

FUEL CONTAMINATION IN THE MARINE ENVIROMENT



This short presentation was given to the Cruising Association explaining the reason for catastrophic failure of boat engines caused by bacterial and fungal slimes. In depth detail can be found at www.fuelcare.com

Commonly called the diesel bug, the bacteria, yeast and molds, are mostly fungal growth that ends up as a slimy mat in your fuel tank. And it's not just confined to boats

I have excluded the controversial topics of fire dangers, sulphur lubrication, biofuel waxing, and red diesel tax since they are discussed elsewhere..

I'm sure everyone can vividly remember the time when your engine stopped for no apparent reason. It's a heart stopping moment Almost as bad as your GPS alarm.

Drifting at 6 knots in the rocks and tides of the Channel Islands or the North Brittany coast, not under command

Screaming baby in the carry cot,
Partner asking what are we doing out here,

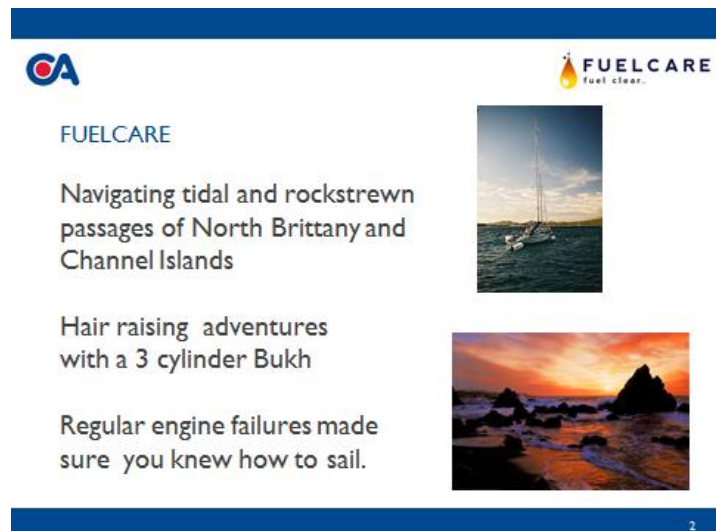
Young son asking what time we are getting there.

And dad down below sucking diesel through the fuel pipes covering the saloon loor in a slimy smelly mess.

In my case I found my fuel pipes and filter full of slime and in the panic wondered what I should have done to prevent it.

I will you with that thought and come back to it later

I hope I can show you how you may prevent biological contamination, and if not how to get rid of it.



My business in Bromsgrove happened to be a main distributor for a chemical called Kathon, a biocide for preservation of paint.

A biocide is a chemical that can control or kill off micro-organisms.

We found out that this biocide had also been formulated as Kathon FP 1.5 and given approvals as one of the best fuel preservatives in a wide range of industries.



After trying this biocide on my own boat, my company eventually became a sole distributor and the eventual establishment of Fuelcare Ltd supplying every type of industry where diesel and kerosene is used.

Biological contamination is not just a problem in the marine environment which my presentation is about. It affects the railways, aviation, road transport, fish farms, agriculture, home heating, emergency power generation and fuel tank farms to name a few applications.

To understand the problems I would like to go through the different stages of contamination and prevention recommendations.

1. FUEL CONTAMINATION
2. FUEL QUALITY CHANGES
3. DETECTION & MEASUREMENT
4. PREVENTION RECOMMENDATIONS
5. TREATMENT REGIME

Diesel and kerosene can be infected by fungal growth and this starts in the supply chain from its first storage point after the refinery down to the point of combustion.

EU fuel quality directives are encouraging fungal growth.

I hope I can show you some housekeeping to prevent contamination and how you might spot it

And if you can't stop it I'd like to make some treatment recommendations.



This growth manifests itself in fuel and water emulsions and in the bottom of the tank as slimes and jelly like substances.

These black brown or grey slimes are commonly called Biomass. This can be found in many tanks attached to tank bottom surfaces as a slimy matting or as an sludgy emulsion at the fuel water interface.

And guess where your fuel tank suction pipe inlet is. Usually within 2" to 4" from the bottom of the tank

Sometimes it is difficult to recognise this as "the bug" because of the accumulated debris.



