	Technical Information No. 02
Subject	Engine failure due to fuel contamination by micro-organisms – Future Fuels
Category	Engine
Content	Due to changes in the composition of diesel fuel, it became more susceptible to the growth of micro-organisms. This increases the risk of engine failure. This TI discusses the causes and consequences and provides practical tips on prevention. It also pays attention to the new generation of fuels, such as GTL and HVO Fuels

1. Introduction

In these last few years, several international media focussing on water sports have paid attention to the problem of fuel contamination by bacterial growth and the consequential engine failure and shutdowns, this due to the clogging of filters and fuel lines. More and more boat owners have experienced this themselves. The KNRM (Royal Dutch Rescue Organisation) also reports that more rescues as a result of engine failure have taken place, yet without discussing the universally known fact this is partially due to polluted diesel oil (around 80%). The market plays into this problem by offering filtering systems and additions to fuels. In short, plenty of reasons to assume that this is a problem that every boat owner should be sufficiently aware of and should be able to act upon it with responsibility.

2. Bacteria

Below, we will use the term ‘bacteria in fuel’ to define everything that is alive. This includes both bacteria and fungi. They are natural micro-organisms growing in a wet environment, whose excretion and multiplication can cause slimy substances, that in turn can clog fuel filters. The fuel supply is reduced or even completely blocked, resulting in an engine with impaired power or even in complete engine failure. This phenomenon is also known as ‘Diesel Bug’ or ‘Diesel Pest’.

Bacteria are everywhere; not just in our food and bodies, in the water and air, but they also occur in many industrial fluids, such as coolants for metalwork and fuels. The presence of bacteria in fuels (diesel and petrol) is not new. The first substantial investigation dates to the fifties, when a research into the cause of an airplane crash showed that the fuel had been contaminated with micro-organisms.

Slimy substance on tank wall and bottom due to micro-organisms

3. Conditions for bacterial growth

The most important growth factors for bacteria are the presence of water (even in very low quantity or in dissolved form), the absence of 'toxins' or growth regulators, and the temperature.

Sulphur in fuels used to be an important regulator. For environmental reasons, the percentage of sulphur in diesel fuels has been reduced from 800 ppm in 1972 to 10 ppm (only 0,001%!). This is an influential cause of why we encounter more issues with our fuel tanks.

Water is one of the main enemies of fuels, not just because it can contain bacteria (in rain water or through the supply chain of vendors with storage tanks that have not been well-maintained), but also because it can cause corrosion to the fuel system. Unfortunately, we cannot prevent water in our fuel tanks on board, for reasons such as condensation forming in the tank, ill-fitting tank caps, or frequently fuelling in humid weather types. Not only that, but our engines rooms are often too small and do not have features to tap the water from the lowest level of the tank. Over the years, this will result in water accumulating in a tank.

Growth of micro-organisms on interface of oil and water

In relation to this, there is a new development in the engine fuels that facilitates bacterial growth. The Dutch government has decided that oil companies are obligated to **add a percentage** (7 % according legislation in 2020) **of biofuels** to our normal diesel fuel. This biofuel, also known as FAME (FattyAcidMethylEster), is being blended with diesel fuels since 2008. It is legally defined that the bio-blended percentage should increase every year. The downside of this component is the strong hygroscopic effect it has. It ensures that the (often unavoidable) water in the diesel oil is no longer separated and that there is no interface between oil and water, which means that bacteria have a bigger living environment.

- ***Which is why we have a problem***

Because of the obligation to blend a bio component and the reduction of sulphur, combined with the unavoidable water in our fuel tanks, the phenomenon of clogging fuel filters and pipes has become more prominent in these last few years.

4. Preventive measures

Taking away the main cause of bacterial growth – water – has the highest priority. We can do this by:

1. Checking if the tank lid closes properly
2. Fuelling during dry weather types
3. Keeping the tank as full as possible, which ensures the least condensation forming
4. Regularly tapping water from the tank, by using a drain valve or by using a vacuum pump on the lowest part of the tank.

Reality teaches us that, despite paying attention to the preventive measures, a water free storage tank is hard to realise. That is why these next actions are particularly important to keep the bacterial growth (and pollution) in check, or even limit or completely stop it:

1. Checking the current level of bacterial pollution by taking a sample and doing a test
2. Preventing bacterial growth by using a maintenance dose of a biocide.

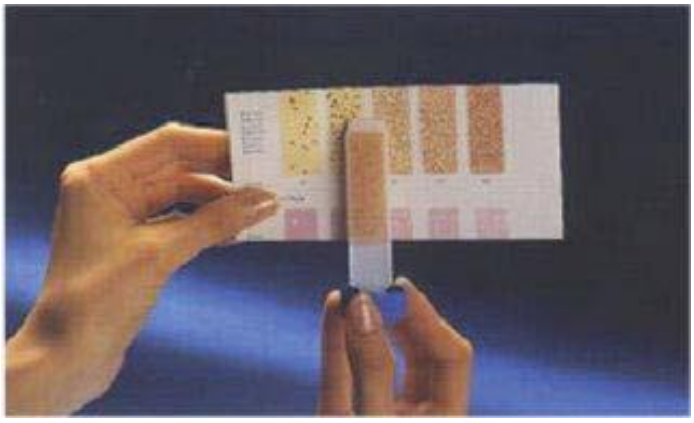
To prevent that, despite all these preventive measures, an engine fails due to a clogged filter, we recommend installing a duplex coarse filter and a water separator. This ensures that when one filter is clogged, you can switch to the other filter to keep the fuel supply steady. Please do remember that replacing a filter does not fix the problem. Inadequate fuel supply can also be caused by clogged lines due to pollution.

