Reducing Maintenance Costs & Improving Fuel Economy In Today's Diesel Engines

Introduction

The diesel engine manufacturers face more and more challenges in designing new equipment as more and more government regulations are conceived and implemented to lower fuel related engine emissions.

These new equipment design changes, unfortunately, add increased responsibility for the diesel engine buyer/operator to correctly maintain the new systems in order to achieve the end result of emission reductions.

DPFs (diesel particulate filters), **EGR** (exhaust gas recirculation) **Valves**, **CRI** (common rail fuel injection) **Systems**, **HPFI** (high pressure fuel injectors), **EFI** (electronic fuel injection) **Systems** and others all are designed to lower fuel related combustion emissions.

But, these systems only work to accomplish the task at hand if they are properly maintained and the diesel fuel quality used is optimal. That is where the difficulty comes in.

The Problems

All of the above systems are directly impacted by the diesel fuels running through them.

1. If the diesel fuel physical properties change from one fuel delivery to the next (which they consistently do even when obtained from the same source), then the operational performance of these highly engineered emission reduction systems will be altered.

2. If a less than typical (poorer) quality diesel fuel is periodically received and used (which occurs more times than the average fuel user realizes), the proficiency of these expensive emission reduction systems will be negatively affected.

3. If a biodiesel fuel blend is added to the No. 2 diesel fuel and used without the knowledge of the fuel purchaser (which is more prevalent today because of the cost and the benefit of biodiesel as a lubricity agent), the effectiveness of these emission reduction systems will be changed.

4. If the diesel fuel delivery system is not kept clean and free of deposits, the efficiency and any positive benefits designed into these emission control systems is reduced.

All of the above listed 'typical' conditions increase operating maintenance costs AND lower fuel economy. But, all of these negative effects/influences can be overcome to eliminate the impact on the fuel user's bottom line.

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Fixing the Problems

Combustibility and *fuel system cleanliness* are two main issues that need to be addressed to dramatically minimize or eliminate the negative effects of diesel fuels in today's diesel engines.

Combustibility describes how well (or how poorly) the diesel fuel ignites and burns during normal operating conditions of the diesel engine application. However, there are several things that determine whether or not the diesel fuel ignites and burns properly at all engine power settings.

If the diesel fuel Cetane Number (ignition delay time) is 51 or above, there is a better chance the diesel fuel will ignite and burn properly throughout the full range of engine RPM (revolutions per minute) settings. Lower Cetane Numbers will decrease the entire ignition and burning process.

If the fuel ignites and burns properly, the BTU Content (heat energy) in the fuel will be efficiently converted to horsepower (power production generated by the engine) and optimum fuel efficiency/fuel economy - MPG (miles per gallon) will more likely be achieved.

Diesel fuel combustibility can be improved with the addition of specific fuel additives and combustion enhancement chemicals. Cetane Improver (2-ethylhexyl nitrate) is the most commonly used and widely accepted fuel additive for reducing the ignition delay time and enriching the combustion process in a diesel engine. Today's modern diesel engines require a 51+ Cetane Number to achieve ideal combustibility and optimum engine/vehicle performance.

Unfortunately, todays ASTM D-975 'Cetane Number' Specification for Diesel Fuels requires the petroleum refiners (suppliers) to provide only a minimum 40 number. Many delivered diesel fuels in America today test in the **low to mid-40s** –a long way from the optimal 51 number.

Fuel System Cleanliness in a diesel engine is broadly described as whether or not the fuel delivery system, the combustion chamber and after (post) combustion system areas are free of deposits. As deposits accumulate in the fuel delivery system (tank, lines, pump and injectors), the operation of these engine components will be impaired. When the tank is filled, these deposits and sediment are dispersed and carried by the fuel flow into the filters, pumps and injectors.

These fuel contaminants lead to fuel filter fouling, reduced fuel lubricity, increased pump deposits and eventually increased fuel injector deposits culminating in more rapid pump and injector wear.

As fuel injector deposits increase, the spray pattern in each cylinder will be negatively affected. This impedes proper fuel combustion and ultimately reduces fuel burning efficiency which increases fuel related deposits, reduces engine power production and lowers fuel economy (MPG). As engine power production is reduced, the driver increases the throttle setting (steps on the accelerator) and down shifts the transmission further lowering vehicle fuel economy.

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Fixing the Problems - *Fuel System Cleanliness* (cont)

Diesel Fuel System Cleanliness can be corrected with the addition of explicit fuel chemicals treatments (*additives*) that are compounded to cleanup existing fuel related deposits and prevent future deposits from forming.

With today's CRI engines (2005 and newer), a good ***Diesel Fuel Detergent Additive*** is becoming more of a necessity than an option. Instead of fuel pressure in the injectors only at the time of injection, the new CRI fuel delivery systems are designed with a very high 'constant' fuel pressure on the fuel injectors. These new engines are also manufactured with extremely small tolerances.

