

# DIESEL BUG – THE ULTIMATE TEST!



## 10 diesel bug fuel treatments

**TESTED**

**Diesel bug is your engine's worst nightmare – and it's becoming more common. Many products claim to kill or prevent it but do they really work? We tested 10 in the laboratory. Alison Wood reports**

In 1959 a US B52 bomber dropped unexpectedly out of the sky. As it went into an uncontrolled dive from 11,000m (36,000ft) to 2,440m (8,000ft) in less than a minute it exceeded the speed of sound and began to break up. Four of the eight crew managed to eject but only the co-pilot survived. The fact that the plane had not been carrying atomic weapons was of little comfort to investigators when they discovered the cause of the tragedy – a lifeform so small it takes a microscope to see it, yet so catastrophic that to this day it remains a menace to planes, ships, trains and leisure boats.

Fuel contamination is an increasingly common cause of engine breakdowns, particularly in shipping and leisure boating. Known to yachtsmen as diesel bug, the microbial growth – which is in fact a 'cocktail' of bacteria, yeasts and moulds – leaves a slime in the fuel and the sides of the tank which, when disturbed,

such as in rough seas, blocks fuel filters and can lead to engine failure.

### How does it grow?

It's impossible to prevent microbes entering fuel tanks and systems. However, the presence of water is a key factor in determining the rate and extent of microbial growth. Condensation or free water suspended in the fuel clings to the tank walls or slowly sinks to the bottom of the tank, and microbes will grow at the fuel/water interface. They feed off dissolved oxygen and nutrients in the fuel, and their growth creates more water as they break down the hydrocarbons. Slime is formed, which blocks filters and restricts fuel lines. The resulting sludge is acidic, and can corrode vital engine components such as fuel pumps and injectors. Sulphate Reducing Bacteria (SRB) are a particular hazard in steel tanks, as their acidic by-product can eat right through the walls.

### Symptoms

Engines can function with a surprisingly high amount of microbial growth in the fuel, so the chances are you'll see the warning signs before it gets to the point that the engine actually fails. Symptoms include poor starting, fuel starvation, erratic running and black smoke from the exhaust. Even at this point, changing the filter should be enough to get you home. But that won't solve the problem. You'll need to eradicate the bug and, if necessary, have the tank cleaned.

### Prevention

As the saying goes, prevention is better than cure, and that's certainly the case with diesel bug. You can minimise the risks of buying contaminated diesel by using a respected fuel supplier with a high turnover. However, this doesn't guarantee your diesel will be bug-free. The best way to prevent microbial growth is to stop water getting into the tank. If you're

leaving your boat for some time, keep the fuel topped up to stop condensation gathering (especially in the winter) and regularly drain the water from the water-separating pre-filter (primary filter).

Another option is to add a preventative dose of biocide, or water-absorbent, to the fuel. The former works by killing any bugs as soon as they become introduced to the diesel, while the latter is said to absorb water by taking it into suspension so it's removed with the fuel.

Often these products are the same as those used to treat diesel bug, only the dosage is lower. There's an argument that preventative dosing with biocide is a bad idea because you run the risk of creating tolerant microbes. For example, if you treat a system which becomes contaminated with five types of bug, you may find the biocide only kills four of them, and the fifth – a strain resistant to the biocide – starts to grow back and will be even more difficult to kill than before.

This is a problem across all industries, particularly in hospitals struck by the MRSA superbug.

### Treating the bug

There are several products on the market that claim to treat diesel bug. Biocides kill the bugs outright, whereas water-removing treatments claim to 'suffocate' the bugs by removing the environment in which they thrive. A third type of product, based on enzymes, is said to work by breaking down microbes so they're small enough to pass harmlessly through the filters.

The last point is particularly important. It's all very well killing the bug, but if you have a mass of dead microbes that won't pass through the filters, they're still going to cause problems.

PBO decided to test fuel treatments in a laboratory to see how effective they were at both preventing and eradicating diesel bug. A third test was applied to see how quickly the treated fuel flowed through a fine filter. If the products killed the microbes but didn't break them up, this is where we'd see problems.

