IMO 2020

LOW SULPHUR FUEL PAPER

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1. INTRODUCTION

Following a review of the International Maritime Organization (IMO) 2020 regulations in which the limit for sulphur in fuel oil used in ships was reduced, Consultant Marine Engineers John Boyd and Scott Lennon from Solis Marine Consultants consider alternative vessel fuels, the impact of the recently introduced regulations and what measures should be taken to ensure compliance.

2. IMO 2020 REGULATIONS

The recent implementation of IMO 2020 regulations reduced the limit for Sulphur in fuel oil used on ships from 3.5% to 0.50%.

There is also a requirement for vessels entering the Emission Control Areas (Baltic Sea, North Sea, North America and the United States Caribbean Sea) that fuel oil with a maximum of 0.1% Sulphur (Ultra low) or Gas Oil be used.

3. MARINE FUEL OIL

Whilst heavy fuel oil, on which this review is predominately based, is the most common type of fuel used on vessels, with the maximum limit of Sulphur in the IMO 2020 regulations being reduced from 3.5% to 0.5%, and the maximum limit of Sulphur for vessels entering the Emission Control Areas being 0.1%, the following is a brief review of other fuels.

3.1 Marine Gas Oil

Marine Gas Oil (MGO) is a distillate fuel oil having a maximum Sulphur content of 1.5% with the Ultra-Low Sulphur Fuel Oil (ULSFO) type having a maximum sulphur limit of 0.1%.

When Marine Gas Oil (MGO) contains water there is the risk of bacteria and fungi developing, which can result in fuel filters being choked, although this can be combated by chemical treatment.

When a vessel consuming Heavy Fuel Oil (HFO) changes over to using Marine Gas Oil, such as in an Emission Control Area, there is the risk of problems arising from burning two, what are in effect, incompatible fuels, in the engine.
3.2 Marine Diesel Oil

Marine Diesel Fuel Oil (MDO) is a blend of distillate and heavy fuel oil with a maximum Sulphur content of 3.5% although the Low Sulphur type has a Sulphur content of less than 1.0%.

As with Marine Gas Oil (NGO), when Marine Diesel Oil (MDO) contains water there is the risk of bacteria and fungi developing, which can result in fuel filters being choked although again this can be combated by chemical treatment.

3.3 Heavy Fuel Oil

Heavy fuel Oil (HFO) is a residual blended type with a maximum Sulphur content of 3.5% although the low Sulphur type has a maximum Sulphur content of 1.0% and the Ultra-Low Sulphur type having less than 0.1%.

3.4 Liquid Natural Gas

Liquid Natural Gas (LNG) with a typical sulphur level of less than 0.004% is increasingly being used as a marine fuel oil since it produces less harmful emissions than conventional fuel oil.

3.5 Biofuels

Biofuels produced from rapeseed and vegetable oils etc, which have sulphur levels below that of fossil fuels, are reported to be experimentally used on several vessels, however due to limited world-wide availability and probable cost, its future use on larger and conventional vessels is in question at this time.

While Biodiesel is understood to provide better lubricity that Marine Diesel oil, as Biodiesel also attracts moisture this can result in the formation of acids and bacteria, which can have a detrimental effect on an engine.

Biodiesel formed by combining vegetable oil with methanol in the presence of a substance that increases the rate of chemical reaction (catalyst) is sometimes added to heavy fuel oil to produce a blend. However, it has been found that at low temperatures Biodiesel can form wax crystals due to the fatty acids in the vegetable oil coming out of solution, which can result in fuel filters being clogged. It has also been found that as the fuel pumps and injectors on the
engine operate at a considerable higher temperature with Biodiesel in a blend than when using Marine Diesel Oil, this can result in lacquering and sticking of the fuel pump and injectors.

It should be ensured that when ordering fuel from a supplier that the fuel complies with the latest IMO 8217-2012 or as applicable standard, which limits the quantity of biodiesel in a blend.

3.6 Alternatives

In addition to the above, it is understood that LPG (Liquid Petroleum Gas) Methanol and Ethanol are also being experimentally used in dual fuel engines with the use of hydrogen also being investigated. As LPG, Ethanol and Methanol have significantly lower flash points than the 60 degrees centigrade, as set out in the Safety Of Life at Sea (IMO - SOLAS), the IGF - SOLAS (International Code of Safety for Ship Using Gases or other Low Flashpoint Fuels) Code is understood to apply.