Another alternative to keep the fuel supply from blockage, is applying a so-called magnetic filter. Its effect is still a topic of discussion. It should ‘cut up’ the ‘strands’ of micro-organisms into smaller parts, which should result in filters clogging less easily. The downside is that it does not prevent the cause of the clogging, bacterial growth, in the tank.

5. Application of biocides

Several products serving as ‘shock therapy’ or maintenance dose can be found on the market. As a novice, it can be hard to verify these products and suppliers. Practical Boat Owner (April 2017) has tested 10 Diesel bug fuel treatments. The results give a practical overview of these products’ effects. Two products came up Best in Test: Grotamar 71 (often applied in oil industry) and Marine 16. Of course, this does not mean that the products that have also been tested cannot have been further developed in the meantime.

If these chemical additives, biocides, are applied, it is important that the instructions are followed to a tee. Equally imperative is to keep taking samples and paying attention to colour, clarity, and presence of visible pollution. The best way to check for bacteria in an apparently 'clean' fuel is to use a costly test in a laboratory. The outdated and cheaper test, called a dip test, is still used but it gives a less accurate result on the presence of harmful micro-organisms.



Using a dip test to determine the level of bacterial growth

6. Modern Diesel Fuels - Future Fuels.

Fuel suppliers keep applying quality improving measurements to their products. These developments are largely prompted by strict environmental and subsequently requirements for combustion engines. This compels engine and fuel producers to further develop their products with a more efficient combustion, reduced fuel consumption, and cleaner fuels.

Even though diesel fuel needs to meet the standard EN 950, modern diesel engines and their users require fuels that are better than this standard quality. Using the new generation of synthetic fuels, considerably lower emission values can be realised, contributing greatly to energy transition.

In 2020, several types of new diesel fuels can be bought. They are all based on the Fischer-Tropsch process. This technology allows you to use different feedstocks. Natural gas forms the source material for **GTL Fuel** (Gas-to-Liquid), and biomasses such as frying fat is used as a feedstock for **HVO Fuels**.

GTL Fuel
Shell has a leadership position in the development and application of Gas-to-Liquid technology, not only for fuels but also for base oils for premium lubricants. Natural gas acts as a feedstock for this GTL diesel fuel, so it comes a no surprise that the largest GTL factory is in Qatar, where natural gas is readily available.
GTL is clear and nearly odourless. It does not contain a bio component like standard diesels do, so it is not hygroscopic. This is a big advantage for sailing boats with a higher risk of water and condensation forming in the diesel tank. The composition of this aromatic and sulphur free diesel ensures that there is hardly any visible smoke development with a cold start. This is very convenient for older diesel engines, and with that, for other marina residents.

GTL Fuel combusts cleaner (r) than 'regular diesel (l)

HVO Fuel
Biomass is used to produce HVO Fuels (Hydrotreated Vegetable Oil). This biomass can come from several different sources. As a feedstock, this biomass is converted through the FT process into a syngas, after which the step to producing functional liquids such as diesel follows. As a result, it is also called Biomass-to-Liquid (BTL), a variant to GTL.
Contrary to GTL, HVO Fuel can be a bit yellow and have a faint smell. There are many different products and suppliers of HVO Fuels.

As for their properties, both GTL and HVO Fuels are equal in their combustion properties and emissions, and both meet the standards of the EN Norm 15940. This norm is used to classify new fuels based on their manufacturing techniques and product properties. Due to the absence of unsaturated hydrocarbons, they have very low values for NOX, particulate matter, and sulphur.

A difference between HVO and GTL Fuel is the CO2 impact during the entire life cycle of the product (source material, production, distribution, and combustion), based on the Well to Wheel analysis. The EU has created a guideline (EU 2015/652) that compares the carbon intensities of different fuels. This is favourable for HVO because biomass is seen as a waste product and is considered CO2 neutral. Companies that want to reduce their CO2 footprint can use HVO containing diesel fuels to realise this.

Diesel Blue
The Diesel Blue product is a bit confusing. It is a diesel fuel that can contain HVO fuel in different concentrations (ranging from 10% to 90%). HVO containing diesel fuels are provided with a blue colour, hence the name Diesel Blue. This product is not sold through regular pumps, but mainly through distributors to companies who want to lower the CO_2 footprint of their fleets. To optimally profit from the technical and ecological advantages of the new fuels, you should pay attention to use the 100% HVO version Diesel Blue.

7. To conclude

The phenomenon of pollution of diesel fuel is directly linked to safely sailing our boats and can essentially be taken care of by a focused approach and maintenance of the fuel and the entire fuel system. The application of new, innovative and synthetic fuels (such as GTL and HVO Fuel) cannot prevent the formation of bacteria but can help reduce the growth. Furthermore, this new generation of fuels greatly contribute to a reduced environmental impact and with it, energy transition.

Sources (mainly in dutch language)

Waterkampioen: 22/2008. Het brandstofsysteem

Waterkampioen:20/2011. Wat doet bio in diesel?

Practical Boat Owner April 2007

www.shell.nl/klanten/commercialfuels/gtl/products.html

http://en.wikipedia.org/wiki/EN_590 (diesel fuel standard specification)

Toerzeilen No. 262, 264, 266.

Many Internet publications

Author: P. van der Waa
Revised: May 2020