Managing the Risk of how diesel degrades in storage

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Introduction

The essence of this document is to highlight the problems associated with storing diesel. For some this will be an educational experience and one that we hope will assist in avoiding diesel fuel related failures. Project managers, system designers and end users may find the following pages useful in creating an essential diesel management program.

Filter Solutions Ltd is not a manufacturer of storage tanks and hence cannot give advice of them. They are however manufactures of diesel fuel polishing systems. The following content is based on experience in the field, information handed down from suppliers and content found on the Internet.

The idea that diesel fuel will go off is presently an alien thought process. ”its diesel, what on earth could go wrong with it?” Just how important is the fuel when the time comes that it is needed? For example most stored diesel is put there as fuel for a backup generator or heating system. Nearly every city tower building has a number of generators in the basement or on the roof, put there in case of a major mains power failure. The same goes for the thousands of Data Centres and Supermarkets around the World. Imagine all that cooled or frozen food defrosting in a power cut. Or the critical data stored in the cloud suddenly going offline because of failures in both mains power and backup.

The chemical makeup of diesel has changed so even if you already have protocols in place you may wish to read on and potentially revise them.

The base fuel itself – Diesel

Most diesel generators are built to run on exactly that, diesel. The large engine manufacturers like CAT, Cummins, Perkins, MTU etc focus most of their development budget with idea that the engine uses diesel. In this document we will focus on the use and storage of diesel or gas oil.

The chemical makeup of diesel is fairly complex and a nice description of such can be found here. However we are going to focus on recent changes to certain aspects of the chemical cocktail.

Starting with Sulphur

This is naturally found in crude oil and was simply a by product of the refining process. However with increasing pressure to improve air quality governments stipulate that sulphur be processed out of the diesel to very small levels. The main reason being is that in the combustion process sulphur di & trioxide is passed out of the exhaust into atmosphere.

Sulphurs positive attributes

Now refineries have to add a number of other additives to take over the role of sulphur as a lubricant. However we have also observed that sulphur serves as a microbial deterrent. It is highly acidic and toxic to organic growth microbes.

Low Sulphur Diesel

Now serves to improve our air quality but fails to deter organic growth in the stored diesel.

Bio content mixed into Diesel

The term bio fuel normally refers to a liquid or gaseous fuel for transport produced from biomass. Bio fuels can offer exhaust emission savings over fossil fuels if the CO_2 that is emitted by their use is lower than if fossil fuels were burnt instead. For example, ethanol produced from sugar cane can deliver greenhouse gas savings of some 90%.

What exactly is Bio content in diesel?

First generation bio is normally made from conventional food crops such as wheat, which are converted into a liquid or gaseous form. They are usually blended into conventional fuels such as petrol and diesel and are commonly known as biodiesel, bio ethanol and biogas. The Department for Transport (DfT) explained how they are produced for use as transport fuel:

Biodiesel can be made from any vegetable oil, with rape seed, palm and used cooking oil being the most common. Although chemically different, it has similar properties to mineral diesel when burnt in a compression diesel engine. However, at high blend levels certain types may harm parts of an engine and consequently engine manufacturers currently only warrant their vehicles for use with 5% blends in line with the CEN [European Committee for Standardisation] standards.

The significance of Bio fuel in relation to Diesel Storage

Bio fuel blends have been known to have a range of issues including the erosion of metals in tanks and the fuel system itself, material incompatibility with existing engines and components, fuel oxidation and instability, viscosity at low temperatures.

Microbial spoilage is synonymous with the presence of water, an ever present contaminant in bio. Bio is hygroscopic – it has the capacity to absorb water, held in suspension as micro-droplets. Water being the key ingredient to microbial spoilage, thus provides a catalyst to the reproduction of microbial organisms present in storage systems; hence the higher the bio content in bio fuels, the higher the likelihood of microbial spoilage.

Water, however, can become separated from bio and form a water bottom in a fuel tank; a problem commonly found in all fuel storage systems. Water bottoms are a particularly attractive breeding ground for microbial spoilage and consequently provide an excellent catalyst to aggressive growth. Microbial spoilage primarily achieves growth in the fuel-water interface where water is present as well as nutrients from the fuel phase that provides hydrocarbons on which to metabolise. Combined, these provide excellent environs for reproduction.

Secondly, bio is itself a nutrient for the successful reproduction of microbial organisms. In fact, reports from the academic and research sectors have shown that biodiesel can degrade at half the time as mineral fuels when microbial spoilage has been introduced.

Worst Case Concentrations of Bio fuel

Under laboratory conditions, the likelihood of contamination is directly related to the proportion of bio in the bio fuel. At blends of between B2 and B20, microbial spoilage has been shown to be a major issue in storage systems. However in scenarios of between B20 and B100, microbial spoilage may not be such a problem. This is because the fuel itself attracts water, which is then unavailable for the reproduction of microbial organisms.

Although bio can hold a higher proportion of water to that of mineral diesel, this only impedes microbial spoilage when the maximum capacity of the bio fuel to absorb water has been reached. Once this has occurred, microbial spoilage can once again become prevalent, similar to a mineral diesel storage system with excessive water.

UK Diesel is currently 5 – 10% Biofuel.

