Ultra-Low Sulfur (S-15) Diesel Fuel Facts
July 16, 2006

Within the industry there is a lot of speculation, personal opinion, half-truths, guesses (nearly all of which are wrong), and a lot of just plain bad information regarding this "new" fuel, how it will affect the new engines, the old engines, and how this is all going to work in the field.

There are refiners, distributors, and fuel jobbers on one side, engine and component manufacturers on another side, truck and equipment makers on another, regulators on another, politicians in the middle, and you the lowly customer is at the bottom of the pile where there is precious little useful information or actual hard facts.

We would like to offer you some useful information and hard facts.

Ultra Low Sulfur Diesel or S-15 is diesel fuel containing less than .0015% or 15 parts per million (ppm) of Sulfur. The EPA has required that all refiners producing fuel and all importers of fuel for on-highway use begin shipping this fuel no later than June 1st, of 2006. Some refiners actually began shipping this product or versions of a near-ULSD product much earlier. Distributors and retailers have until October of this year to "purge" their storage systems of the Low Sulfur Diesel so that by October only ULSD is used to fuel on-road vehicles.

It is illegal to put fuel containing more than 15 ppm of sulfur into a 2007* or later on-highway diesel powered vehicle. (*there are some cases where some 2007 vehicles delivered in 2006 will not have to meet the Tier III requirements)

This "new" fuel is considerably more difficult and costly to produce. The major refiners have been forced to invest hundreds of millions of dollars in order to comply with these new regulations.

Ultra Low Sulfur Diesel is derived through one of several processes the most common of which are known as "Severe Hydrotreating" and "Severe Hydrocracking". In these processes sulfur is stripped from the fuel through the use of low pressure or high pressure catalytic cracking. These processes remove sulfur through molecular manipulation via catalysts. It is important to note that in addition to removing sulfur this manipulation also has several negative consequences for the resulting fuel.

First, I want to concentrate on the loss of the sulfur and why this is important to you. Sulfur is an Extreme Pressure (EP) lubricant. It is regularly added to lubricating oils and greases to increase the lubricity and to raise the amount of pressure that the lubricant can handle before the lubricating molecular barrier begins to break down. Sulfur has always been a vitally important factor in providing lubrication to diesel engine fuel pumps, fuel injectors, and to a lesser degree engine valves.
In 1993 the EPA forced the reduction of sulfur in on-highway diesel fuels from an unlimited amount (typically 1/2 to 1% (5,000 to 10,000 ppm), although occasionally as high as 2% (20,000 ppm)) to a maximum of 500 ppm (.05%). At that time, there was a 12 to 24 month period where significant problems with failures of some metallic fuel system components such as pumps and injectors due to the dramatic lowering of lubricity and with seals, gaskets, and other rubber or synthetic components due to the reduction of elasticity caused by removing the sulfur. It was nearly two years before changes were completed in the new engines that ameliorated those problems and repairs made to older engines that controlled these problems.

During this period many fleets and individual operators began additizing their fuels to restore this lubricity and elasticity.

The reduction now being made takes on-highway diesel from less than 500 ppm to less than 15 ppm, which for all practical purposes eliminates sulfur as a lubricant in the fuel.

To explain this further we need a basic understanding of how lubricity is measured in fuels.

There are several methods of determining lubricity in fuels. The most common are: Ball on Cylinder Lubricity Evaluator (BOCLE), Scuffing Load on Ball Lubricity Evaluator (SLBOCLE), and High Frequency Reciprocating Rig (HFRR). The HFRR has emerged as the world standard and has been adopted by the ASTM and all of the engine manufacturers as the de-facto standard for measuring lubricity of fuels. HFRR ratings are counter-intuitive with the lower number showing better lubricity than a higher number.

On an HFRR test the number given is a measurement of the scar diameter produced during the test. The larger the scar diameter, the lower the lubricity, the smaller the scar the better the lubricity.

High Sulfur #2 Diesel can contain sulfur in the .5% to 2% range (5,000 to 20,000 ppm). This fuel will generally have an HFRR rating of 300-390.

