Customer Technical Service

IS VLSFO DAMAGING YOUR ENGINE?

Innospec is your partner in ensuring predictability when using marine fuels. Octamar™ performance chemicals are used by thousands of vessels globally as part of their strategy to proactively mitigate the risks of using low quality fuels.

The past year has revealed that many vessels are continuing to experience problems after making the switch to Very Low Sulphur Fuel Oil (VLSFO), even when these fuels are on-spec. This bulletin will explore the latest findings related to VLSFO and demonstrate how they are responsible for a drop in performance and engine damage, due to poor quality and what can be done in the face of ongoing issues.

Fuel Quality

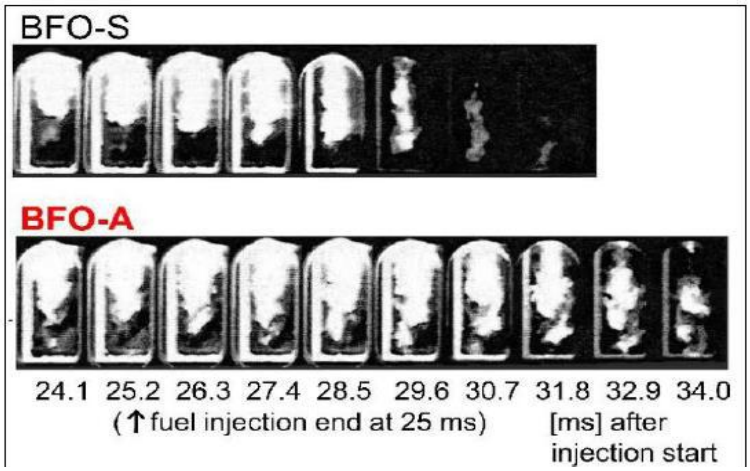
The changing landscape

Engine failures caused by broken piston rings and excessive liner wear have increased since the onset of IMO2020. High levels of deposits from combustion and elevated scrape down analysis results have been blamed on poor CLO (Cylinder Lube Oil) detergency and in response, engine OEMs (Original Equipment Manufacturers) reacted by demanding that CLO producers improve their formulations in order to counter the deposits and liner wear seen when using VLSFO. Few questioned why fouling was now a bigger problem after the industry had changed to a supposedly 'cleaner', 'lighter' fuel. Innospec's fuel experts made the case from the beginning that if deposits and liner wear were increasing despite the use of CLO designed for a more residual fuel, then the industry should be looking at the combustion quality of these fuels instead of treating the symptoms of poor combustion by adjusting CLO.

The latest reports now confirm this, it has been shown that the combustion quality of some VLSFOs is a major contributor to engine damage. CLO producers have warned that even if they increase CLO detergency to overcome the surge in combustion deposits caused by VLSFO, the extended after-burn period of these poor quality fuels will remove the CLO film of any new formulation, rendering any increase in detergency useless.

Traditional fuel quality measures such as CCAI (Calculated Carbon Aromaticity Index), a calculation developed in the 1980s to predict the combustion quality of HSFO based on its viscosity and density, offers little insight into the combustion or after burn characteristics of VLSFO, which contains vastly different blend components to traditional HSFOs.

In Figure 1 we see two fuels with similar CCAI, BFO-S (Bunker Fuel Oil – Singapore) & BFO-A. While BFO-S is a traditional HSFO with a higher asphaltene content, it was the lower sulphur BFO-A that caused engine damage and scuffing. The cause can clearly be seen when we compare the length of combustion between the two fuels. While they both have a similar start of ignition, the longer combustion period in the lighter fuel causes flames to impinge upon the liner surface, removing vital CLO and causing engine damage.