### How we tested them

PBO arranged for ECHA Microbiology, specialists in fuel contamination, to do a laboratory study of 10 fuel treatments. While it should be pointed out that ECHA is a supplier of two of the products, the tests were all conducted blind. We wanted to evaluate the products' ability to:

- a) Decontaminate heavily infected marine diesel ('shock treatment'), and
- b) Prevent microbial growth

For the **decontamination test**, samples of bacteria, yeasts and mould taken from ships' heavily contaminated fuel tanks were mixed with 10 litres of clean marine diesel and allowed to grow for a few weeks before being dispensed into 10 bottles: nine for testing with fuel treatments (one of the products was not used in the decontamination phase of the test), and one control litre with no product added. 1ml of contaminated water (from the water phase of the original source) was also added, giving a fuel/water ratio of 1:1000.

With the marine diesel contaminated to the extent that it would cause serious problems on a yacht, the fuel treatments were added, and each analysed for live microbes after three hours and three days.

After three days the samples were poured through a 0.8-micron filter and timed to see whether any build-up of dead microbes affected flow rate (which, on a yacht could lead to blocked filters and engine failure).

For the **prevention test**, the nine fuel treatments were each added to one litre of clean marine diesel, with a tenth bottle untreated as a control. A much smaller dose of diesel bug was then introduced to each sample, giving a



▲ The effectiveness of fuel treatments was measured after three hours, three days and 14 days





▲ After three days the samples were poured through a 0.8-micron filter

fuel/water ratio 1:1000. After 14 days the fuel was analysed to see how well the products had worked at preventing microbial growth. If they were effective, there ought to be significantly fewer microbes than in the (untreated) control. In both experiments the bottles were stored in the dark, kept warm (28°C), and agitated on a mechanical shaker to replicate the conditions of a fuel tank while under way.

The samples were assessed using MicrobMonitor2, a test developed by ECHA for the oil company BP, and which shows microbial colony-forming units (cfu) found both in the water phase and fuel phase of the sample. The more spots you see in the sample photos, the more colonies of diesel bug were found (note: the size of the spots is irrelevant).

## Results

Microbial kill is assessed by the reduction in colony-forming units (cfu) over three days. There are no universally accepted standards for a 'significant kill' but ECHA likes to see a reduction of at least 1,000 fold (99.9%) (a three-log reduction). So, for example, if your fuel has a microbial count of  $2 \times 10^6$  (ie two million), an effective product ought to reduce the cfu to  $2 \times 10^3$  (ie two thousand). Because the water sinks to the bottom of the fuel, it's possible to take the cfu count in both the fuel and water phase of the sample. You will always expect more cfu in water and it is useful to assess whether the treatments act on microbes in both fuel and water phases. In most instances in this trial, the effect on fuel and water phases was the same. MicrobMonitor2 can detect down to 50cfu per ml in water and down to 2,000cfu per litre (2cfu per ml) in fuel – so below these levels, the product is assumed to have achieved a total kill.

Our costings for shock and preventative treatments are based on using the products in a 100lt (22gal) fuel tank.

As a control for our tests, this is what the contaminated fuel looked like when left untreated



## BIOCIDES

### Eradicate

**Cost:** 500ml = £26  
**Shock:** 25ml = £1.30  
**Preventative:** n/a  
**Contact:** 01505 504165  
**Web:** www.cyrus-energy.com

3 HOURS shock treatment    3 DAYS shock treatment    14 DAYS preventative dose



Eradicate was only assessed in the decontamination test, as its suppliers recommend an alternative product – Cyrus – for prevention.

After three hours Eradicate had done little to rid the sample of diesel bug, but after three days it had achieved an impressive 10,000-fold reduction or, in other words, total kill.

The treated fuel took 2.3 times as long as clean fuel to pass through the filter, only marginally better than untreated control.

**CONCLUSION:** While not the fastest acting biocide, Eradicate is very effective over time and achieved total kill.

### Fortron

**Cost:** 325ml = £7.05  
**Shock:** 200ml = £4.70  
**Preventative:** 100ml = £2.17  
**Contact:** 01582 475585  
**Web:** www.fortron.co.uk



After three hours Fortron did little, but after three days the microbial count in the fuel was reduced to below detectable limits, and the count in the water was reduced to only a very few surviving viable microbes (2000-fold reduction). However, the product took over two hours to pass through the filter, compared to only a few minutes for the other products on test.

