WATER AND DIESEL OIL DON'T MIX - OR DO THEY? by David Thorley

Engine Failure!

You can imagine the scene — it has been an exhilarating day's sail and together with your mate and crew you are approaching harbour, a little tired and looking forward to being tied up alongside with some welcome (liquid?) refreshment. Several other boats are about and the harbour entrance is busy. The wind is getting up and there is a bit of a cross-tide so it's time to get the motor on and sails down.
You turn the key, press the button, the engine revs up, sputters and dies! You know there's plenty of diesel in the tank, so you try again and the same thing happens. The problem is almost certainly fuel starvation, but what is the cause? There are two or three possibilities, but one of the most likely is that your fuel system has become contaminated by water. Water contamination of diesel fuel systems is a topic that consistently generates articles in the yachting press and this year has been no exception. There still seems, however, to be an element of confusion about the nature of the' problem and the best strategies for dealing with it.

Attempts at Prevention

British and European Fuel Standards seek to limit the amount of water present in diesel fuel at the point of sale, but these are of little real benefit to those of us who sail and who have to allow for water getting into our fuel systems. The main source of this water is condensation of water vapour in the atmosphere and, sometimes, leakage into the fuel system. The presence of this free water creates an environment that encourages bacterial growth leading in turn to sludge formation, fuel line blockage, poor engine performance and ultimately breakdown. Such problems are not unique to either diesel engines or small craft. They can occur in any plant powered by liquid fuels, including buses, trains, ships, and agricultural and military equipment. Similar problems also occur in aircraft fuel tanks in hot, humid, climates.

Keeping Water Out

The issue that we have to address as sailors is how can we best avoid the problems and what can we do if they still occur? The start of the answer has to be good fuel husbandry. The fuel system must be maintained in good condition, free of leaks into, as well as out of, the system, great care taken when refilling to avoid leakage of water via the filler pipe and only refuelling from reputable and clean sources. These points are all fairly obvious and not too difficult to meet. A greater problem comes with the more insidious accumulation of water in the system from condensation. It can be minimised by keeping the fuel tanks nearer full than empty and leaving less free space for the ingress of moist air as the tank breathes naturally. Nevertheless, there will still be a gradual accumulation of condensation over a period of time.

Dealing with Water Already in the System

A common practice for dealing with this is to fit filters and water traps. They must be inspected regularly and changed/drained when appropriate to do so. The main disadvantage with filters and traps is that the water remains separate and the environment in which bacteria can develop is not destroyed. An alternative strategy is to use an additive to bond the water to the fuel so that it passes through the system and burns with the fuel in the combustion chamber. In this approach there is no interface between the two liquids, and the environment conducive to bacterial growth is thereby eliminated. It is absolutely essential, however, that the water is properly bonded to the fuel by using sufficient additive of the right type. Opaque emulsions are not good enough: they have been tried unsuccessfully and given this approach a bad name.

New Research

At City University we undertook a research programme to look at the possibility of developing a suitable additive. In our preliminary work we encountered a number of existing additives that claimed to create emulsions which would help convey water through fuel systems. We tested many of them, of which only some are available commercially and discovered, regrettably, that they all failed one crucial test — that of stability of the resulting mixture. In a stable formulation the 'mixture' becomes completely homogeneous and remains so over an extended period, without any settling out of the constituent parts. This is crucial to avoiding bacterial growth and corrosion of system components. The question of stability became one of the main focal points of our research programme. After extensive tests, and giving particular attention both to the stability of mixtures of diesel and water and to the compatibility of the additive ingredients with system components, we devised a range of additives capable of absorbing up to 15% of water, by volume, in diesel fuel. The additives are a blend of surfactant materials similar to domestic washing-up fluids and industrial degreasing agents. The optimum blend really depends on the amount of water present, but in the context of contamination by condensation this will be quite small. For example, a commercially available version of one of our additives, called Aquasolve, is tailored to handle water contamination of the order of **2%** — a quantity that will not cause any adverse effects to diesel engines or fuel systems provided it is properly bonded to the host fuel.

Practical Uses of Additives

There are two reasons for using additives that properly bond the water to the fuel; one as protection against the slow build up of water as a separate entity, but also in an emergency situation when a large amount of water has inadvertently gained access. In the preventative case, a small dose of the Aquasolve is added to the fuel tank immediately prior to refilling. This will be sufficient to absorb the small quantities of condensation that fall from the sides and roof of the tank. For example, I frequently sail on *Atanua,* a 32 *ft.* Jeanneau fitted with a Yanmar diesel engine, and moored on the Beaulieu River. About three and a half years ago the owner volunteered to try the additive we were developing at CityUniversity. Prior to this, at the beginning of each season he regularly changed the fuel filter, after draining out water, followed by a pink slime, before he got to clean fuel.

For the last three years he has been adding a small quantity of additive each time the boat was refuelled (approx. one egg cup ful to 20 litres of fuel). At no time since then has there been any evidence of free water or the accumulation of the telltale slime that indicates the presence of bacteria in the fuel. When the filter bowl drain is checked, the fuel is quite clear and clean. Many similar bench-top experiments confirmed this to be a suitable strategy. In the case of a large quantity of water gaining access to a fuel system, first drain out as much as possible, then use an additive to absorb the rest that clings to the various tank, pipe and component surfaces. The important thing is to ensure that sufficient additive is used so that a stable mixture is formed. There will be no adverse effects if an excess of additive is used.

Fuels for the Future

Though not yet directly relevant to sailors, but pertinent to our research programme, is the intentional addition of water to fuel. At least one major fuel manufacturer, as well as other research laboratories, is working on water addition to fuels since there are several aspects of interest. Firstly, there is evidence that the presence of water can improve the quality of exhaust emissions and secondly, in some types of engine (though not all), the power output can be increased put another way, less fuel is required for a given power requirement. The ability to control water in distillate fuels is the key advance in our research programme. The technology developed in the course of our work has also shown that not only water can be blended satisfactorily with diesel oils. Animal and vegetable oils have been used and at the time of the EEC butter mountain a fuel comprising *25%* butter oil was developed, with the assistance of the Moorepark Research Institute in Eire, and used successfully to power a diesel engine. Although butter is not of any real significance as a fuel, the ability to create stable fuel oils from vegetable sources is of long term interest to countries which currently have to rely on imported fuel oils. Meanwhile, we now have at our disposal a means of ensuring that our iron maidens will not let us down at critical times due to the presence of unwanted bugs in our fuel systems!

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