



Gowlland Towing's 41-foot tug **INLET RANGER** comes in alongside for fuel in Campbell River. All diesel fuel sold in Canada must meet strict performance standards, but your fuel is subject to ongoing chemical and biological changes when sitting in your fuel tanks after delivery.

Diesel Fuel and Fuel Additives

Diesel engines have become increasingly complicated over the years, and so has the fuel they burn. Here's how to get the most out your fuel.

BY SIMON HILL

Running a successful marine business requires many inputs: Personnel, vessels, workspace, financing, fuel, and the list goes on. Naturally, marine operators want the best they can afford — the best employees, the most reliable and efficient vessels, the most suitable workspace, the most flexible and affordable financing.

Of all these inputs you'd think that diesel fuel would be the simplest and easiest to deal with, but in reality modern diesel fuel is a surprisingly complex product subject to strict environmental regulations, complicated refining processes, variable crude oil feedstocks, and ongoing changes in chemistry both during the refining process and when sitting in your fuel tanks

after delivery. The fuel in your tanks today is not quite the same fuel as you purchased a few days or weeks ago!


Certainly when you look at the bigger picture, the diesel fuel we can buy in 2015 is vastly different from the diesel fuel we were buying 10 years ago. As David Conn wrote in *Western Mariner* last year, a large part of this has to do with the move to ULSD (ultra-low sulphur diesel) fuel, a move mandated by government regulators around the world in order to reduce sulphur dioxide and sulphate particulate emissions, which are lung irritants and key components in acid rain (see *Diesel Marine Fuel: Meeting Emissions Challenges*, in *Western Mariner*, April 2014).



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Heavy crude oil can contain up to seven percent sulphur in its unrefined state, and until 2012 refineries had to bring levels in refined diesel down to 40 ppm (parts per million) of sulphur, although marine diesel was allowed as much as 500 ppm of sulphur. Since 2012, however, the limits have been made much more stringent and modern fuel — whether for on-road or marine use — can contain no more than 15 ppm of sulphur. Typically, refiners remove the sulphur using a process called hydrosulphurization, also known as hydrotreating.

Fuel Challenges

The move to ULSD fuel is great for the environment and for our health, but it raises several challenges for refiners and marine operators. One notable challenge, especially for West Coast mariners, relates to ULSD fuel's lowered resistance to diesel bug (also known as HUMbug, where the "hum" stands for Hydrocarbon-Utilizing Micro-organism). Diesel bug is a fact of life for West Coast mariners, a widespread microbe that thrives in our moist environment (especially during months with condensation-provoking temperature swings) and can run especially amok in marine fuel tanks due to generally lower fuel turnover rates compared to road-going vehicles. The

Diesel bug has always been a challenge, but the change to ultra-low sulphur diesel ... has exacerbated the problem.

microbes live within any water present in your fuel and feed off the fuel itself. As the microbes grow, reproduce and then die off, they leave dark, slimy, acidic mats of dead organic matter in your fuel. The inevitable result, if left unchecked, is clogged filters, corroded fuel tanks, and engine breakdowns.

Diesel bug has always been a challenge, but the change to ultra-low sulphur diesel, and the introduction of biodiesel blends (up to five percent biodiesel is used in much of the diesel for sale today) has exacerbated the problem. Sulphur is a bit of a natural biocide, and while the amount of sulphur present in older fuels couldn't stop an unchecked outbreak of diesel bug, it did tend to prevent the bug getting a foothold in previously uninfected storage and fuel tanks — and as with any infection, prevention is most of the battle.



From fuel conditioners, to biocides, to stabilizers, there's no shortage of additives made for diesel fuel. You don't always need additives — and some marine operators get away without ever using them — but they do have a place in the mariner's toolbox.

