Fuel Contamination

Stored fuel is the life blood of business and government, yet it's also one of the things most taken for granted by those that need it the most. Out of sight, out of mind, it seems. Diesel fuel is purchased and kept in inventory in storage tanks, generators and emergency management systems, waiting for the time when it will be called upon to be used. The expectation is that when the need arises, the fuel is going to do what it's supposed to, and in turn, the engines and systems it powers will get the job done that they need to do.

So it can be a real shock when stored fuel fails to do what it's supposed to, when it's needed most. In fact, in an emergency, fuel issues are the #1 cause of equipment failure. And when you dig into these "fuel issues", it becomes apparent that diesel fuel contamination is a primary problem that deserves both blame and consideration.

Solve diesel fuel contamination issues and you can prevent a lot of headaches. But contamination in diesel fuel is a broad umbrella. There are multiple culprits to look at. And they can all be interrelated as well – contributing to and supporting the development of each other in the fuel.

Fuels and Engines Aren't What They Used To Be

The fuels landscape is completely different than it used to be, for a number of reasons. Changes to fuel, driven by stringent environmental regulations, have given the marketplace fuels that need more care than before.

Engine designs have evolved to meet more stringent emissions regulations, and these engines require a much higher level of fuel cleanliness. These changes make apparent the greater need for preventing and managing fuel contamination.

Kinds of Diesel Fuel Contamination

For contemporary fuels, there are three basic areas of contamination concern – water, inorganic debris (sand / dust / rust), and organic debris (products of fuel breakdown, microbial products and the waste products of fuel deterioration). These make up the bulk of the contaminants found in fuels.

Specific to "organic debris", many times people mistakenly refer to microbial contamination as diesel fuel algae, when in fact, it has more to do with petroleum gums, varnishes and lacquers than it has to do with "algae". Algae doesn't grow in storage tanks (It needs light to grow). But other kinds of microbes – bacteria / mold / fungus - they very much do grow and cause problems in stored fuel.

How the Fuel Itself Has Changed

Fuel management and operations professionals who have been in the industry for a long time can readily see that there's something fundamentally different about today's fuels vs. the fuels from decades past. If they can't see it in the fuel itself, they definitely see it in the problems that develop more readily than before. It's important to have a clear understanding of how fuels have changed if you're going to understand these fuel contamination problems and what to do about them.

Change #1: Fuel Used to Have Longer Storage Life

Fuel used to be much more “stable” when you stored it than they seem to now. In the 1960s, the US Army did a study of fuel storage life.

What they found was gasoline storage life could be expected to be 2-5 years. They also found that diesel fuels could be stored for 10 years or more without a problem.

Today, it’s not even close. The expected shelf life for common gasoline (E10) is 90 days. Diesel Fuel #2 degrades 26% in the first 28 days, and may be up to 95% if it has water in it. So fuel storage life is way, way down.

So what changed? Simply put, refineries are under pressure to produce more fuel from the same amount of crude, in order to meet ever-growing demand, they’ve had to develop new processes and methods to maximize that yield – processes like hydrocracking.

In a nutshell, they break the larger molecules in crude oil into smaller molecules that can be turned into fuels like gasoline and diesel. So they get more diesel fuel and gasoline from each barrel of crude oil.

While this is a good thing, the fuels they produce in this manner are less stable and start out with large proportions of “unstable precursors” – molecules that will turn into sludge and gums and deposits and varnishes.

Change #2: ULSD, Water and Microbes

The move towards ultra-low Sulphur diesel fuel (ULSD) in the last ten years has been great for the environment. Millions of tons of Sulphur gases have been prevented from entering the atmosphere, and that’s good for things like preventing acid rain.

But these ULSD fuels attract more water and are less resistant to microbes than the higher Sulphur diesel fuels from before 2006.

So when you’re linking this to the issue of fuel contamination, this fuel change means that today’s diesel fuels are far more likely to develop contaminants like microbes, biomass, sludge and water.

Stored Fuel Doesn’t Tend To Be Checked

With these considerations in mind, consider all those thousands of old stored fuel tanks scattered across the country.

Some have partial or trace amounts of old diesel fuel in them, and many of those have had newer ULSD added to them.

Stored fuel like this doesn’t tend to be checked until there’s an apparent or urgent need to do so – like the threat of a major hurricane.

What do you think’s going to happen with those tanks and the fuel when we get the next hurricane blitz? They’ll go to use the fuel and find some serious fuel contamination problems.

Most Common Fuel Contaminants: Water

Water build-up in diesel fuel tanks is a universal problem across the nation. Almost any stored diesel fuel left for any amount of time will end up with water in the bottom of the tank. And given the changes to the properties of ULSD fuels, it's an even bigger issue than in the past.