The first rough passage of the season will stir up contaminants.

Result: you end up with the slimes and sediment blocking or blinding the filter so that nothing can get through

Large mats of slime can form very quickly in the right temperatures. They can trap water which may cause corrosion in mild steel.

If contaminated fuel is left to stagnate without oxygen for a long period, Sulphate Reducing Bacteria can grow that produce acidic by-products. These cause rapid pitting and severe corrosion of steel tanks and can be recognised by the smell of Hydrogen Sulphide

Keel tanks are the very worst for slime problems due to stagnation and temperature variations

If the biomass breaks loose it will enter the fuel suction pipe and usual block and blind the primary filter.

It can even grow in the fuel pipes and block or cause suction loss of the low pressure fuel lift pump.

If it gets into high pressure pump this will usually end up as an expensive repair job

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FUELCARE
fuel clear.

FUEL CONTAMINATION

WHERE IT MIGRATES

Biomass will be sucked into the fuel pipe and will blind the primary filter.



Blocked primary filter





It's easy to see the problem in a glass bowl



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Sediment such as dirt, sand and rust particles are not normally a problem, until you add the "diesel bug" If you have any slimy gel or matting in the bottom of the tank this can accumulate the debris, make blockages much worse and make you think you have a dirty tank problem

Usually there is no drain on tanks in small boats so removal of sediment is difficult and further hampered by baffle plates. Often you will consider fitting a new tank.


If you remove and filter or polish your fuel the infection may still be present and can easily grow again.


As if we don't have enough to worry about, changes to the diesel fuel specification are making things worse.

Colin Heywood and John Lansdell monitor these changing rules for us all and regularly report through the Regulation & Technical Services committee.

The EU Fuel Quality Directives specifies that all diesel is now supposed to be Ultra Low Sulphur Diesel reducing the sulphur content from around average 750 ppm to less than 10ppm in order to aid emissions reduction technology.

High sulphur levels act as a retardant to the growth of micro-organisms so we may see higher growth levels








FUEL QUALITY CHANGES

The major changes happening to your fuel:

1. Ultra Low Sulphur Diesel (ULSD)
2. Increase in F.A.M.E. or Biodiesel content



The other change is the introduction of F.A.M.E. (Fatty Acid Methyl Ester) or Biodiesel.

The content of F.A.M.E. in diesel is increasing from 7% to 10% over the next 8 years. It is probably 20% or higher in some EU countries and just unknown in some parts of the world.

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F.A.M.E. or biodiesel is a rich source of food and can also have a higher water content. It provided nutrients for microbial growth leading to many more reports of bacterial contamination in the supply chain.

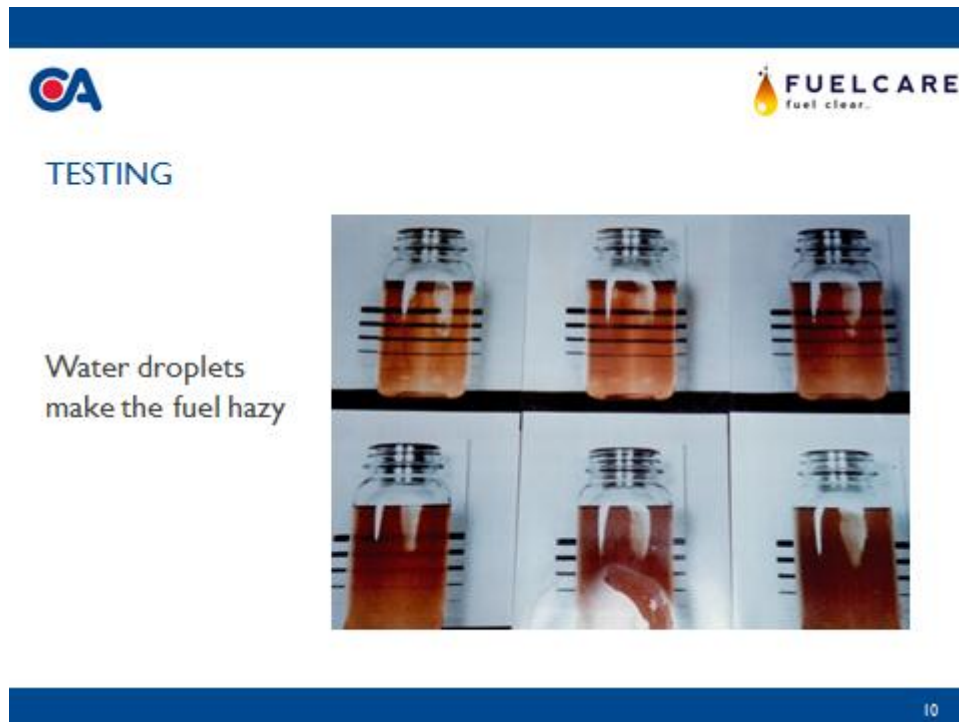
UK Petroleum suppliers are supposed to supply the marine industry with red and white diesel free from biodiesel but I'm not sure if this always the case and don't think it will last. I am sceptical about the grades of fuel we end up with particularly in the rest of Europe.

