe engine conditions and to shut-down injection if and when any dangerous condition develops. Technocarb partially accomplishes this by installing their own EGT, RPM, turbo-boost and throttle-position sensors. These indicators, however, fall short of the complete monitoring and fault code detection available through a CanBus interface – like the remaining units all have.

PRINS and ICOM are European companies, and both of them use high quality components, and employ impressive technologies. ICOM injects liquid fuel directly at the intake point of each cylinder using specially designed pulse-width injectors. This method of injection necessitates that the systems be put through a Certification process with the EPA and CARB for each specific engine type they will be installed on. This is an expensive time-consuming process. In most cases, it brings the cost of ICOM's system to a point of being beyond economic benefit. The same is true for the CCAT Dual Fuel System and Engine Control Technology's 2-Fuel System - but for different reasons. Both CCAT and ECT go into the truck ECU's and take control over the diesel fuel flow. This automatically puts their technologies into a category of "tampering with an engine emissions control system" - which is illegal. For this reason, like ICOM, they must put their systems through the expensive Certification processes and protocol to gain approvals from the EPA and CARB.

This brings **Group A)** down to two remaining candidates; 1) American Diesel Systems and their Diesel Magnum II, and; 2) the PRINS Dieselblend System. On the surface, when compared side by side, these two technologies appear very similar. Both can inject either Propane or CNG. They are both passively CanBus interfaced, and do not interfere with or control any of the engine functions. Both employ computer intelligence to maintain an exact ratio of propane to the engine's consumption of diesel fuel. Neither requires any adjustments. And both come from a long history of development. The Diesel Magnum-II is a 5th generation product – dating back more than 10 years in development. PRINS and its parent company, SHV Energy, have been involved in alternative fuel technologies for some 25 years. The PRINS system has not yet, however, arrived in US markets. The Diesel Magnum-II was invented, fully developed and built in the USA.

In the end, AltGas endorses ADS's Diesel Magnum-II as "The Best Alternative Fuel Injection Technology in the World". In all fairness, AGT was not able to physically test the PRINS system directly, like they have extensively - the DM-II. Again, the Dieselblend system is not currently available in the US. All things being equal, however, the DM patents are what win the battle. They are broad, and include planned near-future improvements that will preclude and obsolete anything PRINS, or any other competitor in the world has or is doing today.

The DM-II Technology:

The Diesel Magnum II Alternate Fuel Diesel Injection System is the only system that takes the guesswork out of fuel mapping and adjustments, and the only system we found that performed perfectly, safely and without flaws.

How it Works:

DM – II injects propane or natural gas through electronically controlled pulse-width injectors. The controller is tied passively into the engine control unit (ECU) and constantly monitors all pertinent engine functions. Liquid is drawn from the propane tank into a two stage regulator/vaporizer, where it expands into vapor. The expansion creates pressure within the chamber that is reduced in the second stage of the regulator to the exact desired injection pressure. Using liquid draw from the tank (as opposed to vapor) permits operation in extremely cold environments. Pulse-width injectors open and close at intervals synchronized to the flow of diesel fuel - maintaining an exact ratio of propane to diesel. **There is never too much or too little being delivered.** This is extremely important when it comes to maximizing performance, safe operation, and elimination of the possibility of engine damage – which most competitive systems cannot guarantee. Super-accurate microprocessor control is what separates the DM-II from the others.

Engines change over time, as do atmospheric conditions. The DM-II is intelligent to these changes, and automatically adjusts to them. Others do not, and must be "fine tuned" and periodically adjusted to maintain or correct their performance. These adjustments are almost always "best guess" - where a screw is turned a little, or a program adjusted to where the technician or user "thinks" it should be. DM takes the guesswork completely out of this equation.

None of this is meant to suggest that DM-II's level of sophistication is required in all cases, or that other PDI systems won't work. Any injection of propane into a diesel engine can produce horsepower and efficiency gains. But too much propane can and will cause damage. To achieve efficiency gains and not adversely affect emissions, an exact metered amount of alt fuel must be delivered throughout the power band. If the engine is electronically controlled, there is no system comparable to the DM – II, as it assures a level of performance and safety that no competitor can.

AltGas Technologies, LLC.

485 Victor Way, Unit 16, Salinas, CA 93907

(831) 422-2290 Stuart G. Solomon, Exec. Director