How does water get into fuel storage tanks? There are lots of possibilities. Water enters fuel storage systems through tank vents, but unlike particle contamination, water is not necessarily driven by the fuel level in the tank, but by fluctuations in environmental conditions like temperature and humidity.

Outside air packed with water vapor travels in and out of the tank. In storage tanks, the water from the air condenses and rolls down the side of the tank when the air cools down at night.

Some of the blame for water in diesel can also be laid at the feet of the diesel engines themselves. In diesel vehicles, the temperature change comes from hot diesel fuel returning to the tank after being used to cool the injectors. Injectors get hot due to their tremendous pressures. The engine uses diesel fuel circulated from the tank to dissipate some of this heat. The now-hot fuel is then circulated back to the fuel tank. This temperature difference causes water condensation even in this vehicular environment.

Today's fuels like to hold on to water. The common practice of blending low levels of biodiesel in conventional diesel also accelerates water problems, as biodiesel is hygroscopic and migrates toward any water presence in the fuel. Another culprit for increased water in today's diesel is the fact that, in ultra-low Sulphur diesel, the loss of naturally occurring lubricants must be compensated with lubricity additives to protect the moving components of the engine that rely on fuel as a lubricant.

These lubricity additives increase the fuel surfactant ability, which has an unintended effect of increasing the stability of water trapped in fuel.

What this basically means is that adding of conventional lubricity agents to diesel fuel makes it easier for water to become emulsified in that fuel.

So Why Does Water Matter?

It matters, for the following reasons:

- Water allowed to accumulate in a tank increases the chance of a microbial infestation – bacteria and fungi which can play havoc with the fuel system.
- Water in fuel accelerates the oxidation and break down of the fuel.
- Water contamination contributes to tank corrosion

All of these are good enough reasons to control the build-up of water in the storage tank; this is typically done by using some kind of concentrated fuel treatment. Unless the amount of water in the tank is substantial, in which case, the best course of action would be to pump the water out as part of a fuel PM program. Even the best chemical water-controllers for fuel have their limits. The best course of action for you would depend on the size of the tank and amount of water in it. This is where having a knowledgeable partner becomes a real advantage.

Water can be found within fuel as free water, dissolved water, and emulsified water. Dissolved water is dispersed in fuel molecule by molecule, and the typical diesel fuel can't hold more than 200 ppm of dissolved water content. Once the amount of water exceeds the maximum level for it to remain dissolved, water will fall out of the fuel and form a fuel-water emulsion, with small water droplets suspended in the fuel. As the water content increases beyond this, the water will turn into free water that exists as a separate layer at the bottom of the tank.

Typical water contamination levels are able to fluctuate widely. Lab testing can show that a ULSD fuel can often have water saturation approaching 50 ppm at 50° and close to 200 ppm at 100°. This amounts to 1.7 ounces of water dissolved for every one hundred gallons of fuel. When fuel in the tank and airspace above it cool to 50°, the dissolved water holding capacity of the fuel is reduced to its starting value, and the calculated amount of water is dropped out of solution and into the fuel tank as free or emulsified water.

Most Common Diesel Fuel Contaminants: Microbes

Storage of diesel fuel, especially ultra-low Sulphur diesel and diesel fuel with small amount of biodiesel, for long periods of time also makes them more susceptible to contamination by microorganisms like bacteria and fungus.

Despite best efforts, water inevitably collects at the bottom of the tank. This provides the necessary environment for microbes to grow and flourish in fuel – they live at the interface with the water and fuel, drawing their necessary elements and nutrients from both phases. Pretty soon you've got a microbial infestation that produces slimy "mats" which float on top of the fuel. The microbes multiply, excreting acids from their biological processes which both corrode the fuel tank and accelerate the breakdown of the diesel fuel, leaving you with a tank of nasty, poor quality fuel.

The earlier mentions about how fuels have changed become important to understand here. Today's ULSD fuels have virtually no natural resistance to microbial growth because of the removal of the fuel Sulphur. Sulphur, historically, has functioned to retard microbial growth – they don't like to be around it. And it's not just Sulphur, it's also the mandate reduction in aromatic content of ULSD. Microbes don't like to consume aromatic hydrocarbons as a fuel source. If you reduce their proportion in the fuel makeup, you increase the amount of the things microbes do like to feed on.

So while ULSD fuels are much better for the environment, they are extremely prone to microbial growth that may happen very quickly. It is not uncommon to start with a completely clean and sterile fuel storage tank and see evidence of fuel microbial activity within 1-2 months.