Biodiesel blends exacerbate the diesel bug problem for the simple reason that organic fuel is a more easily-digested food for the microbes, so they eat better, grow faster,

and reproduce more quickly when biofuel is available. Colonies of microbes can potentially double their population every 20 minutes, and this exponential growth rate means that if your boat sits for a few weeks with bugs in the tank, you can have a serious problem when you next get back out on the water.

An additional challenge with both ULSD fuel and biodiesel is their effect on water-separation filters. Typical water separation systems rely on one of two methods to remove water. The first method uses a silicone-treated hydrophobic (water repelling) barrier filter that allows fuel through but blocks water drops, which then bead up on the upstream side of the media, eventually coalescing and draining into the collection cup. The other method uses a hydrophilic (water attracting) glass micro-fibre or similar media, which doesn't block the



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water from getting through, but rather snatches it up out of the fuel stream. The water again coalesces into larger drops, which fall out of the fuel stream on the downstream side of the filter, and into the collection cup.

These methods of water separation both rely on the fuel having a low surfactancy — that is to say, they rely on the fuel's natural tendency to not mix with water, and for the water to tend to separate out (it's this low surfactancy that normally causes water to separate into a layer at the bottom of your diesel tank).

The problem is that hydrotreated ULSD fuel needs lubricity enhancing additives. These additives, together with biodiesel, rust inhibitors, and anti-wear additives, are almost all surfactants, meaning that they help any water that might be present to mix in with the fuel in much smaller drops, allowing it to pass unmolested through water separation filters and into the fuel injection system, where it can damage fuel injection components and potentially shut the engine down. Because the water collection cup never fills up, there's no indication to the operator that there is in fact water in the fuel.

There's no magic-bullet solution to this problem of high surfactancy in ULSD and biodiesel, but according to Howard Smith at Fueltration Tank Cleaning & Services, good house-

Good cetane ratings are increasingly important in modern, high-speed diesel engines.

keeping practices can help keep water in your fuel to a minimum. "Keeping tanks full when a vessel is sitting idle for any period of time reduces the amount of moist air within the tank, and reduces the side wall surface area available for water to condense into the fuel," he points out, "and so while keeping the tank full won't stop the problem it will slow it down." He also recommends over-sizing your filtration and water separation systems. "Bigger is better," he says.

Without water, your fuel tank becomes an uninviting place for diesel bug, but many mariners take it a step further by adding a biocide to their fuel. Even before ULSD fuel became mandated, fuel-compatible biocides were created to kill diesel bug, and it's a rare mariner who doesn't know some of the more popular name brands such as Biobor JF, Bio Kleen, Racor Diesel Biocide, and so on. Biobor sales manager Blake Rampy is quick to point out that when buying biocide, it's important to determine whether it's water soluble, fuel soluble or dual phase, as each has different applications: water soluble biocides are generally used for shock treatment of badly contaminated fuel, fuel-soluble biocides are most effective as a preventative measure, while a dual phase biocide like his company's Biobor JF isn't just for killing bugs, but for keeping them from getting established in the first place. "We encourage everyone to use biocide on a proactive, preventative maintenance program basis," he says. "Our slogan is 'All the fuel, all the time.'"



PHOTO COURTESY FUELFLUSH.CO.UK

A fuel filter showing clear signs of diesel bug infestation, with gobs of organic sludge completely plugging up the element.

Because Fueltration's Howard Smith runs a fuel polishing company, he's seen some of the worst cases of diesel bug infestation, and points out that biocide has its limitations. "It doesn't hurt, but it's not a magic bullet," he says. "The biocide has to be in contact with the bugs to kill them. They don't live in the fuel, they live in the interface between the water and the fuel," he explains. "So if you've got a lot of water and slime in there, then unless you shear the biocide into the fuel with a gear pump the biocide won't necessarily reach the bugs, and in some cases will simply track to the bottom of the tank. And if you stir up the sludge without removing it by fuel tank cleaning, it's going to plug your filters and possibly get into your engine." For aged fuel, or fuel that has been polished, Smith does see the value of a diesel conditioner to bring the fuel's lubricity back. "Fuel breaks down over time, and diesel bugs eat the paraffins, reducing lubricity," he points out.