Normally Observed Contamination

Generally speaking there are just a handful of factors that will increase the risk of diesel fuel operating in a harmful way. They are:

1. Dust & dirt introduced into the tank. This can occur by:
    a. Clumsy refilling using inappropriate containers.
    b. Tank inspection hatches being left open.
    c. Contamination from the supplier's equipment.
    d. Debris from deteriorating materials for example rust. This can be caused by long term microbial contamination which renders the diesel very acidic. The acidic waste product from the organism eats into the metal surfaces causing accelerated wear.
2. Water contamination
    a. Tank inspection hatches being left open.
    b. Clumsy refilling using inappropriate containers.
    c. Condensation that occurs naturally with air temperature changes.
    d. Condensation can be exacerbated when fuel returning from an engine is warm.
    e. Bio content naturally holds onto water anyway.
3. Microbial spoilage is now very common mainly due to:
    a. Water in fuel
    b. Low sulphur

Methods of reducing the Risk using Common Sense

Of course many of but not all the common forms of contamination can be minimised, if not eliminated with good fuel management practices and common sense. For example:

- Only use dedicated equipment to fill/refuel storage tanks. This helps to eliminate dirty non specific equipment being used.
- Keeping a fuel tank full helps to reduce condensation.
- Only use reputable fuel suppliers whose equipment is visibly clean and well maintained.
- Rather than keeping diesel for long durations, try and use it up. More than likely your storage solution isn't ideal and problems will occur. See this from BP.

Controllable Methods of Reducing Risk

The best and most controllable method of reducing diesel contamination is to create a handling and fuel cleaning process. In our observations of the Power Generation Hire industry the more successful and market leading companies are those who have a cast iron fuel management program. Their program provides not only them but also their customers a consistent trouble free delivery of service. This is how they achieve it:

1. All diesel fuel and storage tanks are stored and handled in one designated area. This is essential for reducing the risk of spillage and contamination from unauthorised equipment. This designated area is fitted with interceptor trays, transfer pumps and fuel polishing plant.
2. Fuel tanks are regularly inspected and repaired as required.
3. Unused tanks are stored empty. Diesel is removed from the tank and pumped through fuel polishing filter and deposited into the bulk storage tank.
4. When a fuel tank is required it is once again inspected and if necessary cleaned.

5. Static fuel tanks are fitted with a high flow fuel polishing system that recycles the diesel in the tank. This ensures that stored fuel is clean and ready for dispensing.
6. Bulk tanks are regularly treated with a biocide chemical what kills organic growths.

Fuel Polishing Plant

Several types of filtration are available that "polishes" diesel to an acceptable level. They are:

Centrifuge

This works on the principle of using gravity as the separating force. Oil is passed over a disc stack spinning as high as 10,000 rpm. Using the laws of physics debris or matter with the highest mass is drawn to the edges of the disc and collected. At the very high speeds even tiny debris cannot help but be draw out of the liquid being processed. Although there are some claims and evidence that water removal is possible we struggle to find any credible certification proving so. Consequently we have to say that the downside is poor water removal. The positive in this case is that debris removal is exceptional with low to zero consumable costs.

Filter Element Type Filters

These types of filtration offer a more consistent and predictable end result. However, in our experience only very few filter brands achieve what is required for this process. With bio fuel blends there is a strong requirement to remove emulsified water. MOST off the shelf filters have very poor emulsified water removal efficiency. Therefore it is important to seek out filtration that can offer some sort of certification of efficiency. For example look for filter that are constructed to the SAE standard J1488 & J1839. This tough standard ensures that the elements perform to the following rated efficiencies.

- SAE J1488 – Emulsified water removal to 99% efficiency in a single pass.
- SAE J1839 – Course water removal to 99% efficiency in a single pass.
- Debris removal to a particle size of 5 microns.

In order to achieve the above results diesel fuel is passed through two elements. The first element functions to coalesce the emulsified water into larger droplets which then fall down the filter and collects. The second element removes debris to the size specified above.

Pros & Cons of either type of Filtration

This is always a subjective personal preference but from a logical stand point the element type of filtration would seem most suitable. The main reason being that there is a provable industry recognised standard of efficiency. Additionally you can offer nearly any condition of diesel at it and the fuel will be cleaned. Whereas centrifugal type filtration has virtually no emulsified water capability and limited capacity to remove free standing water.

Biocide Treatment

Certainly in some industries it has become a regular practice to dose the fuel entering bulk storage with a chemical. This acts to kill the organism and consequently stop the spread. This is a VITAL part of any installation where diesel fuel is being stored for periods of one week or more. Durations of storage shorter than this may be ok because all the fuel is being consumed regularly.

However treating the fuel is no miracle cure on its own. The chemical does indeed kill the organism and solve part of the problem. But you are then left with the dead carcass of the organism floating around the tank. This still poses a high risk and needs to be removed before blocking a fuel line or filter on the engine. Therefore fuel polishing plant is essential in the management program.

Summary

In summary diesel fuel that has a small percentage of bio fuel mixed into it is now unsuitable for unmanaged long term storage. There is a high chance that organisms will thrive inside the fuel, not only contaminating it with their physical presence, but also with their waste by products. If left for long durations without any management intervention the diesel fuel will become less combustible, highly acidic and full of physical matter (the organism).

All stored diesel fuel should be managed with two pronged approach. Firstly treat all bulk storage tanks with a biocide to kill organic growths. Secondly use a good high flow fuel polishing system to filter out dead organism, water and other debris.

Reference material

What is sulfur and why is it present in diesel? – Exxon Mobil
Sulphur Content of Liquid Fuel Directive – UK Government Website
UK Biofuel Legislation – Parliament UK Website
Fuel Biocide Manufactuers – Fuelcare Ltd
Long term diesel storage – BP
SAE International
Definition of coalesce
Fuel Polishing Systems – Filter Solutions Ltd