Low Sulfur #2 Diesel by law cannot contain more .05% (500 ppm) of sulfur. This fuel will generally have an HFRR rating of 350-500.

Ultra Low Sulfur #2 Diesel by law cannot contain more than .0015% (15 ppm) of sulfur. This fuel will generally have an HFRR rating of 600-800.

Ultra Low Sulfur #1 Diesel by law cannot contain more than .0015% (15 ppm) of sulfur. This fuel will generally have an HFRR rating of 700-900.

The major diesel engine manufacturers as represented by the Engine Manufacturers Association (EMA) have suggested and requested that the HFRR standard be set at 400 or better. However the refiners and some other groups that seem primarily concerned with cost feel this level of protection is unnecessary.

Also, the European Union (EU) had set a standard of HFRR 460 for European manufacturers. Based on discussions within the manufacturers group the EMA has now set their minimum recommended standard at 460. (This information is available on the EMA website)
In the US, the primary body that sets the standards for fuels is the American Society for Testing of Materials (ASTM). This is a private (non-governmental) consensus group that has members from a wide range of producer and user industry groups together with representatives from various governmental agencies. This group sets all of the specifications and standards not set by the EPA. It also generally parallels any required EPA standard with a corresponding ASTM specification.

Due to its active membership leaning towards the refiners and high volume users, many of its specifications can appear to be designed to provide the lowest cost product, rather than the best product.

In the matter of Lubricity the ASTM after many years of discussion, has set its standard at HFRR 520. This is significantly less than the EMA and its membership suggest.

While this 60 point difference is unlikely to cause catastrophic failures, it will definitely increase wear on and shorten the life of components that are lubricated by the fuel.

The next regularly asked question is why the refiners aren't adding lubricity agents to this new fuel at the refinery.

The short answer is they could, but they are not allowed to. Most fuel refined in the US travels by pipeline from the refinery to the distributor. These pipelines carry diesel, home heating oil, jet fuel, gasoline and various other products. There is not a separate pipeline for each product but rather a series of single pipelines carrying all of the products one at a time.

The problem with lubricity agents is that they work too well. When fuel containing a lubricity agent is pumped through a pipeline the lubricity agent coats the pipeline and wants to stay in place, however when the next product is pumped through the line, inevitably some of this agent comes off and is carried off in the new product. In the industry this called trailback and in most cases this very small amount would not be a problem.

There is one category of fuel however where this is a problem, Jet A, Jet A-1, JP-8, etc. The Lubricity agents are considered contaminants in Jet fuels, and due to concerns over potential liability, nearly all of the pipeline carriers have banned these agents from their pipelines.

This has forced another industry first. Now fuel distributors and jobbers are being made responsible for adding the proper amount of lubricity agent to the fuel after it leaves the pipeline for local storage or when loading the delivery truck. The logistics of this process haven't been completely worked out even now. There are legitimate concerns about relying on this new system for getting the correct dosage into each load of fuel.

The reason for this concern is that a load of fuel with no or too little lubricity additive could potentially cause catastrophic engine failures.

Other issues caused by the "new" refining processes are:

The "new" refining process results in the loss of 1/2 to1% of the fuels energy content. This means less miles per gallon and less power over the old fuel.
The "new" fuel is and will continue to be more costly than its predecessor.

The fact that the new fuel will hold more dissolved water than the "old" fuel causing faster formation of gums, varnishes, and carbon deposits.

This higher level of dissolved water will lead to more cold weather problems when the higher level of dissolved water freezes and comes out solution sooner causing filter plugging and blockages at higher temperatures.

This fuel with higher levels of dissolved water is more corrosive than the previous fuel.

The severe hydrodesulphurization also reduces aromatics that will likely cause harder starting and longer warm-up periods, particularly in cold weather.

The "new" fuel has lower antioxidant properties, meaning it will degrade or breakdown more quickly than the previous fuels.

The "new" fuel has poor thermal stability, meaning that as the fuel is recirculated by the engine the engine heat will tend to break the fuel down quicker leading to more deposits and the resulting problems.