As you can guess, microbial contaminations are most common in situations where the fuel is stored for long periods of time, and also more common in marine situations where the fuel tank is around water. How do you know if you've got an infested tank? You'll probably notice rough running and poor performance with your vehicle or boat. Fuel filters will clog more often and (if you have a storage tank you can see the fuel in), you should be able to see slime floating on top of the fuel (along with foul sulphurous odours). All of these are strong indicators that the diesel tank has a microbial problem.

How do they get in the tank? Microbes are all around us, so it's not that difficult. There can be ingress from the environment through dust and water, or even fuel drops themselves. The microbes get into the tank from the environment (such as in the air that circulates in the tank, or attached to dust particles), or attached to water vapor. You just can't keep them out.

Fuel Microbe Contaminants linked to Filter Plugging and Can Spread Easily

Microbes grow in the fuel tank, multiply, and produce biomass and slime growths which will plug filters in the storage tank. So, if you're a fuel or tank manager and you notice an increase in the rate of filter changes needed, that's one sign you need to look closer at what's happening in your tank.

But this isn't the only thing to be concerned about. The problem is easily spread to vehicles and other tanks through fuel transfer. This is another reason why it's important to deal with the problem when you find it. If it spreads to things like vehicles and equipment, filter plugging issue becomes a real problem because this shuts down the vehicle or engine, which takes the machine out of commission, and depending on what you need it to do, an extra added expense and headache.

Fuel Microbe Contaminants Linked to Fuel Instability

Microbes are heavily linked to accelerated breakdown of fuel stability because, not only do they produce biomass, but they give off acids and biological by-products that attack and break down fuel quality. This creates the same resultant problems as with unstable fuel, such as the problems that we saw as we talked about fuel instability from cracked feedstocks: engine deposits, black smoke and emissions, rough, inefficient engine operation.

This last problem is the biggest concern, perhaps, for critical use system. Critical use systems and emergency management systems – they're different from fleets and those kind of users. They store fuel because it's intended to be used in an emergency. There's a high value placed on that stored fuel performing properly when it needs to. But because of the nature of these things, you can't predict when that's going to be.

Emergency backup systems aren't like fleets which have predictability in fuel usage. And that makes it more likely that, unless there are rules in place that force users to check and/or test fuel at given specific intervals, it's very likely that this kind of emergency backup fuel may not have been checked in a while. Out of sight, out of mind. And that can lead to unfortunate situations like we've seen in the recent past.

When the fuel quality is degraded, it increases the chance of system failure and engine shutdown at critical times when it can least be afforded. This has been seen in the past, during Katrina, Sandy, and after the 2005-2006 hurricane blitz across the Southeast. Users in all of these times had emergency generators that would not start, or they tested the generators afterwards and found widespread system failures because the fuel quality had been destroyed by microbial growth in the tanks. And they didn't even know it until it was too late. These ended up being huge costs, just as a result of microbes in stored fuel.

Fuel Microbe Contaminants Linked to Microbe-Related

Corrosion in Storage Tanks

The last major problem we see centres on microbial presence in fuel systems over a long period of time being strongly associated with corrosion damage in storage tanks, commonly called microbial-influenced corrosion or MIC. In these scenarios, biological acid production from microbes attack and damage metal surfaces.

Or they cause cathodic corrosion as they grow and flourish behind the protection of biomass formations. Some kinds of bacteria have been known to perforate a 5mm thickness of 316 steel in little more than one month. This may be a rather extreme case, but it does serve to illustrate that microbial corrosion can cause serious damage in shorter time than you might think.

This damage is expensive and needs to be repaired when it happens, often running into the thousands per tank. If you're in charge of purchasing or maintaining storage tanks, you know the scale of expense that we're talking about.

Most Common Fuel Contaminants: Sludge and Particulates

Sludge build-up happens because diesel fuel forms heavy polymers that drop out and collect at the bottom of the tank, resulting in a sludge build-up in the storage tank itself.

This is a problem because, first, sludge like this represents energy value that's not contributing when the fuel is burned. And second, sludge can plug filters and contribute to engine deposits if it happens to be consumed by another piece of equipment.

Organic contaminants in ultra-low Sulphur diesel can damage elastomer fuel filter seals and shorten fuel filter life. In this case, the organic contaminants are the result of free radical reactions in the diesel fuel. These reactions are accelerated in ultra-low Sulphur fuel due to the removal of naturally occurring antioxidants during the hydro treating process for Sulphur removal. As a result, a large number of peroxide molecules are generated. These peroxides promote oxidation and polymerization reactions and have a damaging effect on elastomer seals in fuel systems.