In the prevention trial, Fortron not only prevented microbial growth but killed inoculated microbes to close to the minimum detectable limit\*.

**CONCLUSION:** Fortron provides a good, although not complete, kill of microbes both as a decontaminant and preventative treatment. It was by far the worst performer in the filter test.

\*As recommended by the supplier, we used four times the dosage of that specified in the product literature

### GrotaMar71

**Cost:** 500 ml = £21.73  
**Shock:** 100ml = £4.35  
**Preventative:** 5ml = 22p  
**Contact:** Tel: 02920 496 321  
**Web:** www.echamicrobiology.co.uk



GrotaMar71 gave a complete kill of microbial cfu to below detectable limits after just three hours. Surprisingly it also provided a marked improvement in fuel filterability, which was almost as good as clean fuel (a flow ratio of 1.42), suggesting it breaks down the biomass as well as killing it.

In the prevention trial, GrotaMar71 not only prevented microbial growth but killed inoculated microbes to below detectable limits.

**CONCLUSION:** GrotaMar71 (along with Marine 16, a similar formulation) is the fastest acting treatment of diesel bug and has an additional benefit of improvement in filterability.

## Home testing

The fuel was tested for diesel bug in this investigation using the industry-standard MicrobMonitor2 test kit, which involves mixing a nutritive gel with a sample of fuel. Any living microbes will grow into visible colonies, as seen in the images below. Cost £70 for 5 tests (£14 per test), contact: www.microbmonitor.com

■ For leisure boaters Marine 16 has developed a diesel bug test (pictured right) costing £12.95. Tel: 01792 466 667; www.marine16.co.uk



### Kathon FP1.5

**Cost:** 100ml = £20  
**Shock:** 33ml = £6.60  
**Maintenance:** 10ml = £2  
**Contact:** 01923 819041  
**Web:** www.separ.co.uk

3 HOURS shock treatment    3 DAYS shock treatment    14 DAYS preventative dose

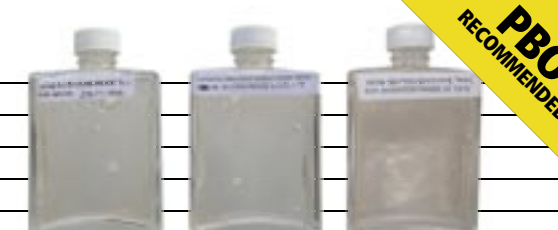


Kathon FP1.5 has the same active ingredients as Eradicate, so it was no surprise to see a poor 5 to 50-fold reduction of microbes after three hours, but a significant reduction of up to 10,000-fold after three days. Filtration time was slower than with Eradicate, with a flow ratio of 3.25, but in the prevention trial Kathon not only prevented microbial growth but killed inoculated microbes to below detectable limits.

**CONCLUSION:** While not the fastest acting biocide, Kathon FP1.5 is very effective as both a decontaminant and preventative treatment.

### Marine 16

**Cost:** 100ml = £6.95  
**Shock:** 100ml = £6.95  
**Preventative:** 5ml = 35p  
**Contact:** Tel: 01792 466 667  
**Web:** www.marine16.co.uk



Marine 16 has the same active ingredient as GrotaMar71 and, not surprisingly, produced very similar results. In the decontamination trial it gave a complete kill after just three hours and came top of the list for filterability. With a flow ratio of 1.21, fuel treated with Marine 16 took only slightly longer to pass through the filter than clean fuel and was significantly better than the contaminated control. In the prevention trial, Marine 16 not only prevented microbial growth but killed inoculated microbes to below detectable limits after 14 days.

**CONCLUSION:** Marine 16 (along with GrotaMar71) is the fastest acting treatment of diesel bug and has an additional benefit of improvement in filterability.

### Star Brite Biodiesel

**Cost:** 473ml = £15.92  
**Shock:** 26ml = 88p  
**Prevention:** 13ml = 44p  
**Contact:** Tel: 01929 551138  
**Web:** www.unipartmarine.com.