4. FUEL OIL STORAGE, SETTLING AND SERVICE TANKS

The vessel’s fuel oil (double bottom, settling tanks and service) tanks will all require to be cleaned to remove accumulated layers of sediment and sludge and the pipelines flushed to prepare for receipt of the new low sulphur fuel oil. However, as this would normally be carried out in a shipyard since it is time and labour intensive, delays would be envisaged while the availability of a shipyard is investigated and thus there is the probability that not all ships will be able to clean the tanks in timely preparation for the new fuel.

It is considered possible that some bunker suppliers will blend large quantities of fuel with high sulphur levels with the minimum amount of low sulphur fuel and while it is expected that the majority will comply in full with the requirements, it is anticipated that some will not, thus potentially leading to engine problems, which highlights the importance of sampling and analysing test samples.

While new fuel oil bunkers should only be loaded into empty tanks, where this is not possible and the new fuel is added to a tank containing a previous fuel, a sample of the original and a sample of the new fuel should be taken and sent for analysis to determine if they can be blended together and if so what treatment is recommended.
The ISO 8217 regulations require that fuel oils supplied to ships are stable, with a total sediment comprising of hydrocarbons and inorganic material, potential of 0.1% maximum. The purpose of fuel oil settling tanks, as the name implies, allows the fuel to settle with any sediment and water coming out of the solution before being transferred to the service tank by way of the purifiers.

Heavy Fuel Oils contain asphaltenes which are molecular substances in fuel oil and which amongst others also increases viscosity. The asphaltenes settling out of the fuel oil solution in an unstable fuel oil, form sludge, which can then lead to filters being blocked. Chemical additives can be used to further stabilise and disperse the asphaltenes in heavy fuel oil although this is not an instant solution as it takes time for them to react.

5. CYLINDER OIL

One of the major problems with Low Sulphur Fuel is the lack of lubricity due to the reduction of Sulphur, thus the use of this fuel can lead to abnormal wear of the engine components (cylinder liners, piston rings and grooves etc) although by changing the type of cylinder oil this is understood to assist.

When consuming heavy fuel oil with a Sulphur content of 3.5%, in main engines this has required the use of a cylinder oil with a high neutralisation capability (Base Number) to deal with the high Sulphur. The Base Number is a measure of the oil’s potential to neutralise by way of the alkalinity reserve the acids formed by combustion and the sulphur in the fuel oil. However, with the use of low sulphur fuel oil, particularly the 0.1% in the Emission Control Areas, this has required the use of a low Base Number lubricant but still requiring the deposit handling capability of high Base Number oils.

In order to determine the correct type of cylinder oil and the feed rate, it is recommended that the engine manufacturers be contacted for advice and that samples of cylinder oil that have passed the pistons and cylinder liners be taken from the scavenging drains, analysed and any recommendations followed.

While auxiliary diesel engines do not have separate crankcase and cylinder lubricants, the use of the low sulphur fuel oil will also have an affect on the components and thus the lubricating oil in the crankcase, and, as a result, it is recommended that lubricating oil samples be taken.
and analysed not only to determine the condition of the oil, but also whether the correct type of oil is being used.

The analysis of lubricating oils in auxiliary diesel engines has been an accepted and recommended practice for some considerable time since it not only determines the condition of the oil and any contaminants but also wear metals.

6. CATALYTIC FINES

Low Sulphur Fuel Oil (LSFO) is considered to contain more Catalytic (Cat) Fines, which are a mixture of silicon and aluminium particles from the refining process, than High Sulphur Fuel Oil. Catalytic (Cat) Fines have long been known to cause serious and abnormal wear, thus any increase in Cat Fines from reducing the sulphur in the fuel oil could lead to abnormal wear. Since it is understood that Cat Fines have a hardness of 8 on the Mohs mineral hardness scale and with diamonds having a hardness of 10, this gives some idea of the damage that can be caused by the Cat Fine particles.

While the ISO 8217 2012 regulations give a maximum limit of 60ppm for Catalytic Fines in fuel oil on receipt of bunkers, the engine manufacturers generally recommend a maximum limit of 15ppm for fuel oil entering the engine, which is a significant reduction.