Blue water sailors already have a distrust of supplies in some parts of the world and would probably get some expletives when asking if it was the correct age, sulphur and F.A.M.E. content.

Sometimes we're lucky if we can catch a taxi to the nearest garage to fill up our drums with no questions asked. At least we can allow the fuel to settle before adding to our tank.

I would like to discuss the water content for a moment, the source of many of our troubles.

We can use a simple visual aid like this to determine whether there is water in the fuel.



The obscurity of the black lines behind a glass jar give us a simple way of assessing the water content in red diesel.

The background lines should normally be very clear and we refer to it as haze factor between 1 clear and 5 very poor

You can get an idea how it should look by taking a sample from the top layer of your spare fuel drum

Hazy fuel indicates a high water content which can lead to bacterial contamination. This should not be confused with "cloud point" that occurs in cold weather.

However, to do any sort of test the fuel should be taken from the bottom of the tank where most water and growth resides. If you have to take it from the separator it's probably best after you've been sailing to shake it up.



You can get a laboratory to measure water content but they will need at least a litre and charge a lot to boil away the fuel and measure the weight difference.

If you can get to the top of your tank you can also use water paste on the end of a stick which changes colour in the presence of water to determine the water level in the bottom of your tank.


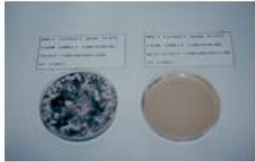
Bacterial and fungal growth is measured as Cfu/ml (Colony forming units per millilitre)

Contamination levels are usually in the range 10^2 to 10^5 and given separately for Bacteria and Yeast and Mold and at any of these levels some action should be taken


Laboratory Analysis is accurate but expensive at £50 to £100 per sample and can take up to 10 days to get results returned

Agar plates used in laboratory to grow bacteria and fungus separately

Run No.	Temp. (°C)	Time (hrs)	Initial Reading	Final Reading	Count	Notes
1	37	24	0.1	0.2	10	Control
2	37	24	0.1	0.5	40	Sample
3	37	24	0.1	1.0	100	Sample
4	37	24	0.1	2.0	200	Sample
5	37	24	0.1	5.0	500	Sample
6	37	24	0.1	10.0	1000	Sample



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TESTING

Dip slides are a faster low cost Alternative




Dip slid chart

Slight growth



Too numerous to count



In comparison to the laboratory, test dip slides are cheap to use at about £3 each

While not as accurate as the lab they give a good enough idea.

After dipping in fuel they need to be incubated in a warm environment at about 30° C for 2 or 3 days

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If you are have a hot water boiler running you could incubate them near this or in a hot engine room.

If you find any colonies on a dip slide we recommend treatment.

The drawback to dip slides is that they have a limited shelf life of only 6 months but I have extended this to a year keeping them in the fridge

Onset of biological fuel contamination is entirely preventable with good house-keeping
However not all ideas are practical on the day.

