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The truth about fuel additives

Fleet Owner
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Wed, 2012-08-01 11:40

The central truism regarding any fuel additive is that sometimes you need it—and sometimes you don't. Aside from the untold legions of snake oil substances touted to improve fuel economy, there are many legitimate and thoroughly tested fuel additives that offer a wide range of important benefits to today's complex diesel powertrains, but only if they are mixed in with a high level of precision.

In fact, many diesel fuel blends on the market today come pre-mixed with any number of additive packages. The familiar face in this crowd is diesel blended with ultra-low sulfur kerosene to provide improved performance in extremely cold climates—a so-called "winter diesel blend" of fuel ubiquitously brewed and distributed on a seasonal basis in the northern reaches of the U.S. and Canada.

(Editor's note: Gary Pipenger, president and owner of diesel fuel additive supplier Amalgamated Inc., wished to respond to some of the information included in the story, "the Truth About Fuel Additives," which first appeared in the August 2012 issue of Fleet Owner. Click here to read his repsonse.)

Then there's an ultra-low sulfur diesel (ULSD) fuel Shell piloted last January, which is blended with a proprietary nitrogen- based cleaning agent. The nitrogen additive package helps prevent and remove deposits that form on fuel injectors— deposits that impair the flow of diesel through the injector, thus resulting in increased fuel consumption and carbon dioxide emissions, according to Ralph Cherrillo, fuels technology advisor for Shell Global Solutions. He also notes that this nitrogen-enriched diesel contains other lubricity agents (as per required specifications) to help prevent fuel pump and injector wear and damage; "anti-gel agents" are added for colder winter climates when needed.

According to Shell's research, fleets can save fuel by keeping diesel engine injectors clean— achieving a 4.8% reduction in fuel consumption in severe stop-and-go city service and a 1.3% reduction in fuel consumption in less severe long-haul highway service using the nitrogenenhanced ULSD fuel as compared to regular ULSD.

Cherrillo, however, adds that the fuel efficiency benefits derived from the injector cleaning capability of the nitrogen fuel additive package were only demonstrated after a long period of internal testing by Shell under precise blending and mixing of the additive with the fuel.

Testing is absolutely critical when it comes to fuel additives these days, as the various emissions control devices added to today's diesel engines—diesel particulate filters (DPFs), exhaust gas recirculation (EGR) systems, and selective catalytic reduction (SCR) technology—make the entire truck powertrain ultra-sensitive to even slight alterations in the chemical composition of fuel, warns David McKenna, director of powertrain sales for Mack Trucks.

"The biggest concern for any OEM when it comes to additives is quality control," he explains. "At the end of the day, you need to remain fully aware of how delicately balanced the entire truck powertrain system is

today—not just in terms of the engine and fuel delivery system, but the lubricants within them as well as the engine coolant."

McKenna says "side effects" from either poorly formulated additives or too high an additive mixture can cause premature wear on any number of components, especially diesel injectors, the very component most additives are designed to protect in the first place.

Cherrillo agrees. "The side effects of any additive are of the utmost importance," he says. "A lot of claims are made to encourage truck owners to buy fuel additives, especially when it comes to improving fuel efficiency. That's why it's critical that any additive demonstrate testing by a reputable laboratory, and that fuel economy improvements not only are verified but occur without causing any damage."

PACKING IT IN

The EPA is one of many groups that maintain a list of "registered" diesel fuel additives to ensure that such additive packages do not contain any trace metals that could end up in truck exhaust and into the atmosphere. (Go to http://www.epa.gov/otaq/fuels/registrationfuels/ web-dies.htm.)

That's why many additive packages are added to diesel fuel right at the start to ensure they are properly blended in at the correct amount, says Gary Parsons, global OEM and industry liaison manager for Chevron Oronite Co.

"Fuel additives are generally chemicals that are added to diesel fuel to enhance its natural properties, or improve performance to better meet the needs of the equipment in which they are used," he explains. "There are various types of additives including cold-flow improvers, corrosion inhibitors, anti-foam, rust inhibitors, oxidation inhibitors, lubricity additives, combustion/cetane improvers, and deposit control additives. In many cases, a combination of additives are needed and many are added at the refinery to meet diesel fuel standards, such as the American Society for Testing and Materials D975 standard."

Parsons notes that fuel additives can be viewed in a similar manner to medicine. "More is not necessarily better and certain combinations can degrade performance or lead to catastrophic problems," he explains. "In the case of engine oils, supplemental additives are not recommended because engine oils are carefully formulated to optimize the performance of the overall engine oil. Adding supplemental additives can destroy the optimized balance and actually lead to a degradation of the engine oil even if the additive itself performs well on its own."

As an example, engine oil contains anti-wear additives that must attach to the metal surfaces to protect them from wear, he points out.

"The oil also contains detergents to help keep metal parts clean and deposit-free, so if, for example, a supplemental additive is used that contains detergents, it might throw off the balance with the anti-wear and prevent the anti-wear additive from attaching to the surface and preventing wear," Parsons cautions.

Far and away the most important role fuel additives play in trucking is to create diesel blends that resist "gelling" in cold temperatures. There are different grades of diesel fuel that are produced regarding low temperature performance, Parsons says, with diesel No. 2 the most widely used—and standard—grade of diesel brewed and distributed during the cold months of the year.

"However, some colder geographical locations will switch to diesel No. 1 or blend in ultra-low sulfur kerosene to provide low temperature performance in winter," he explains. "Additives can also be used to enhance low temperature performance, but the effectiveness of the additives is often dependent on the

properties of the specific diesel fuel."