The CRI engine fuel injector holes are much smaller than previously manufactured injectors and they inject fuel multiple times during each cylinder firing. Consequently, the injectors themselves operate at much higher temperatures which increase the potential for fuel related injector deposits to accumulate.

Additionally, all of the diesel fuels sold today still have minute amounts of allowable moisture (water) that contain minuscule PPMs (parts per million) of dissolved salts. These abrasive salts collect (deposit) on the interior parts of the fuel injectors and cause the injector plungers to stick and often seize completely, stopping the fuel flow.

The negative operational effects related to any deposit accumulation of any kind anywhere within the fuel delivery system are **amplified in severity** in all CRI engines because of the reduced injector and system tolerances and the higher operating pressures and temperatures.

Therefore, it is paramount that the entire fuel delivery system be kept clean and devoid of contamination and deposit buildup. The only way to assure this condition is to use a good quality ***Diesel Fuel Detergent Additive*** at the correct dosage rate on a continual basis. This preventative maintenance procedure will eliminate most of the fuel related injector deposits in CRI engines.

Here again, the ASTM D-975 Diesel Fuel Specification does not include any requirement for the diesel fuel producer or supplier to add any ***Diesel Fuel Detergent Additives***. The task to improve diesel equipment performance, operability and extend its useful life is left solely to the diesel fuel purchaser/user.

Diesel Fuel Lubrication Value

It is also essential for the diesel fuel user to utilize a good diesel ***Fuel Lubricity Additive*** in order to ensure adequate lubrication of the fuel delivery system. The lack of adequate lubrication value in the diesel fuel will increase component wear and will adversely affect the fuel delivery system operation.

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Fixing Diesel Fuel Lubrication Value

Poor fuel lubricity will also cause the fuel injectors to 'stick' or fail to open properly at the correct injection time. This malfunction will severely impact the injector spray patterns and negatively affect engine power production and WILL lower fuel economy.

ASTM (American Society for Testing and Materials) has mandated in the *ASTM D-975 Diesel Fuel Specification* that HFRR (high frequency reciprocating rig) test lubricity to be at or below a 520µm Wear Scar Rating in all diesel fuels sold in the USA. However, based on independent laboratory testing, many of the diesel fuels delivered today do NOT meet this specification.

Policing and ultimately correcting this specification requirement (improving the lubrication value of the diesel fuel) in every diesel fuel delivery through the use of a good **Lubricity Additive** is left to the diesel fuel purchaser and/or user.

It should be noted that during cold weather most fuel suppliers blend measurable amounts of kerosene into their No. 2 diesel fuel before delivery in an attempt to minimize winter time operability issues. This blending is often done without advising the customer and in fact unless the supplier blends a substantial amount (25 percent or more by volume), the added kerosene will have little, if any, significant effect on improving winter vehicle operability.

It should also be noted that blending kerosene into No. 2 diesel fuel REDUCES the diesel fuel lubrication value because kerosene contains less BTU (less heat energy) than No.2 diesel fuel. Therefore, kerosene blending WILL lower fuel economy.

Lubricity Additives treat at very low dosage rates in order to enhance the lubrication value of most diesel fuels. These additives are inexpensive and often compounded with a Conductivity Additive into a single additive product or can be found within a multifunctional diesel fuel additive (including Cetane Improvers, Detergents, Deposit Modifiers, Stabilizers, Corrosion Inhibitors, and/or other operability improver chemistries such as diesel fuel winterization components).

Treating diesel fuels with chemical additives to correct *Combustibility* and *Fuel System Cleanliness* and enhance the *fuel lubrication value* is easy. The difficulty is in finding the "**right**" diesel fuel additive product(s) to actually achieve what needs to be done. That takes time and some laboratory testing on the part of the diesel fuel additive buyer before the purchase is made.

Diesel Fuel Winterization Issues

Another extremely important area of concern is when talking about improving diesel fuel economy and reducing maintenance costs is the physical changes that occur in diesel fuels during the cold weather months of each year.

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Diesel Fuel Winterization Issues (cont)

The petroleum refiners here in America and around the world make manufacturing changes (distillation "cut point" changes) to the refinery productions during their twice yearly scheduled "turn-around-times" (maintenance shutdowns).

Spring refinery manufacturing changes allow the refiners to make additional quantities of gasoline to meet the summer months driving demand and the Fall manufacturing changes permit the refiners to optimize more on distillate (including diesel fuel) productions for the winter heating season.

As the Spring/Summer grade diesel fuels are replaced with the Fall/Winter grade diesel fuels, nearly all of the physical properties will change in the fuels actually delivered to the buyer. These diesel fuel physical property changes present significant operability challenges for the diesel fuel buyer that must be addressed prior to the cold weather months of the year.

The petroleum refiners generally manufacture diesel fuels that meet the ASTM D-975 Diesel Fuel Specification allowable production "**range**". However, the winter time operability requirements within ASTM D-975 for Cloud Point or CFPP or LTFT performance are very broad and often inadequate to meet the actual winter time operating conditions. Additionally, the actual diesel fuel winter time operability parameters specified in ASTM D-975 are not rigorously policed by anyone at the fuel delivery point.