The "new" fuel is less viscous than the previous fuel; this will have an effect primarily on older engines in that they will have more internal leakage and less ability to "cushion" wearing parts. These "older" engines may not atomize fuel as efficiently resulting in lower mpg and higher emissions.

These "new" fuels will likely have what is referred to as a narrower boiling range and will produce larger, irregularly shaped wax crystals. These larger crystals tend to lock together more readily causing the fuel to gel at a higher temperature. The traditional cold flow improvers (Antigels) used in High and Low Sulfur Diesel are far less effective with these larger misshapen wax crystals. Therefore newly developed cold flow modifiers are required to protect from cold weather gelling. Most current cold flow improvers (anti-gels) are still using the old technology.

Beyond Lubricity there are other examples of specifications set for diesel that differ significantly from the generally available fuels.

If you look at the engine operating manual, most manufacturers suggest or require a Cetane rating of between 45 and 50 (depending on the manufacturer). Yet the ASTM specification for Cetane in the US is only 40. I have been involved in several cases where a manufacturer attempted to deny a warranty claim based on low Cetane (40) fuel. The manufacture knows that 40 Cetane fuel is what is generally available, yet they have set their specifications well above that.

If you look at the engine operating manual, most manufacturers set a specification for dissolved water of less than .05%, yet fuel regularly contains several times that amount. This is well known, yet it only comes up when there is a warranty problem.

Again looking at the manual, they set fuel specifications for injector cleanliness, corrosion inhibition, and thermal stabilization at levels that generally are not met in "normal" diesel fuels.
These and several other fuel specifications have been selectively used by some manufacturers attempting to disallow legitimate warranty claims.

The reason we as a country are going to all of this trouble is that starting in 2007, on-highway engines will have to meet the EPA Tier III emissions requirements.

In order to meet these requirements all of the major manufacturers of on-highway engines are using some combination computer engine controls and diesel particulate filters, aka: DPF's, Diesel Particulate Traps, Catalytic Particulate Traps, Regenerative Particulate Traps, and so on.

These new engines require ULSD to operate properly. The very, very expensive Catalytic Traps can be severely damaged or destroyed by exposure to levels of sulfur above 30 ppm.

These traps actually collect particulate emissions from the engine and either continually or periodically superheat or regenerate to burn up this trapped material. Fuels causing gums, varnishes, and carbon deposits will significantly negatively affect the operation and life of these devices.

The lack of real information or hard facts has led some to believe that this "new" ULSD fuel will be a panacea, a wonderful cure-all for all the fuel related problems of the past, present, and future.

While this not a "the sky is falling" moment, we believe it is prudent to investigate the changes in fuels and engines and act to protect the very large investment that is made in today's equipment.

In virtually every case where new rules and regulations have forced dramatic changes to existing technology, there has been a period where failures and unintended consequences have caused significant problems, expenses, and disruptions until the technology "works out the bugs".

Many of the self proclaimed "experts" are companies or individuals with little or no vested interest in your equipment and or the businesses they are consulting, leaving their disciples open to some very serious problems and expensive lessons. It is very easy to make pronouncements when there are no consequences.

The engine manufacturers do have an interest in telling customers there will be no problems. If you think about it, what else can they say that won't have customers looking at other engines? The refiners, distributors and fuel jobbers also want to deflect any criticism or potential liability away from them, the truck makers really have their hands tied, and you again are left to sort it all out.

Well Worth has "done our homework" working with Ultra Low Sulfur fuels over the past 5 years, first in Europe, next in California, and then nationwide in the US. We have products that are tested and proven to work with ULSD, Biodiesel, E-Diesel, and many more combinations.

We have products that utilize the most technologically advanced, highest quality components, formulated into products to meet or exceed the requirements of yesterday's, today's, and tomorrow's engines. We have tested our products with all of the new DPF's and Catalytic Particulate Traps and certify that our products cause no-harm to any of them.