Adequate or Optimum?

A second major challenge in the switch to ultra-low sulphur diesel relates to the fuel's lubricity, a measure of how well the fuel protects fuel system parts against wear as it makes its way from the tank, through the filters and fuel pump, and into the complicated, delicate and expensive-to-repair fuel injection system. With injector tolerances as tight as a few microns, it doesn't take much wear to impair injector function, resulting in compromised fuel spray patterns, reduced combustion efficiency, smoke, and other problems.

A common misconception is that it's the sulphur in raw diesel fuel that provides lubricity, and that removing the sulphur thus reduces the fuel's lubricity. In reality, it's not the sulphur that provides lubricity, but rather a range of naturally-occurring chemicals within the fuel. The problem is that the best option for removing sulphur is hydrotreating, but

Diesel Fuel and Fuel Additives

PHOTO BY SIMON HILL



A fuel polishing and tank cleaning operation underway. Fuel tanks are typically cleaned inside with a high-pressure spray of diesel fuel, while large, extremely fine filters remove all moisture and contaminants from the fuel, returning it to within specifications.

because hydrogen is highly reactive it removes not just the sulphur but also most of the natural lubricity-providing chemicals.

To restore lubricity, refiners rely on additives. The fact is that modern ULSD fuel almost always contains lubricity additives, whether or not the end user chooses to put in further brand-name fuel conditioners and additives.

Standards for fuel lubricity are mandated in the US by the ASTM (American Society for Testing and Materials) and in Canada by the CGSB (Canadian General Standards Board). In both countries, the recognized lubricity test is the high-frequency reciprocating rig (HFRR) test, which moves a ball bearing rapidly between two steel plates immersed in the test fuel for 90 minutes, and then measures the wear scar on the plates. The ASTM standard specifies a maximum wear scar

diameter of 520 microns, while the CGSB specifications match the more rigorous European standard with a maximum wear scar diameter of 460 microns.

As Chevron Canada spokesman Adrien Byrne explains, the diesel fuel sold in BC meets or exceeds this 460 micron standard. Indeed studies have shown that the diesel fuel sold on both sides of the border tends to exceed the 460 micron standard, with an average lubricity in the 424 micron range. It's worth noting, however, that OEM diesel engine manufacturers want the lubricity specification lowered to 450 microns, and the World Wide Fuel Charter recommends an even more rigorous standard of 400 microns.


A similar story exists when it comes to the cetane rating of diesel fuel, which measures how easily and efficiently the fuel burns. In this case, higher numbers are better, indicating a fuel that ignites more easily and burns more smoothly and evenly than lower cetane fuels, resulting in easier starting, less diesel knock, reduced smoke and, arguably, better fuel economy. Good cetane ratings are increasingly important

in modern, high-speed diesel engines, and especially critical in engines with common-rail injection systems.

In the US and Canada, diesel fuels must be at least 40 cetane, and Chevron's Byrne confirms that the diesel sold by Chevron in BC meets or exceeds this number. But in Europe, the minimum cetane number is 51, and the Engine Manufacturers Association has been pushing to raise the minimum standard here as well.

As David Conn pointed out in his April 2014 article in *Western Mariner*, the mandated minimum standards for retail diesel fuel mean that the use of further additives isn't strictly necessary. If you can keep water and diesel bug out of your tanks, the fuel you get from the fuel dock should be perfectly adequate for your engine's needs, and several of the large tug

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and barge companies Conn interviewed said they find additives unnecessary. But additive manufacturers are quick to counter that “adequate” leaves room for improvement. Many diesel users agree, and employ additives to address the gap between the minimum standards mandated by the CGSB, and the optimum standards recommended by various engine manufacturers.

