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Best practice

Sulphur is a biocide which means that ECA-compliant distillate fuels are more susceptible to microbial infestation than fuel oil. Albert Leyson of Drew Marine outlines some onboard measures which can keep microbial growth at bay

Since fuel prices have come down by roughly half from a year ago, bunker buyers have consequently reduced a substantial portion of ship voyage costs. However, regardless of fuel cost, ship operators must still address the same challenges in ensuring that the fuel bunkered is effectively managed onboard. One of the easiest challenges to address, but often overlooked, is the standard fuel management practice of good housekeeping, that is, in maintaining fuels free of water and microbial infestation.

While the current ISO 8217:2012 marine fuel specification limits the maximum amount of water present in bunker fuel, there is no specific reference to microbiological contamination. Water is limited to a maximum of 0.50 vol. % to all fuel grades except for RMA 10 and DMB, which have lower limits of 0.30 vol. %; and except for distillate fuel grades DMX, DMA, and DMZ, there should be no water present. In addition to those limits there is mention in Annex A of fatty acid methyl esters' (FAMEs) affinity to water, and it mentions the risk of microbial growth. Fortunately, the specification limits the amount of FAME allowed in distillate fuels to a *de minimis* level (or approximately 0.1 vol. %), but this alone does not prevent microbial growth.

Given the often warm and humid marine environment, water condenses readily on

Category ISO-F-			RMA	RMB	RMD	RME	RMG	RMG	RMG	RMG	RMK	RMK	RMK
Parameter	Unit	Limit	10	30	80	180	180	380	500	700	380	500	700
Hydrogen sulphide	mg/kg	Max	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Water	% v/v	Max	0.30	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50

Excerpt from ISO 8217:2012 Table 1 – Distillate marine fuels

Parameter	Unit	Limit	DMX	DMA	DMZ	DMB
Hydrogen sulphide	mg/kg	Max	2.00	2.00	2.00	2.00
Water	% v/v	Max	-	-	-	0.30

Excerpt from ISO 8217:2012 Table 2 – Residual marine fuels

tank walls and eventually accumulates, along with any water in the fuel, in fuel storage tank bottoms. Bacteria, yeast, and mould, which may be present in fuel, water, and/or from the surrounding air, are living organisms and, in turn, begin to thrive and multiply at the oil-water interface. In fact, water provides an ideal environment for these organisms to grow unabated provided that their source of food, the fuel, remains available.

As the microbial infestation ensues, there are four main problems that will need to be managed onboard. Two of the problems stem from the waste byproducts generated from the microbial activity itself, hydrogen sulphide (H_2S) and biomass or slime. The third problem is related to the potential microbially induced corrosion that can occur on tank surfaces. Finally, the fourth problem pertains to the loss of fuel as it is consumed by the microbes.

The latest edition of ISO 8217 limits the H_2S in all fuel grades to a maximum of 2.00 mg/kg in the liquid phase. H_2S is generated by sulphate reducing bacteria (SRB) as they consume the sulphur in the fuel. Similar to the water specification, the H_2S limit would only be applicable to fuel as it is bunkered. In other words, the fuel supplier cannot be held liable for any new H_2S generated onboard after bunkering. Ultimately, it is the responsibility of the crew to ensure that the fuel remains free of SRB growth and corresponding H_2S formation. H_2S is a highly toxic gas. Crew exposure to high H_2S vapour concentrations is hazardous and in severe cases can be fatal.

The biomass or slime formation in fuel storage tanks is indicative of severe microbial infestation. Additional symptoms may include the plugging of fuel filters, emulsification of fuel and unusual sludge deposit formation in centrifuges, fuel piping and/or injector fouling, and in the worst-case scenario, fuel starvation of the engines.

Microbially induced corrosion (MIC) on fuel storage tank surfaces occurs when tanks remain untreated with an appropriate fuel biocide and/or uncleaned for an extended period. Once the initial microbes, mainly SRB, multiply sufficiently to form an initial layer of slime or nodule, then these confined conditions allow additional types of microbes, such as iron oxidising bacteria and acid producing bacteria, to flourish. Iron oxidising bacteria reduce iron to iron oxides and iron hydroxides during respiration. On the other hand, acid-producing bacteria change the local chemistry to create a more corrosive (acidic) environment. The effect of MIC can be seen from localised pitting of fuel storage tank surfaces and black staining of copper piping.

In addition to regularly draining fuel tanks of water, fuel tank bottom samples should be obtained after draining to check the water concentration and the presence of microbial growth. Both marine residual and distillate fuel tanks, especially those for emergency diesel generator and lifeboat engines, should be sampled every three to four months.

Simple, onboard test kits, which can determine the presence of water and degree of microbial infestation, are widely available. Although water test kits can run a fuel sample and determine the amount of water present in minutes, most microbial contamination tests require several days under incubation to complete. Newer pass/fail test kits have been made available to the marine market in recent years; however, the tests, while rapid and convenient, are significantly more expensive to run. Alternatively, fuel samples can be analysed by a shore-based analytical laboratory.

Should severe microbial infestation be detected, fuel storage tanks and affected systems must be thoroughly cleaned and treated with a fuel biocide, such as Drew Marine's AMERSTAT® 25. Disinfection of the fuel oil system must be done before new fuel is loaded and used. One may ask why complete disinfection would be required after a thorough cleaning has already been done. This is because the most pervasive fungus, *Hormoconis resinae*, that is commonly found in marine distillate fuels, has been known to stick to tank bulkheads, and other tank surfaces, including tank bottoms.