In the decontamination trial Star Brite gave a 10-fold reduction of the microbial count in the fuel phase and complete reduction in the water phase after just three hours. After three days it produced a total kill in both phases. Flow ratio compared to clean fuel was 2.44, which was only slightly better than the contaminated untreated control. In the prevention trial, Star Brite not only prevented microbial growth but killed the inoculated microbes to below detectable limits.

**CONCLUSION:** Star Brite is fast and very effective both as a decontaminant and preventative treatment.

## QUESTIONS AND ANSWERS

### Why is diesel bug getting worse?

In recent decades diesel bug seems to have become more prevalent. Sophisticated aviation-fuel storage has prevented any more plane crashes but the bug can take many guises, and just as scientists think they've got it, it rears up elsewhere in another form.

Whereas in the past oil companies would refine, distribute and sell their own fuel, these days fuel sources are blended, or 'co-mingled' – so if one is contaminated, they all are. This was a huge problem following the collapse of the Soviet Union when large reserves of fuel which had been sitting for 15 years brewing the bug were bought by western European refineries.

Another contributing factor to the upturn in diesel bug is the financial pressure that companies are under to turn around fuel quickly. Each time fuel goes into a storage tank it ought to stand so water sinks to the bottom, but this costs money, and is a place where terminals are taking shortcuts.

Finally, biodiesel – that is, fuel made from processed or recycled vegetable oils, has been identified as an environmentally friendly alternative to petroleum-based diesel (petrodiesel). By 2008 the EU wants 5% of all diesel to be derived from biological sources. Biodiesel by its very nature is susceptible to microbial attack (otherwise it wouldn't biodegrade), but this also means it's susceptible to diesel bug, even if blended with 95% petrodiesel.

### Is your biocide legal?

Any product which claims a controlling effect on micro-organisms should now be registered with the Health and Safety Executive (HSE) and by 31 October 2008 they will need a technical dossier confirming the product is safe, environmentally acceptable and effective. Because registration involves significant expense, some biocides such as Biobor JF have been pulled from the market. Most, if not all, of the products evaluated in this trial, fall into the biocide category (even if they are not a biocide but claim to 'eradicate' the bug).

The legislation should ensure treatments that claim to control microbial contamination do what they say, with an acceptable environmental impact. It will probably take a while for the directive to be policed, so in the meantime, we suggest you continue to buy fuel treatments as usual. Anyone with any doubts should query the directive with their supplier.

Non-biocides tested over the page >>

## NON-BIOCIDES

3 HOURS  
shock treatment

3 DAYS  
shock treatment

14 DAYS  
preventative dose

### Cyrus Marine

**Cost:** 500ml = £9.95  
**Shock:** n/a  
**Preventative:** 25ml = 50p  
**Contact:** Tel: 01505 504165;  
**Web:** www.cyrus-energy.com



■ Cyrus Marine is sold as a diesel bug preventative only, so was not tested in the decontamination trial. However, even as a preventative, it was not effective\*. In fact after 14 days, higher numbers of microbial cfu were detected.

**CONCLUSION:** At a dose of 0.025% Cyrus Marine did nothing to prevent the growth of diesel bug.

\*For the purposes of the trial the supplier recommended a dose that was only 1/4 that advised in the product instructions

### Fuel Doctor

**Cost:** 1 litre = £31.49  
**Shock:** 500ml = £15.75  
**Maintenance:** 50ml = £1.57  
**Contact:** Tel: 01444 881883;  
**Web:** www.expresslube.co.uk



■ Fuel Doctor is said to work by absorbing water and dispersing microbes, enabling them to pass harmlessly through filters. Fuel Doctor performed reasonably well in the decontamination trial, albeit with the highest dose rate (0.5%) of any product. It gave a 50-fold reduction after three hours and a further 150-fold reduction after three days. Filterability improved to a ratio of 1.65.

In the prevention trial (at the lowest recommended dose of 0.05%) Fuel Doctor failed to prevent microbial growth, and water was still clearly present after 14 days.

**CONCLUSION:** When used as a one-off treatment Fuel Doctor has a modest effect as a decontaminant, but is not effective as a preventative at the dose rate tested.