“Smaller operators are often better at seeing the benefits directly, because the guy working on the engine is often the same guy paying the fuel and maintenance bills” notes Biobor’s Blake Rampy. The US EPA can limit the blending of biocides and fuel conditioners in the same additive package, so Biobor sells a compatible conditioner, Biobor MD, alongside its Biobor JF biocide. “Biobor MD is a product that suits both the operator looking to improve performance, and the operator looking for preventative maintenance benefits,” says Rampy. “It has additives that help keep fuel injectors clean, improve the fuel’s lubricity, boosts the cetane rating, and helps stabilize the fuel when it sits for any period of time.”

Canadian-based Lubri-Labs sells a product called Xtra Diesel that both conditions fuel and controls diesel bug in a single additive package. “It improves lubricity, eliminates water from the fuel, improves the cetane rating, cleans the fuel system

components and has biocide to control diesel bug,” says Shane Hanna at Lubri-Lab BC. “The combination of all these things gives you cleaner injectors, improved burn characteristics, and better overall efficiency.”

According to Campbell River’s West Coast Tug & Barge, this improved efficiency can translate to real fuel savings. “Being a company that keeps diligent accounting records, and knowing that fuel consumption is the second-largest expense behind

our labour, I thought [the] product was worth a shot,” wrote general manager Lukas Olsen. The company carefully documented the use of Xtra Diesel in a 1,000-hp tug with twin Cummins KTA19M diesels over the course of a year. “Our records report significant improvements with our fuel consumption, which has dropped 9.1 percent,” Olsen reported.

So is ULSD fuel bad for your engine, and do you need additives? The short answer is no. Retail diesel has been refined to meet strict performance standards, and additives mixed in during the refining process help it match the critical lubricity ratings of the high-sulphur diesel used in the past.

The full story, however, is more complicated. Modern ULSD fuel does have increased susceptibility to diesel bug, and this can be addressed both with good housekeeping and through

While modern ULSD diesel must meet strict standards, these standards aren’t necessarily everything that diesel engine manufacturers recommend...

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the careful use of biocide additives.

In addition, while modern ULSD diesel must meet strict standards, these standards aren't necessarily everything that diesel engine manufacturers recommend, and well-chosen, properly used additives can bridge this gap. "It's not like the engine won't run with subpar fuel," says Biobor's Blake Rampy

"but with inadequate lubricity you can get much reduced injector life and other problems." Exaggerated claims from some manufacturers have given retail additives a bad name in the past, it's true, but well-blended additives — including many that are sold as OEM products by diesel engine manufacturers — do have a place in the marine operator's toolbox.

Diesel Fuel Resources

For those interested in the chemistry of diesel fuel and fuel additives, there is plenty of further reading available online. A good place to start is Chevron's Diesel Fuel Technical Review, an older but very thorough discussion:
www.chevron.com/documents/pdf/DieselFuelTechReview.pdf

Fuel Filtration - Protecting the diesel engine examines the water separation challenges posed by modern ULSD fuels:
www.filtsep.com/view/1727/fuel-filtration-protecting-the-diesel-engine/

The Diesel Place performed scientifically rigorous testing of various diesel fuel additives, and the results of that study can be found here:
www.jatonkam35s.com/DeuceTechnicalManuals/Diesel_fuel_additive_test.pdf

The United Farmers of Alberta provides an interesting overview of diesel fuel properties here:
www.ufa.com/petroleum/resources/fuel/diesel_fuel_resources.html

Although it is out of date on current sulphur standards, the following Canadian government report from November 2009 explains much of the rationale behind sulphur reductions and the challenges these reductions raise:
<http://canadianfuels.ca/userfiles/file/ReportoftheTechnicalWorkingGroup%5B1%5D.pdf>

Blowin' Smoke is a third-party editorial on diesel additives:
www.intellidog.com/dieselmänn/b_smoke12.htm ◀

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