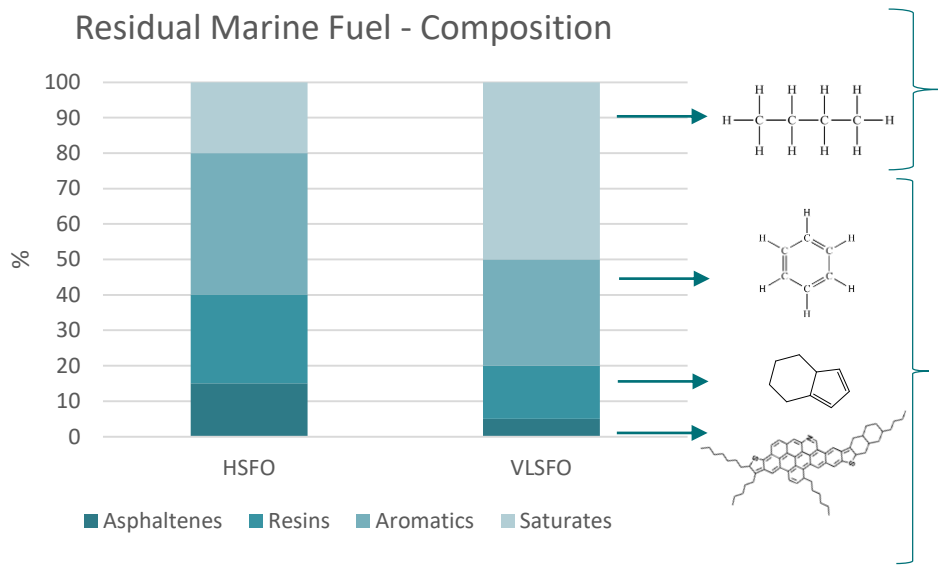
Sample	Bunkering Port	Comment	Sulfur %	CCAI -	Al+Si ppm	Asphaltene %
BFO-S	Singapore	☺ non-trouble	3.5	852	< 20	9.5
BFO-A	Los Angeles	☠ scuffing for (2-stroke) container ships	1.3	849	< 20	4.6

Figure 1. Source: Takasaki, K., et al., Combustion quality of low-sulphur marine fuels after 2020. Illustrates how a fuel with lower sulphur and CCAI in reality, has poorer combustion characteristics.

Combustion Quality

Liner wear, after burn and soot

So why is this happening? When a high proportion of paraffinic components are combined with residual aromatics (which includes Asphaltenes), such as in VLSFO (Figure 2), the lighter paraffinic components dilute the protective aromatics, producing instability that causes the Asphaltene to grow into a much larger molecules (agglomeration) that require more oxygen to burn completely. This is why we are seeing more cases of incomplete combustion, liner wear and engine deposits despite the increase in the paraffin content.



Paraffinic – straight chain hydrocarbons, often from secondary refinery streams. Paraffins are prone to rapid oxidation when heated, or drop out as wax in low temperatures. Octamar™ Ultra HF prevents oxidisation and stabilises these components for a more homogenous fuel.

Aromatics – Similar benzene ring structures. Asphaltenes can remain stable when surrounded by an aromatic portion (Resins, Aromatics) over extended time periods however, in the presence of a significant paraffin mixture, the asphaltenes begin to 'agglomerate'; growing larger to form sludge in tanks, or attributing to poor combustion. Octamar™ Ultra HF targets and protects vulnerable asphaltenes

Figure 2. Typical blend ratios of modern residual marine fuels show a much higher proportion of the saturate (paraffinic) component in combination with aromatics, which are structurally dissimilar, causing separation and instability.

All this means that even though VSFLOs contain less residual components by mass, those that are there are far less stable than those found in most traditional HSFOs. This is because HSFO contains a high ratio of Aromatics to Paraffins, so that the residual aromatics are protected – remaining dispersed, stable, and small enough to burn readily during combustion. It is understood that if a significant portion of fuel remains unburnt, this will impact not only the safe running of you vessel, but the overall efficiency, and therefore emissions of all shipping.

VLSFO

Always better quality?