Traditionally the major engine manufacturers have taken the public stand that their engines do not require the use of fuel additives.
While in most cases the engine manufacturers have been careful not print statements condemning or prohibiting additives or their use (because this would be illegal), they have printed statements saying that they feel additives are not necessary or recommended. However it has been reported that on occasion their employees and or agents engaged in verbal "arm twisting", suggesting that the use of these products may cause warranty problems.

While some manufacturers have been legitimately concerned about poor formulation, harmful components such as alcohol and metals, or inferior quality products, others appear to have the goal of diverting users to their own branded products.

More commonly the manufacturers reasoning against recommending additives has been a "mine is better than yours" marketing concept. This concept says that my engine will operate on any available fuel, so that if another manufacturer were to suggest the use of additives he must have an inferior engine.

While this bit of marketing bravado sounds good and has been around for a very long time, it is unrealistic and impractical in today's real world with $25,000 - $30,000.00 engines,$8,000.00 catalytic particulate traps all relying on a new and unproven fuel.

In spite of what the industry would like to have you believe, diesel fuel is not a homogenous product that is always the same no matter where or who you buy it from. Today's petroleum market is almost incomprehensibly complex with diesel is derived from a wide range of crude stock, whose chemical makeup and quality varies widely. Fuel in the US is refined in hundreds of refineries, no two of which are the same, using different methods, different equipment, and under different quality controls. A significant percentage of our fuel is no longer even refined domestically, but rather it is processed in a foreign country far away from even our mediocre quality controls and regulations.

If you have traveled and have had the opportunity to drink tap water from various locations, you know that water, our most basic element varies in quality dramatically from place to place. Some is wonderful to drink, while some smells so bad you don't want even wash with it. Yet it is all water. There are huge industries that make additives to add things to water, additives to remove things from water, and processes to make water more usable.

It then would certainly make sense that petroleum products would be different depending on where they come from and how they are processed. And it would also seem likely that things could be added or removed to make the fuel better.

Refiners use millions of gallons of chemicals to change the characteristics of the fuels they produce and to bring them up to certain specifications.

You have an important obligation under standard and extended warranties to use fuel meeting the engine manufacturer's requirements. However, this fuel is generally not available from suppliers or where it is available it is prohibitively expensive. You most certainly can use additives to protect your investment and improve your performance.
Recently some large engine manufacturers have taken a more enlightened attitude towards aftermarket additives. Acknowledging that there are some issues with fuels, these manufacturers now say that using additives to bring fuel up to desired specifications is acceptable and even desirable.

In your situation this is far more problematic as large quantities of fuel are purchased on the road, where you have little or no control of quality. A combination of treating bulk fuel and providing packaged goods for use while on the road will allow you to have complete coverage.

The point of this informational letter is not to indict or raise any negative issue with any engine manufacturer or fuel supplier. But rather to suggest that it is prudent to consider the option of using additive products that will bring your fuel into compliance with or exceed the manufacturer's specifications and requirements.

We believe that you need to control your own destiny and the only way to know your fuel meets those requirements at a reasonable cost is to additize it yourself.

Properly formulated fuel additives use the same base components available to and regularly used by refiners and blenders for use in producing fuels. A quality additive manufacturer takes these safe, proven components and blends them in varying combinations and treatment levels to cause the treated fuel to meet or exceed published or desired requirements.

We also certify that our additives comply with the EPA requirements that they do not contain more than 15 ppm of sulfur (in actuality there are only trace amounts in our fuel additives).

We warrant that Well Worth, Inc. products, when used as directed will not adversely effect or void any engine manufacturer's warranty.

I have tried to provide a lot of information in a very small space. Our purpose is to educate and provide a basis for a dialog on these very important issues. We actively support the engine manufacturers, refiners, and fuel distributors in their efforts to provide the best products and services possible.

We believe that protecting your investment is your number one priority. We have the knowledge, technology, and products to help you do just that and save you money on your fuel costs.

I would welcome the opportunity to meet with you, demonstrate our products, discuss what we can do for you, and answer your questions. Or if you prefer, I am available by phone or e-mail at your convenience.

Applies to:

Summit