\*The manufacturers recommend a decreasing dose rate in successive fuel bunkerings – not simulated in this experiment

### Fuel Set

**Cost:** 250ml = £7.75  
**Shock:** 50ml = £1.55  
**Preventative:** 25ml = 78p  
**Contact:** Tel: 01794 884963;  
**Web:** www.liquideng.co.uk



■ Fuel Set claims to prevent diesel bug by absorbing water in the fuel, however the manufacturers suggest several successive treatments or on-going application may be required, so the results of a three-day once-only application would be insubstantial. In the decontamination trial Fuel Set gave no significant reduction in microbial count and the flow ratio was 3.2. In the prevention trial the product did nothing to prevent microbial growth.

**CONCLUSION:** When used as a one-off treatment, Fuel Set is not an effective decontaminant or preventive treatment at the dose rates tested.

\*As with Cyrus, the recommended dose was only 0.025%, and possibly a higher dose may have been more effective

### Soltron

**Cost:** 500ml = £29.99  
**Shock:** 40ml = £2.40  
**Preventative:** 10ml = 60p  
**Contact:** Tel: 07797 715997;  
**Web:** www.soltron.co.uk



■ Soltron claims to kill microbes by using enzymes to break them up, allowing the dead matter to pass harmlessly through the filter. We were advised to apply twice the dose recommended in the product instructions, but despite doing this there was no significant reduction in microbes after three days. At a flow ratio of 2.44 filterability was slightly better than the control (2.57).

In the prevention trial the product appeared to prevent growth in the water. However, the fuel phase cfu had increased 10-fold. Both were still lower than the control.

**CONCLUSION:** At the doses tested, Soltron is not effective as a decontaminant and marginal as a preventative treatment.

## Which is best?

In short, GrotaMar71 and Marine 16. They were not only the fastest acting, complete-kill treatments, but improved filterability when compared to the control. The finding that some of the biocides improved filterability came as a surprise, as conventional wisdom suggests the sudden mass of dead microbes would increase filterability problems. It seems that GrotaMar71 and Marine 16, as well as Fuel Doctor, actually break up the biomass. The opposite appears to be the case with Fortron, which could be problematic for engines with fine filters.

It's no surprise that biocides outperformed the other products, yet it's a shame that Soltron and Fuel Set were unable to live up to their claims. To be fair to the latter, it might be that a test over extended refueling would be a fairer trial, but this would be difficult to prove in the laboratory.

So as the new season gets underway, how do you avoid diesel bug problems? The best advice is to buy fuel from a reputable source with a high turnover. If you have to fill up from a source you have doubts about, a preventative dose could be a good idea. We'd certainly recommend carrying a bottle of treatment in case you experience symptoms of the bug.

### TEST RESULTS

Fuel treatment	Microbes after 3 hours (cfu/ml)	Microbes after 3 days (cfu/ml)	Microbes after 14 days (cfu/ml)
CONTROL	10 <sup>5</sup> - 10 <sup>6</sup>	> 10 <sup>6</sup>	10 <sup>5</sup> - 10 <sup>6</sup>
Cyrus	n/a	n/a	10 <sup>6</sup>
Eradicate	10 <sup>4</sup>	<50*	n/a
Fortron	10 <sup>5</sup> - 10 <sup>6</sup>	250	50
Fuel Doctor	10 <sup>4</sup>	3550	10 <sup>6</sup>
Fuel Set	10 <sup>5</sup> - 10 <sup>6</sup>	> 10 <sup>6</sup>	10 <sup>6</sup>
GrotaMar 71	<50*	<50*	<50*
Kathon FP1.5	10 <sup>5</sup>	<50*	<50*
Marine 16	<50*	<50*	<50*
Soltron	10 <sup>5</sup> - 10 <sup>6</sup>	> 10 <sup>6</sup>	10 <sup>5</sup>
Starbrite	<50*	<50*	<50*

\* None detected

### FILTRATION TEST RESULTS

Fuel treatment	Ratio of time taken to filter treated fuel compared to clean (pre-filtered) fuel
CONTROL	2.57
Cyrus	n/a
Eradicate	2.30
Fortron	102.91
Fuel Doctor	1.65
Fuel Set	3.21
GrotaMar 71	1.42
Kathon FP1.5	3.25
Marine 16	1.21
Soltron	2.44
Starbrite	2.44