In trying to keep water out of your system let's start with your own fuel supply chain



PREVENTION and GOOD HOUSEKEEPING

Try to keep water out

If fuel supplier is suspect use a funnel or Baja filter

Check your tank filler cap and leave tanks full before layup

Run engine for 30 minutes after layup and check separator regularly on first trip

Beware of stirred up contents after fillings the tank





Beginning with bunkers, and a bigger problem for blue water sailors, some fuel stations will supply water and plenty of debris with your fuel.

Carry a funnel filter or a Baja filter for these times where you are suspicious.

Sometimes it may be necessary to fill up your diesel drums and let them stand before decanting to your tanks.

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Water can get to your fuel tank via the filler cap so make sure the gasket is still there and that it is a tight fit to exclude rain, sea and air. You cannot do much about it but water could be getting in via the air vent in big seas.

Although rare if you have a drain on the bottom of the fuel tank use it every month and check the condition. If you are lucky enough to have a day tank this is easy to do.

If you are leaving the boat always try to leave the tanks full to prevent ingress of air and condensation. This is perhaps not so critical in hot climates but beware in high latitudes and high rainfall areas.

Remember that filling the tank, and your first passage after a layup, will disturb and loosen debris and any slime. After a layup run the engine for 30 minutes before contemplating a long trip.

Regularly drain water from the separator. Fit a glass bowl on the primary filter water separator and keep an eye on it for signs of water or sludge.


Look out during a rough passage. Check the separator at the same time as checking your oil.

Occasionally take a fuel sample from the separator, decant into a clean glass and check if it looks hazy.

Keep your tank free of water and you won't have a problem, but, this is easier said than done.

You have maintained your good housekeeping but if you get or suspect an infection then treat immediately with any good biocide.

Try to circulate treated fuel through the fuel system by manually operating the lift pump and open the secondary polishing filter drain.



FUEL PRESERVATIVE

Fuel preservative is a biocide that will kill bacteria and fungus

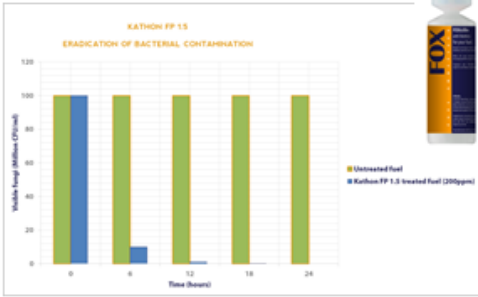
Will clear your system


Separates water & fuel

Stops the slimy matting

Less chance of debris

Filters will not blind





Treatment can rescue you in 12 hours and get you going again.

It will at the very least give you breathing space to look at other options and discount the fuel bug.

It is cheap to do and while you may be impatient and have doubts it is doing it's job.

Make sure you use any good dedicated biocide and not some concoction. In most cases it will completely clear your system in less than 24 hours.

Biocide treatment of an infected fuel tank will kill off the bugs and cause water to separate out from the fuel water emulsion. It will eliminate the sludgy fuel water interface and keep the water in the bottom of the tank.

Any water entering the fuel suction pipe will easily be removed by the water separator without blinding the filter.

The dead growth has a very much smaller volume because it is not matted like bubble wrap. Although dead growths and sediment can still be sucked up they will not blind or overwhelm the primary filter in a catastrophic way.

The filter will continue to do its job but after an infection should be changed more frequently to begin with.

After an infection use the biocide 24 hours before filling your tank. Dilute the appropriate dose in 5 litres of fuel before adding so that good mixing takes place.

Regular use of biocide treatment will make it difficult for slimes to become established.

Implement the use of fuel biocide as a preservative at every tank refill and use $1/3^{\text{rd}}$ the normal dose rate. Or use it every 2 or 3 tank refills at half dose. Smaller doses should be avoided since resistance may develop although this would take up to 12 months

FUEL PRESERVATIVE

Regular treatment at half dose will make it difficult infections to become established

Use a good fuel preservative once a year or every 3 or 4 tank refills

Use before winter layup

If layup treatment missed dilute in fuel and add to tank 24 to 48 hours before spring refit.





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Always dose before winter layup. Dilute in 5 litres of fuel before adding.