'Both marine residual and distillate fuel tanks, especially those for emergency diesel generator and lifeboat engines, should be sampled every three to four months'

Ships operating in emission control areas (ECA) that are unequipped with an exhaust gas cleaning system (e.g., SOx scrubber) will be more likely to experience microbial infestation as they will use additional marine distillate fuel to remain within compliance. Since sulphur itself is a biocide, compliant distillate fuels that contain less than or equal to 0.10% sulphur will be susceptible to microbial infestation. Furthermore, the smaller and simpler molecular structure of distillate fuel makes it easier for microbes to assimilate the fuel hydrocarbons.

For disinfection purposes and to effectively treat low to moderate levels of microbial growth in fuel storage tanks, AMERSTAT 25 can be initially 'shock' dosed at a ratio of 1:12,500 (1 litre per 12.5 metric tonnes). AMERSTAT 25 effectively kills all known types of microbial

'The smaller and simpler molecular structure of distillate fuel makes it easier for microbes to assimilate the fuel hydrocarbons'

growth typically found in all grades of marine fuel, including bacteria, yeast, and fungi.

Unlike certain competing biocides that require higher dosage rates, AMERSTAT 25 has been proven to be effective at very low dosages. An independent third-party laboratory evaluated the effectiveness of AMERSTAT 25 using ASTM E1259 Standard Practice for Evaluation of Antimicrobials in Liquid Fuels Boiling Below 390°C.

The ASTM E1259 test method is designed to evaluate antimicrobial agents or biocides for the prevention of microorganisms' influenced deterioration through the inhibition or elimination of the organisms in fuel bottom water. ASTM recommends that the level of microbial reduction considered significant to be 4-log reduction, as compared to untreated control samples. (A 4-log reduction means the number of microbes is 10,000 times smaller or essentially a 99.99% reduction.)

The test method evaluation includes two general assessments. The first assessment pertains to the biocide's ability to kill the organisms in the fuel and the length of time it takes to achieve that kill. The second assessment evaluates the biocide's persistence or the length of time it can preserve the fuel over time. The second assessment essentially identifies the next dosage interval to ensure the fuel remains free from any further microbial growth. Without a follow-up biocide dose, the fuel would once again be vulnerable to microbial growth.

Both assessments require that samples (e.g., marine gasoil) be first inoculated with a mixed inoculum of test microorganisms. The test microorganisms used in the inoculum include bacteria (Pseudomonas aeruginosa), yeast (Candida tropicalis) and mould (Candida tropicalis). Samples were removed from each test sample and then plated to determine the organism counts derived from each of the treated samples and the untreated control.

AMERSTAT 25 - ASTM 1259E: Time Kill Assessment - Log_{10} reduction

Initial Dosage Rate	Fuel	Inoculum (Organism)	Untreated	Hours after treatment			
				0.5 hrs	3 hrs	6 hrs	24 hrs
1L to 12.5 MT	MGO	*bacteria*	0	4	4	6	7
		yeast	0	4	3	4	5
		mold	0	2	3	4	5

Figure 1

AMERSTAT 25 - ASTM 1259E: Fuel Preservation Assessment

Maintenance Dosage Rate	Fuel	Inoculum (Mixture)	Persistance Interval	Highest Result Log10 reduction
1L to 25 MT	MGO	*bacteria*	35 days	6
		yeast	35 days	5
		mold	21 days	5

Figure 2

AMERSTAT 25 - ASTM 1259E: Time Kill Assessment - Log_{10} reduction

Maintenance Dosage Rate	Medium	Inoculum (Organism)	Untreated	Hours after treatment			
				0.5 hrs	3 hrs	6 hrs	24 hrs
1L to 25 MT	MGO	*bacteria*	0	4	6	6	7
		yeast	0	4	3	4	5
		mold	0	0	3	4	5

Figure 3

The laboratory analysis confirmed that AMERSTAT 25 demonstrates a time kill assessment between 30 minutes and six hours. Essentially within a half-hour after dosing, full effectiveness is reached for bacteria and yeast, with partial effectiveness for mould. However, by six hours, the fuel sample is under control (refer to Figure 1).

The biocide's persistence to maintain control was also evaluated. This simulates the scenario when no additional new fuel will be loaded into a treated tank. The analysis confirmed that the treated fuel will remain free from microbial growth up to 35 days for bacteria and yeast and up to 21 days for mould. However, to ensure that complete control is maintained the follow-up treatment is recommended after three weeks (refer to Figure 2).

The follow-up treatment for AMERSTAT 25 consists of a ratio of 1:25,000 (1 litre per 25 metric tonnes). The same dosage rate would apply if new fuel is loaded into an already treated tank. Similar to the results from shock dosage, the maintenance treatment becomes effective after 6 hours (refer to Figure 3).

With good housekeeping and an effective biocidal treatment programme all the risks associated with H_2S formation, fuel system component fouling, and corrosion that are attributable to water and microbial contamination can be mitigated. Finally, even though bunker prices have indeed come down, marine distillate fuel, over the last 12 months, has held a premium of anywhere between 50% to 80% over the price of residual fuel. It is essential that the appropriate fuel management practices are reviewed, evaluated and in some cases, initiated, to ensure that microbes do not consume this fuel investment.

Drew Marine provides technical solutions and services to the marine industry with a comprehensive range of advanced marine chemicals, and equipment.

Contact Drew Marine to learn more about controlling microbial growth in fuel oil tanks, or visit us at Marintec, China 2015, #N3G61.

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