FIA (Fixed Ignition Analysis) provides exceptional insight into the combustion quality of fuels. Used by both fuel specialists and major fuel suppliers, FIA gives the combustion profile of a fuel (Figure 3). It allows engineers to identify major fuel quality markers such as the ID (Ignition Delay), which is used to calculate the all-important ECN (Estimate Cetane Number), the EMC (End of Main Combustion) and EC (End of Combustion). If delayed, this indicates a fuel's tendency for after-burn, incomplete combustion and products of combustion that lead to engine damage.

We will demonstrate how you can improve fuel performance and remove the risk of engine damage caused by poor quality fuels with the use of Innospec's new Octamar™ Ultra HF, which is proven to improve fuel quality through the ECN and EMC.

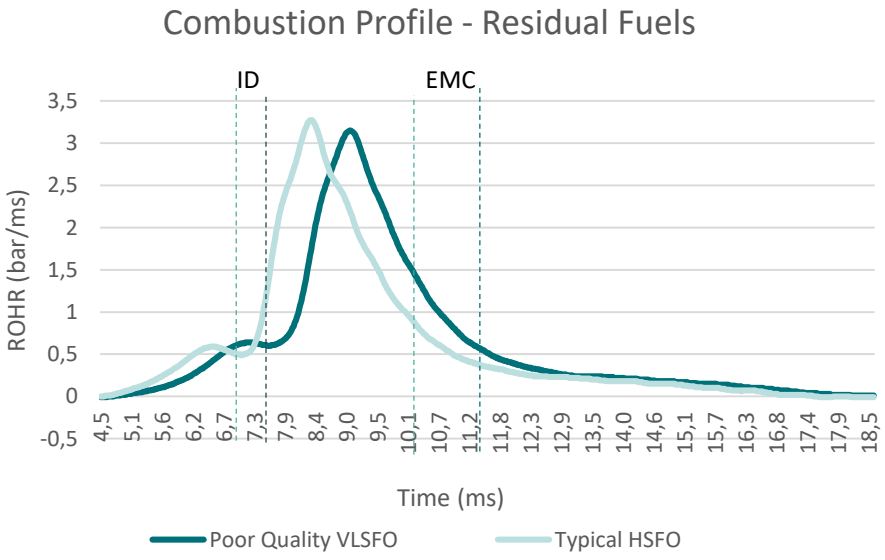


Figure 3. The combustion profile of a typical HSFO (ECN 20) against a VLSFO (ECN 16) with similar CCAI, but vastly different combustion characteristics.

Fuel Quality

The changing landscape

FIA testing of twenty-five (25) representative VLSFO samples from every major bunker port has shown that 23% of the fuels tested have a lower ECN than even HSFO (Mean HSFO ECN = 20, see Figure 4). Of these low ECN fuels, we can also see that the End of Main Combustion (EMC) and End of Combustion (EC) are well above 10ms, indicating the extended combustion period that would risk engine damage and fouling.