Despite the controversy it is my strong conviction that fuel water emulsions are not good for your high pressure fuel pump or your injectors, and can result in corrosion or incomplete combustion.

Given the amount of water in any typical fuel tank, water removal by chemical treatments is so miniscule as to be a complete waste of time and money

If you suspect you have the diesel bug don't bother emptying tanks and discarding diesel since treatment will effect complete recovery.

Boats have discarded 1000's of gallons of infected fuel. Others have taken it out for polishing and put it back with the infection still present. All that was need was to kill off the organic matter.

Only remove your fuel if you want to clean out sediment such as sand, dirt and rust from a tank. This can still difficult in a baffled tank.



TREATMENT

1. Good fuel house-keeping is an absolute minimum
2. Suspicious fuel should be tested for microbial growth
3. Remedial action should only be taken in the form of a fuel biocide.

To sum up

Implement a good housekeeping regime to keep water content to a minimum

If you think you have a contamination problem treat with a fuel biocide, work treated fuel through fuel lines and leave for 12 to 24 hours.

Never be tempted to bypass the 2nd polishing filter when trying to sort out a problem otherwise you may end up with expensive high pressure pump repair.

Don't use multiple application chemicals since you need all the strength of the biocide

Test the fuel when you get to port and have a couple of days spare.

Implement the use of a fuel preservative regime.

Use any good biocide that you can get.

So you find yourself floating above drying rocks with a slime & bug problem and the tide going out. This bloke says wait there for 12 hours while his biocide works!

Well if all else fails and you end up with fuel starvation for any reason go to plan B

Make sure it is fuel starvation and check there is no fuel bleed back from the injectors.




EMERGENCY BACKUP

The fuel supply may fail for other reasons.

Carry a small 12volt electric fuel pump and filter .

Practice connecting your spare fuel can to suction of low pressure fuel lift pump






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Carry and fit the spare 12volt electric fuel pump and connect to some sort of filter. These can be obtained quite cheaply from a car parts shop or even a scrap yard. These 2 parts are on ebay at £25.

Connect some fuel hose and connect the delivery to the inlet of your lift pump or secondary fuel filter. And the suction in to your spare can of diesel fuel.

You may need a couple of pipe fitting to do this so do a practice rig up.

In the event of a serious stoppage you can have a direct supply of fuel deployed in a few minutes.

Make sure you use a filter. You do not want ANY contaminants blocking your secondary filter or entering the high pressure fuel pump.

You can make it sophisticated such as the one I carry, or simple with a cheap solenoid fuel pump, a strainer and some fuel hose which is self regulating. This will save you from those questions about being safety conscious.

It just might save you from those drying rocks.

Of course the inverse of Murphy's law will ensure that if you carry one of these you will not get another fuel failure.

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Lastly just a bit of advertising

Fuelcare Ltd is the sole supplier of Kathon FP1.5 and has approval from most engine manufacturers. It is supplied in 5 litre to 1 tonne containers to most industries that use fuel.

Kathon FP 1.5 is the only fuel preservative now used by most airlines with approval from all jet engine manufacturers.

Kathon FP 1.5 is now being sold in 250ml containers branded as Foxicillin . Only 30 ml of Foxicillin is required to treat 100 litres of infected fuel (about £3) or 10 to 15 ml as a preservative. It should soon be available from ASAP supplies.

Fuelcare supply 2 pack dipslides for fuel testing and Kolor Kut water paste for tank water testing.

Kathon FP1.5 achieves virtually a complete kill in 12 to 24 hours where Biobor used to take 3 days for an incomplete kill. The aviation industry has largely abandoned this because of loss of use of aircraft for 3 days

Fuelcare abandoned the use of Fuelclear M68 containing Grotamar 71 (Marine 16) in 2006 . Although a good biocide it failed some applications such as keel tanks and is now more expensive.

New EU legislation is forcing out most suppliers of biocides. Fuelcare Ltd will be one of only 3 likely suppliers.

Kathon is based on the active ingredient Isothiazalone developed by Rohm & Haas, now owned by Dow Chemicals and used by every conceivable industry from cosmetics to the oil fields.