Particles in Fuel

Not only are today's fuel susceptible to formation of solids in storage as a result of their inherent instability, but they can also be affected by particle contamination from other sources. These particles in fuel can be road dust, engine rust, wear particles or any other hard particles. Particle contamination gets into diesel fuel in multiple ways. The fuel itself can pick up particles during transit, even from gas pump to gas pump. Particles can also ingress through the tank vent. As the fuel tank is drawn down, ambient air is drawn into the tank, providing a source of particle contamination. Wear debris from fuel system components is another source.

Historically, fuel cleanliness levels are ISO rated at 22/21/18, which means a particle count of 20,000 – 40,000 per ml for particles of 4 microns or higher, 10,000 – 20,000 per ml for particles of 6 micron or higher, and 1,300 – 2,500 per ml for particles of 14 micron or higher. But today, diesel fuel pump manufacturers are requiring fuel with ISO cleanliness counts of 13/9/6 or better at the injector.

This difference represents a 1000-fold reduction in contamination between the fuel pump and the time the fuel reaches the injector system. Today, particles significantly smaller than 4 µ in size are potential wear contributors to important parts.

Preventing Diesel Fuel Contamination

The storage problems that ultra-low Sulphur diesel fuels experience, mean it is more important than ever before for businesses, emergency services, governments, military, and other back-up fuel storage entities to keep preventive maintenance in mind for their fuels.

Today's diesel fuels have enough problems that they cannot risk their fuel not performing exactly how they need it, when they need it.

There are easy options available, such as DIESELCURE and DIESELCURE MARINE, and whereby PETREXX can partner with these entities to solve existing fuel storage problems (like microbial problems, water build-up and sludge or biomass present in storage tanks).

Anyone or any large Company or Entity who relies on consistent stored fuel quality to get the job done, would be well to keep this in mind.

Problem: Tank Sludge Build-up

Problem: Build-up in the bottom of storage tanks. Takes energy value out of fuel. Burns incompletely if drawn into the engine, leaves deposits.

Which change is it caused by? Cracked fuel instability, microbial destruction of fuel quality. So who might experience it? Anyone that stores ULSD.

Preventive and remediative measures: Fuel stabilizers will slow the formation of sludge. A good stabilizer treatment should have certain characteristics (you'll want it to have): Antioxidant, Dispersant, and Metal deactivator. They should also have a low treat rate, at most 1:2000.

The most effective ones will be less than that. If you have to use more, chances are you don't have one of the better ones available. For best effectiveness, stability treatments have to be added early in the fuel's life, because they work to stop chain reactions before they start. They won't reverse chain reactions.

Anti-microbials can prevent the formation of sludge induced by microbial activity. Use an anti-corrosion tank treatment that also absorbs sludge. The best such treatments combine both of these benefits for better value.

Problem: Microbial Contamination and Fuel & Tank Microbes (To Prevent Instability, Filter Plugging, Tank Corrosion)

Which change is it caused by? Removal of Sulphur and aromatics from diesel fuel, yielding a fuel with less resistance to microbes.

Who can experience it? Those that store ULSD fuel, and those that use fuel from infected tanks.

Preventive and remediating measures: There's a lot to be said for this, split into two categories.

Housekeeping – *reducing conditions that might lead to microbial growth.*

For housekeeping measures to prevent microbial growth, control of water build-up in tanks is the biggest factor.

Existing microbes *– essential steps to get rid of an existing problem*
For existing problems, use biocides to kill microbes (water control additives won't do it). You cannot kill microbes simply by removing water bottoms. You ESPECIALLY cannot get rid of a microbe problem through simple fuel polishing. YOU HAVE TO USE A BIOCIDE.

If they don't have an EPA registration number, they aren't registered and it may be illegal to use it in your particular State.

The Solution to all Problems, is getting rid of the ROOT of all the problems! WATER!

DIESELCURE and DIESELCURE MARINE gets rid of **ALL** problems caused from water and moisture build-up in diesel fuel, especially diesel stored in large storage tanks…

Why choose DIESELCURE…

- It is EPA registered;
- It is manufactured from **NON** petroleum chemicals;
- It has been extensively field tested in **ALL** industries, including Naval Testing;
- It has been successfully sold and distributed internationally for more than a decade;
- It has been tested and approved by MTU (Owned by Rolls Royce Power Systems);
- It has been tested and approved by Detroit Diesel Corporation.
- It is guaranteed to reduce Carbon Emissions in both Diesel and Gasoline engines.
- It is guaranteed to combine all the benefits found in more than 8 additives all in one.

Need we say more?

For more information on our products, please visit our website at: www.petrexx.com