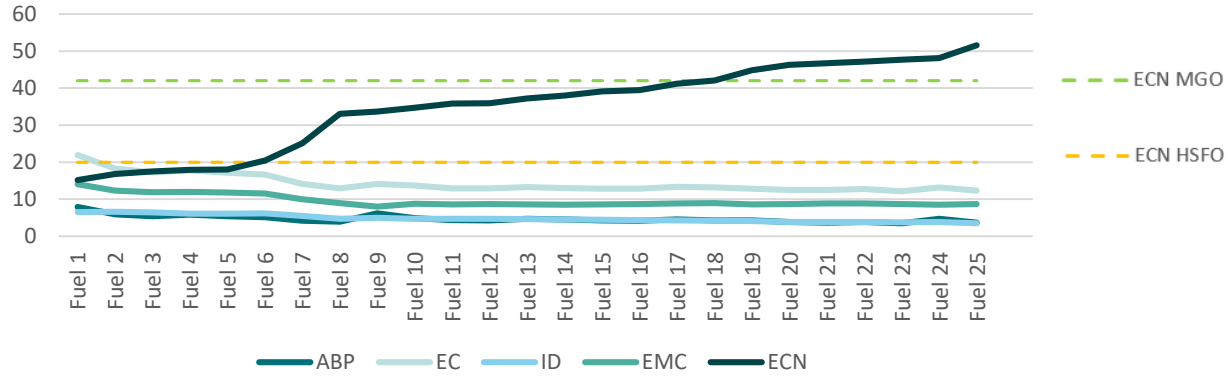


Figure 4. The distribution of key combustion characteristics of (25) ISO 8217 compliant VLFOs from around the world. All units are in Milliseconds (ms) except ECN, which is an index figure.

All of the fuels in Figure 4 were on spec to ISO 8217, and while the majority had reasonable combustion characteristics, there was no way to predict from the ISO 8217 which of the fuels would be included in the low quality fuels seen in the bottom 23%. Innospec provides much needed certainty for those using unpredictable residual fuels such as VLSFO, by introducing Octamar™ Ultra HF to your fleet as part of a proactive approach toward fuel safety and efficiency, while mitigating against the risks of using low quality fuels.

Octamar™ Ultra HF contains the best anti-aging and combustion catalyst chemistry to improve combustion and reduce operability issues. Innospec provides targeted fuel treatment chemistry to thousands of vessels globally, boosting fleet performance and fuel quality in every way that matters to reduce engine damage.

The Facts

Figure 5 shows how the ECN of VLSFO can be improved by more than 7% in fuels using Octamar™ Ultra HF, regardless of the perceived fuel quality. Low quality VLSFO can be made safe thanks to a 10% reduction in MCP, a 5% reduction in EMC and APB, parameters critical to preventing the CLO film removal, engine damage and fouling.

This technology also acts to boost fuel economy and efficiency, eliminate fouling and maximise the energy capture from fuel. Our studies have proven that SFOC can be reduced by 2.2%, which more than covers the cost of implementing fuel treatment chemistry as part of a proactive approach toward mitigating the risk of low quality fuel for your vessel, crew and the environment.

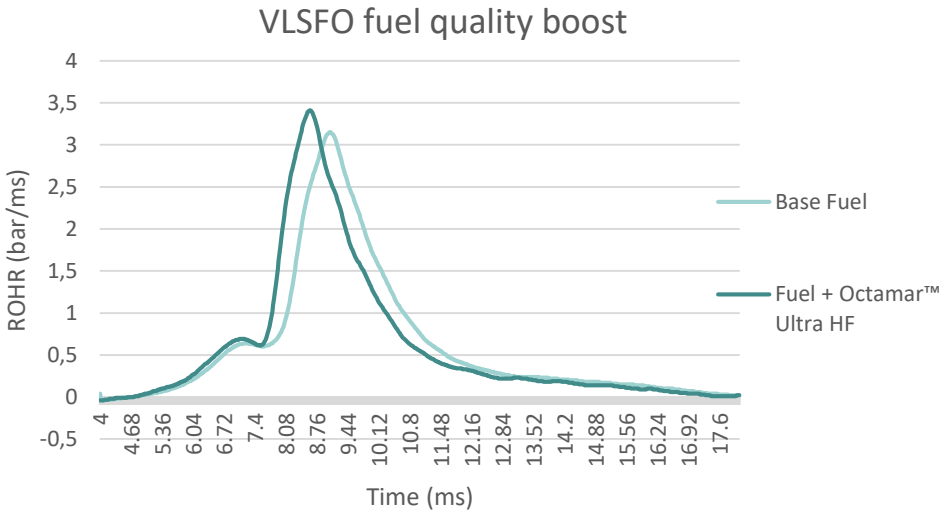


Figure 5. Fuels treated with Octamar™ Ultra HF see immediate boosts to key parameters, reducing ignition delay, after burn and combustion period, but also enjoying a higher peak and rate of heat released from fuel and improving quality in every way!