BETTER FLOW

Mark Nyholm, technical product manager-heavy duty for lubricant maker Amsoil Inc., adds that coldflow protection is one of the most important additive packages a fleet needs. Yet he also notes that it provides a perfect example of "sometimes you need it, sometimes you don't" where these products are concerned.

"Basically, these cold-flow additives prevent the naturally occurring paraffins, or waxes, from turning into a paste in cold temperatures, leading to clogged injectors, filters, and fuel pumps," he explains. "Obviously, though, you don't need to treat your fuel with them year round."

Since many locations in northern climates switch over to winter diesel blends during the colder months, a fleet operating in those areas doesn't need to treat its fuels with an aftermarket cold-flow inhibitor, Nyholm notes; however, that scenario can shift significantly.

"Let's say you're based in Florida and you're hauling a load into Minnesota during the winter and booking freight to haul in that area until you get a load back to Florida," he says. "Now this is a situation where you are entering the colder regions with a load of non-winterized fuel, and it'll take a while before you refuel up there with a winterized blend. This is a case where you should treat your fuel with a cold-flow additive before reaching those climates."

A similar situation can occur when fleets are hauling freight from low altitudes into high mountain ranges, areas where colder temps can exist even in the warmer spring and fall months. "That's another scenario where pretreating your fuel with additives can help," Nyholm points out.

When it comes to improving fuel economy, though, there are actually at least a couple of different additive pathways from which to choose.

"Deposit control additives, for one, can be used to keep fuel injectors clean or to clean up dirty injectors," Chevron's Parsons says. "In the diesel engine, the injectors inject fuel directly into the combustion chamber. Dirty or fouled injectors can result in a poor injection spray pattern, which usually degrades fuel economy and increases particulate emissions. Use of a deposit control additive to clean up dirty injectors can thus improve fuel economy."

Lubricity is another concern, notes Amsoil's Nyholm. When the sulfur content of diesel was reduced from 500 parts per million (ppm) to 15 ppm back in 2006—a move required for SCR technology to work properly since sulfur "poisons" the catalysts used to reduce emissions—one fallout was quicker wear on fuel system components that needed that sulfur for lubrication.

One of the most cost-effective ways for refiners to produce ULSD fuel blends is through a process called hydrotreating. In hydrotreating, the fuel is treated with hydrogen, which removes sulfur; however, as hydrogen is a highly reactive element, it reduces the amount of other lubricityenhancing chemicals within diesel. Thus the need to put lubricity additives back into the fuel, says Nyholm.

Deposit control additives, often referred to as detergents, are necessary to accommodate the high-pressure common-rail fuel system and smaller injectors used in today's emissions-compliant engines. Fuel at much higher pressures is being forced into smaller holes if you will, and the blockage of those holes with any sort of deposit can lead to more pronounced fuel consumption penalties, Nyholm notes.

"The key with injectors is the spray pattern," he explains. "They fire more frequently with a larger spray

pattern in order to better control the atomization of the fuel, helping control combustion and fuel consumption. Any blockage that disrupts that spray pattern leads not only to degradation in fuel economy but performance as well."

CETANE CAUTION

Chevron's Parsons points to still another set of additives that are designed to boost diesel's cetane rating. Basically, these additives act as combustion improvers to enhance the combustion properties of diesel, which improves cold starts, fuel economy, and reduces smoke.

However, Mack's McKenna adds a note of caution where increases in diesel cetane numbers are concerned. "Higher cetane ratings certainly improve combustion, but they also raise combustion temperatures, and that creates more NOx [oxides of nitrogen] emissions," he says.

NOx emissions are reduced in SCR systems by spraying diesel exhaust fluid, or DEF, into the truck's exhaust stream. DEF is a clear fluid that's comprised of 67.5% water and 32.5% automotive grade urea with a very slight yellowish tinge to it and smells faintly of ammonia. By spraying small amounts of DEF into a truck's exhaust stream, ozone-causing NOx gets converted into harmless nitrogen gas and water vapor.

Of course, if more NOx is created by the engine, more DEF gets consumed—and it's not cheap. The average pump price for DEF in the U.S. held steady at around $2.74/gal. between March and April of this year, however, a big uptick in bulk and tote pricing occurred during the first half of May. This was by as much as 21¢ per gallon, according to Chris Goodfellow, emissions analyst for Integer Research, which tracks DEF prices on the website, discoverDEF.com.

ALWAYS A PLACE

While a cetane booster might reduce diesel fuel consumption due to higher combustion temperatures, it might raise DEF consumption. Amsoil's Nyholm adds another wrinkle to the cetane picture. "You don't gain any additional performance benefit once the cetane rating of the fuel exceeds 52," he explains. "Obviously, though, if you take fuel with a 40 cetane rating and boost it to 50, you'll see more efficient combustion and some fuel economy benefits. But if you're taking 50 cetane fuel and boosting it beyond 52, you won't see any measurable benefit."

Still, even with all that being said, Chevron's Parsons stresses that there will always be a place for the use of additives that help enhance diesel fuel properties and/or performance while minimizing any adverse side effects—and the role for additives is only projected to increase along those lines, he predicts.

"Tighter emissions standards and the desire for improved performance created much higher [fuel] injection pressures for today's truck engines," he says. "The demands on the diesel fuel for cleanliness, oxidation stability, and lubricity are increasing."

At the same time, the varieties of crude oil and refinery processes being used to produce the diesel fuel are also increasing. "Additives can be effectively used to minimize variability from a performance standpoint and, in many cases, will be called upon to keep the engine running in an 'as new' condition without a deterioration in performance over time," Parsons notes. And that's exactly what fleet owners want to hear.