Engine changes by the operator could be made to the equipment in order to more optimally consume the diesel fuels when the refinery fuels physical property changes occur. But, since the fuels are different from one supplier to the next and fuels from the same supplier can change from delivery to delivery, making changes to the engine is not an option for the diesel fuel user.

The diesel fuel buyer/user must act to improve winter time operability in order to optimize the utilization of the fuel dollars spent. Diesel engines can be operated at nearly any ambient temperature or cold weather condition, if the "**right**" ***Winterization Diesel Fuel Additives*** are specifically formulated to counteract the physical property changes in the diesel fuels used.

Finding the "right" *Winterization Diesel Fuel Additives* is the difficulty.

This requires the diesel fuel buyer/user to be proactive and consider multiple product suppliers. Each additive product should be verified by actual independent laboratory testing contracted by the diesel fuel buyer/user before the ***Winterization Diesel Fuel Additives*** purchase is made. The diesel fuel buyer/user should determine what benefits and improvements are desired from the ***Winterization Diesel Fuel Additives*** and instruct the testing laboratory to make direct testing comparisons of each product in the same base (untreated) diesel fuel.

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Diesel Fuel Additive Testing

Nearly every promoted 'claim' of a diesel fuel additive from a given additive supplier can be tested for verification in the right petroleum fuels laboratory. Additive changes to the diesel fuel physical properties such as Cetane Number improvement are much easier to verify than a generic claim improvement such as a "fuel economy increase".

Monitoring and proving an actual MPG increase from using a fuel additive requires the additive product to be properly treated in the fuel and tested in a group of vehicles (or engines) over an extended period of time (6 months is recommended). Testing for an extended period will allow the exact same vehicles (or engines) fuel efficiency (MPG) to be directly compared to the immediate previous months MPG 'without' the additive along with a direct comparison of the exact same units during the same operating months of the previous year.

Choosing the Right Diesel Fuel Additives

Chemically treating diesel fuel to improve the *combustibility, fuel system cleanliness, lubricity and winterization* should be viewed as a means to achieve lower ongoing equipment maintenance costs instead of just an unwarranted upfront expenditure. These operational performance improvements will ALL lead to better fuel efficiency/economy and longer equipment life for a reasonable cost, if the '**right'** chemical additives are chosen.

The task of choosing that right fuel additive product does not have to be as difficult as many buyers assume. In fact, conducting a few simple laboratory tests (using the same diesel fuel) with each fuel additive candidate usually weeds out most of the non-performing products.

Step one for the fuel additive buyer is to determine (list) the precise performance benefits he wants to achieve from a fuel additive product.

Step two for the fuel additive buyer is to compare his performance list to the claims made by the fuel additive suppliers and select several products that might provide the desired benefits.

Step three for the fuel additive buyer is to select a fuel testing laboratory and consult with the laboratory to determine the testing necessary to prove or disprove the performance benefits based on the diesel fuel additive supplier's product claims.

Step four for the fuel additive buyer is to collect samples of each fuel additive to be tested and secure a large enough sample of his own base (untreated) diesel fuel in order for the laboratory to test each of the diesel fuel additives in that same base diesel fuel.

Step five for the fuel additive buyer is to send the fuel additives **and** base diesel fuel to the chosen petroleum laboratory along with each additive treat rate and a list of the analytical testing required.

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Choosing the Right Diesel Fuel Additives (cont)

The particular up front cost of the individual fuel additives, at this stage, is not important. Once the laboratory results are received, the fuel additive buyer can compare the actual test results achieved to the individual fuel additive's "**treat cost per gallon**" using the additive supplier's recommended treat rate. This is the only way the fuel additive buyer can determine the most cost effective fuel additive product based on the actual test results achieved in the buyers' diesel fuel.

The process of finding the right fuel additive product should be thought of as "protecting a capital investment" by taking steps to ensure a long term return on the expense of operating the equipment.

Maintenance Benefits to be Observed

Fuel cost savings achieved by increasing fuel economy/efficiency from chemically treating a diesel fuel with an additive product can be substantial. But, the *maintenance cost savings* achieved from the same diesel fuel additive product (and the reduction of many operational headaches) may represent even bigger benefits for the diesel fuel user.

These *maintenance cost savings* may be realized over a longer term, but they will be just as profound on **DPFs** (diesel particulate filters) regeneration costs, **EGR** (exhaust gas recirculation) **Valves** replacement costs, **CRI** (common rail injection) **Systems** cleaning costs, **HPFI** (high pressure fuel injectors) rebuild costs, **EFI** (electronic fuel injection) **Systems** adjustment costs and other maintenance and downtime repair costs taken to lower fuel related combustion emissions.

Summary

Reducing maintenance costs and improving fuel economy CAN be achieved with yesterday's AND today's newer engines. But, it does take a little work and the diesel fuel user must select the **right** chemical additives based on sound testing and his own proof. The benefits to the bottom line will be substantial and well worth the effort expended.