	Octamar™ Ultra HF - Performance Improvement	
ECN	Estimated Cetane Number	7%
MCP	Main Combustion Period	10%
EMC	End of Main Combustion	5%
ABP	After Burning Period	5%

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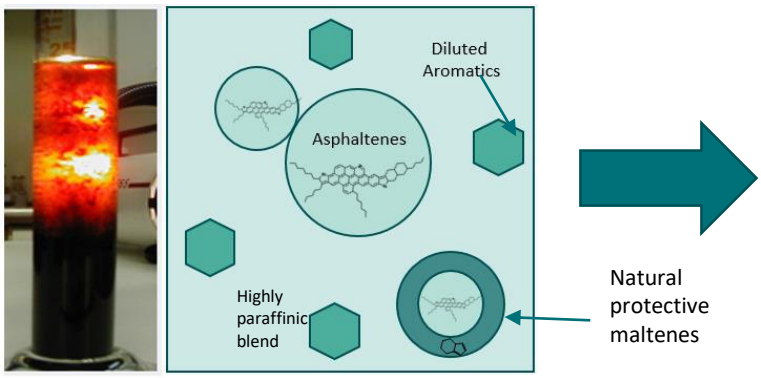
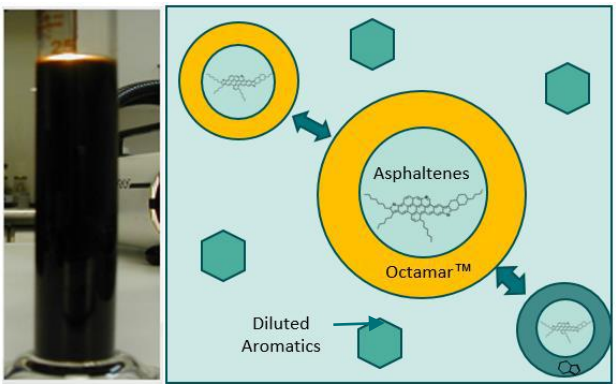
Stability

Upgrade fuel handling

Fuel stability contributes to both reducing sludge levels and better combustion. This is achieved by preventing asphaltenes from growing into larger structures (agglomerating) that either drop out of solution in storage tanks and purifiers as wasted fuel, or contribute to engine damage and exhaust fouling through poor combustion. Octamar™ Ultra HF contains Innospec's unique asphaltene dispersant stabiliser to ensure the maximum amount of fuel reaches the engine, and burns completely once there.



Untreated VLSFO 1 with a SN (Separability Number) = 14.5, demonstrating a poor ability to retain asphaltenes in a stable mixture, growing larger and settling out.



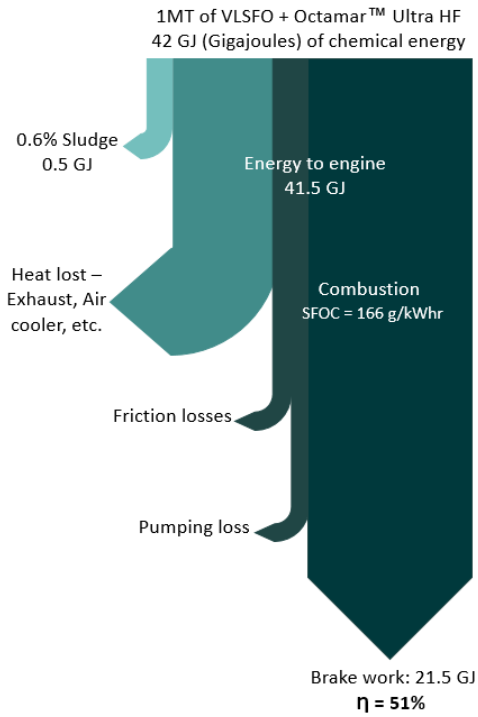
VLSFO 1 treated with Octamar™ now has a SN (Separability Number) = 0.1, a vastly improved stability, the asphaltenes remain small and homogenous