Catalytic (Cat) Fines can be controlled and thus prevented from damaging the engines, however this relies very heavily on the fuel treatment and in particular purification, which should be as slow as possible and at optimal temperature, as set out in the fuel oil analysis and usually in the order of 98 degrees centigrade, something that is apparently not always adhered to by the crew.

In controlling the level of Cat Fines it should also be taken into consideration that in rough weather the sediment, which will probably contain a high concentration of Cat Fines, in the bottom of the tanks can be transferred into the fuel, thereby increasing the risk of Cat Fines entering and damaging the engine.

As an example, in one case, while the analysis of the fuel sample taken on bunkering was well within the limit of 60ppm, the analysis of the fuel taken before the purifier reported Catalytic Fines over 100ppm and thus well above the limit. The source of the high level of Catalytic fines was found to be from sediment in the settling tank. Since in the afore mentioned case as the
single purifier did not reduce the level of Catalytic Fines to within acceptable limits (below 15ppm), contaminated fuel entered and damaged the engine.

When dealing with damages (abnormal wear) caused by Cat Fines, it is standard practice as part of the investigation into the cause that samples be drawn from various sources to include both before and after the purifier, in order to determine if the purifier has been correctly maintained with the appropriate gravity disc and is functioning correctly.

It has often been found that when dealing with insurance claims for engine damages caused by Cat Fines, of which there have been many, that the ship's crew have used a single purifier at a high flow rate rather than ensuring that the flow is as slow as possible using two purifiers in series or parallel, as appropriate, in order to reduce the level of Cat Fines to an acceptable level.

When cylinder liners and pistons are considered to have been affected by catalytic fines in the fuel oil, replica imprints can be taken from the cylinder walls and analysed. While the taking of replicas is considered to be a procedure that can be carried out by the crew, it is recommended that the analysis of the replicas be carried out by a specialist.

7. COMMENTS ON OPERATIONAL MATTERS

While there are MARPOL regulations and recommendations by Clubs and engine manufacturers etc, for fuel oil sampling and testing, not only for the fuel oil as it is loaded on board (bunkered) but also in the system, whether this will be strictly adhered to, with the exception of the initial MARPOL loading and drip samples, is another question.

It is also recommended that the vessel’s fuel oil, storage, settling and service tanks be regularly cleaned to remove any build-up of sediment, which will include Cat Fines.

It should be taken into consideration that the sediment in fuel storage and settling tanks could, and probably will, contain a significant amount of Cat Fines, which have settled out from the fuel oil.

It was standard practice in an engine room and as part of routine watch keeping that the test cock on the fuel oil settling and service tanks be opened to check for water at least once every watch. In the case of an unmanned engine room, the period between the test cocks being
opened to test for water should be determined by the Chief Engineer based on the analysis and the quantity of water detected at the test cocks.

Fuel oil heaters should also be cleaned and inspected to ensure they are operating correctly and heating the fuel to the optimal temperature usually 98 degrees centigrade. The temperature controls and viscometer should also be inspected to ensure they are all operating correctly.

Where heat tracing of the fuel pipes either by steam of electrical means is employed, it should be regularly checked to ensure that it is fully operational.

Fuel oil purifiers should be opened, cleaned and inspected in accordance with the manufacturers recommendations and also operational results, ensuring that the correct gravity disc is fitted. It is also recommended by engine manufacturers that samples of fuel oil be routinely taken from both before and after the purifier and analysed in order to ensure that the purifier is operating correctly. While the standard recommendation for taking fuel oil samples from the purifier is every few months, this is dependent on the analysis of the fuel taken at the time of bunkering or other indicators such as defective engine combustion.

Fuel oil filters should be inspected and cleaned regularly depending on the type of fuel bunkered. It should also be taken into consideration that a fuel oil filter rated at 10 microns will not remove all particles of 10 microns but only a percentage albeit high being dependent on the efficiency rating and condition of the filter.

On the requirement for vessels entering the Emission Control Areas (Baltic Sea, North Sea, North America and the United States Caribbean Sea) that fuel oil with a maximum of 0.1% Sulphur (Ultra low) or Gas Oil be used, procedures should be developed regarding the change-over procedure from high sulphur to a very low sulphur oil fuel, particularly as the high sulphur fuel oil will remain in the system for some time until it is all flushed out.

8. EXHAUST GAS SCRUBBERS

Exhaust Gas Scrubbers can be used when the Sulphur in the fuel is higher than the 0.5%, however there is the question of water treatment, what to do with the wash water and where it can be discharged, although this is dependent on the type of scrubber installed.
There is also the question regarding any malfunctions of the scrubber since this will result in an increase in emissions should it breakdown and while the regulations state that the vessel should immediately change over to sulphur compliant fuel, if this is not available or if there is insufficient fuel then the Port and Flag State should be consulted.

Consulting the Port and Flag States is expected to be time consuming although it is understood that under Safety of Life at Sea Regulations, the excess emissions may be acceptable since they would only be of short duration but such a situation would probably result in an investigation by the authorities and delays.

It is also understood that some flag states including China and Singapore have banned the discharge of water from Scrubbers within their territorial limits.

In the event of the failure of the scrubber it is understood that the authorities have recommended contingency planning.

![Diagram 1: On-board scrubber installation](image)

9. TRAINING

While it is generally found that the Owners and Managers have issued instructions to the crew for the sampling, analysing and treatment of the fuel oil bunkers, there is the question based on the number of insurance claims for damage, as to whether the crew have received appropriate training on sampling and reviewing the fuel oil analysis results.
Where this does not already take place, it is recommended that the Superintendent ensures that fuel oil samples are analysed and the results provided to the vessel on an urgent basis and that the recommendations in the analysis report are fully understood and complied with in full.

10. CONCLUSION

While the intention of the regulation for vessels consuming Low Sulphur Fuel Oil is a reduction in greenhouse gases, unfortunately this will also have the effect of increasing the ship owner’s costs in purchasing the new fuel, and with the added costs of cleaning tanks etc, it is anticipated that there will be an increase in the cost of freight.

While it may be possible to offset some of the additional costs involved with Low Sulphur Fuel Oil by reducing the speed of the vessel, this will also have the effect of extending the passage time and thus introducing additional costs.

The risks associated with the use of Low Sulphur Fuel Oil, including the damage caused by Catalytic Fines to engine fuel pumps, injectors, cylinder liners, pistons and the possibility of the incorrect cylinder oil being used, should be identified and corrective action taken to include, as applicable, enhanced crew training.

11. RECOMMENDATIONS

The following are a number of recommendations for consideration.

11.1 Ensure that when ordering fuel from a supplier that the fuel complies with the latest IMO 8217-2012 or as applicable standard.

11.2 Samples of fuel oil bunkers to be analysed and the results provided to the vessel prior to receipt on board.

11.3 Drip sample of fuel oil taken on bunkering to be analysed before the new fuel is used.

11.4 Bunkers to be loaded into empty tanks wherever possible.

11.5 If bunkers are loaded into a tank already containing a previous fuel, sample analysis of the original fuel and the new fuel to be carried out to determine if they can be blended together satisfactorily and if so, what treatment is recommended.

11.6 Fuel oil heaters to be routinely cleaned and the controls including viscometer checked to ensure that they are fully operational.
11.7 Fuel oil purifiers to be opened, cleaned, and inspected to ensure that the purifier is fully operational and has the correct gravity disc fitted.

11.8 A fuel oil sample to be taken from before and after the purifier on a regular basis and analysed to determine if the purifier is operating correctly.

11.9 Cylinder oil drain samples to be taken and analysed to determine the condition of the cylinder oil, feed rate also ensuring, in consultation with the engine manufacturer, that the correct type of oil is being used.

11.10 Superintendent to ensure that fuel oil sampling and analysis are carried out in accordance with the procedures and that the results are sent to the vessel and, as applicable, discussed with the Chief Engineer.

11.11 Appropriate training to be provided to the crew on the handling and treatment of low sulphur fuel oil.

Note: The above recommendations are only those considered to be directly associated with the treatment of fuel oil and cylinder oil and do not include items of routine maintenance such as checking the fuel tank drain cocks every watch, renewing fuel filters, checking the trace heating (if fitted) and ensuring that the exhaust scrubber is fully maintained etc.

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