Fleet Performance

Fleet wide performance, every time

Innospec understands that fuel efficiency and fleet performance start at bunkering. On average, 2% of fuel worldwide is wasted as sludge; sludge that if stable would remain in solution, and small enough to burn completely. This means that for every metric tonne of fuel with an energy content of 42 GJ (Giga Joules) one will loose more than 1 GJ of that energy before it even reaches the engine, not to mention the additional cost of service kits and spare parts caused by unstable fuel.

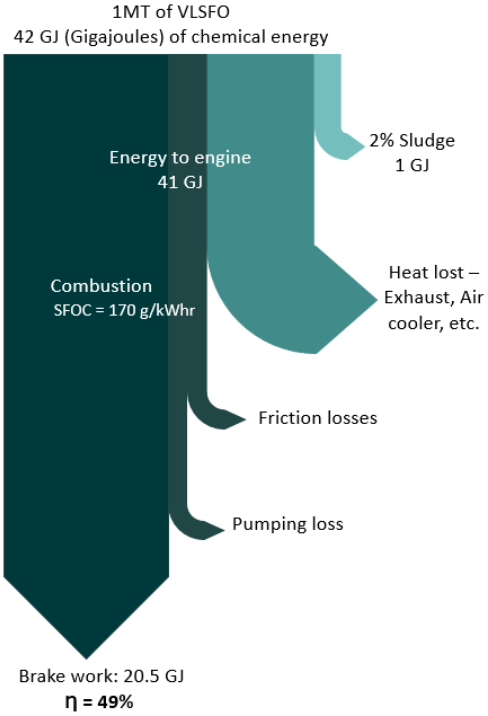
This is why Innospec has included the best chemistry known to improve fuel quality into our ultimate package for VLSFO: **Octamar™ Ultra HF**. Vessels using Innospec's performance chemistry can expect an immediate improvement in fleet performance today!



70% improvement in asphaltene stability and retention, reducing sludge produced on-board and increasing the fuel available to the engine.

Improve SFOC by 2,2% and remove the effects incomplete combustion to give a 60% reduction in exhaust deposits.

Octamar™ Ultra HF is the ultimate chemical solution to unlocking the potential of modern marine fuels. From storage tank to exhaust stack



VLSFO – PERFORMANCE REPORT

Octamar™ Ultra HF

Join thousands of vessels around the world already implementing Innospec's fuel treatment chemistry as part of their strategy to proactively mitigate the risk of using low quality fuel. Octamar™ Ultra HF is the ultimate safeguard against the losses experienced when handling and using low quality VLSFO that can't be seen in advance.

Improve the safety, running costs and performance of your fleet, today.

- Prevent engine damage from liner wear, deposits and post combustion fouling by boosting combustion quality.
- Reduce fuel waste from sludge by up to 70% (fuel saving) and the cost of unplanned maintenance by improving fuel stability and compatibility.
- 60% reduction in Particulate Matter (PM), for a cleaner post combustion system and lower back pressure.
- 7% Boost in ECN (Estimated Cetane number), giving a 2.2% reduction in SFOC and a cleaner combustion, improving useful output and covering the cost of your fuel quality strategy.

Summary

Innospec is at the forefront of developing fuel additive technology for a changing world. Our focus is on supporting the fuel industry as it adapts to major environmental challenges, new legislation and the more demanding performance targets set by OEMs. While we operate at the novel and cutting edge of technology, our goal as market leader is always to create reliable and highly functional products. We build global supply chain solutions by understanding the important differences within regional and national markets. Our worldwide network spans 23 countries. **We can work with you to create the next generation of fuels, today.**

Please contact your local sales representative for more information.

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