marine lubricants

taking the temperature of the 2020 fuel sulphur switch

As shipping moves further toward a future powered by cleaner fuels, the introduction of IMO's global sulphur cap on 1 January 2020 offers some valuable lessons about how to ensure the safe and reliable operation of main engines.

Alongside everything else that an unprecedented period of uncertainty has thrown at shipping, 2020 started with the biggest-ever shakeup of the marine fuels market. A majority of internationally trading ships switched to very low-sulphur fuel oil (VLSFO), with a sulphur content of 0.50% m/m or lower, in compliance with IMO's MARPOL Annex VI sulphur regulations. The remainder either continued to burn high-sulphur fuel but with exhaust gases funneled through cleaning systems (or 'scrubbers') to reduce their sulphur emissions, or adopted other low or no-sulphur fuels such as liquefied natural gas (LNG) or methanol.

Prior to the fuel change, there was industry-wide concern about how new fuels could affect ship operations. One major question was whether ship operators would be able to successfully adjust their fuel handling and engine operations — including adopting new cylinder lubrication products and practices — to manage use of the new VLSFO blends. Several months after the switch, Chevron Marine Lubricants assesses how the industry dealt with these issues.

Taking the temperature of the 2020 fuel sulphur change is particularly important considering the challenges shipping will face in the future. As the industry explores options for meeting IMO's greenhouse gas emission reduction ambitions — most crucially the aim of cutting emissions by 50% by 2050 compared to 2008 levels — more new fuels will come into play. According to DNV GL, 30–40% of the global fleet's energy demand will need to be met by carbon-neutral fuels to achieve this target.

"Using new fuels — whether it is today's VLSFOs or the carbon-neutral fuels of tomorrow — requires careful planning as well as a rigorous monitoring programme to avoid engine issues," says Ian Thurloway, Brand, Marketing & Business Development Manager for Chevron Marine Lubricants. "As ship owners and operators look towards 2050, the lessons of the great sulphur switch are far too valuable to ignore."

A turning point for marine fuel

Such a wide-ranging change inevitably led to concerns as 2020 approached. The most fundamental were about price and availability: would VLSFO be widely available and priced competitively compared to the high-sulphur heavy fuel oil (HSFO) that scrubber-equipped vessels could continue to use?

In the end, these fears about VLSFO were not realised. As oil majors and refiners announced their VLSFO plans in the run-up to 2020, worries about availability diminished and (barring a few isolated incidents) lack of compliant fuel has caused little disruption. Meanwhile the low oil price throughout the first half of the year has meant that the relative cost of fuels has been less critical than was imagined in 2019.

There were also concerns beyond price and availability. It was widely anticipated that the VLSFO blends, produced specifically to meet the new sulphur regulations, would have very different characteristics not just to traditional fuels but also to each other. This would mean operational challenges relating to the variable properties of the new fuels and how they should be handled.

Preparing for the switch meant cleaning fuel tanks so that residual high-sulphur fuel would not inadvertently make vessels non-compliant. Fuel tanks would need to be arranged so that specific batches of fuel could be segregated if needed. Fuel supply lines had to be able to chill or heat fuels to the viscosity requirements of engines. And fuel purification and filtration had to be bolstered to protect engines from damaging contaminants either inherent in the new fuels (such as cat fines) or resulting from the accidental combination of incompatible fuels.

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Luc Verbeeke, Senior Engineer, Chevron Marine Lubricants

Another crucial consideration was cylinder lubrication. Whichever fuel is used, cylinder oil is critical to ensure that engines run safely and reliably. Low-sulphur fuels need oils with a lower base number (BN) that require different management to those used for HSFO. But beyond the base number, the new VLSFO blends were a relatively unknown quantity. If the individual fuels were not stable or if ships bunkered different blends that were incompatible, asphaltene precipitation could cause sludge to build in the fuel supply system which could lead to deposits in the engine, potentially affecting performance and reducing time between planned maintenance. Effective lubrication could help protect against potential deposits.

Taking stock of 2020

According to Luc Verbeeke, Senior Engineer, Chevron Marine Lubricants, despite the daunting challenges it appears as though the switch went smoothly for most ship operators.

“The large majority have made the transition well and were adequately prepared,” he says. “Most of our customers switched from HSFO to VLSFO. We did see OEMs report a temporary spike in scuffing issues on engine cylinders. This was not unexpected, and the majority of issues are more related to housekeeping — such as handling fuels properly and following OEM advice — than fuel quality or cylinder lubrication.”

There have also been some important learnings about VLSFO itself. As late as December 2019, the consensus was that the marine fuels market would feature myriad VLSFOs with a widely varying range of fuel quality. The reality has been somewhat better for operators. In fact, by Luc Verbeeke’s analysis, VLSFO has in general turned out to be a high-quality product with a greater energy content and faster combustion than traditional HSFO.

“You could say that customers get more value for money from VLSFOs,” he says. “But that has still created some challenges. While newer ships do not have a problem using these fuels, engines already closer to an overhaul did struggle sometimes. Cylinder units that could have run for another six months or a year on HSFO did not survive the tougher conditions with the new fuels.”

The reason for the difficulties in older engines was the calculated carbon aromaticity index (CCAI), which measures the ignition qualities of fuels. Most VLSFOs have a CCAI score of 820 or below, significantly lower (and therefore with more energy content) than a typical HSFO with a score of 850 or higher. Combustion analysis by Chevron Marine Lubricants identified that ship operators will need to keep their engines generally in better shape to burn these fuels, and that lubricant monitoring services will play a vital part in this process.

Another lesson has been about the impact of some methods of tank cleaning on engine running. In the period leading up to 2020, several operators cleaned their fuel tanks by using fuel additives or diesel oil that flushed high-sulphur waste through the fuel system — effectively using their engines as an incinerator to burn off the waste.

“Some of these engines failed pretty quickly and this will potentially also have a longer-term effect,” says Luc Verbeeke. “I think this will become clear in future overhauls. All the cat fines and sludge that were in the tank were put through the engine.”

Combined with incorrect fuel handling, these challenges with older engines and the impact of flushing waste material through engines account for most scuffing incidents. The fact that reports of scuffing have since declined to usual levels suggests that the industry has now come to terms with the procedures it needs to operate safely and reliably with VLSFO.

Most issues that have arisen in the use of VLSFO have very little to do with the quality of the fuel itself. This is clear because the number of issues reported would not have declined if the problem was with fuels — and cylinder oils — that are still being used. As well being a relief for fuel purchasers, that fact also vindicates the cylinder lubrication strategy advocated by Chevron Marine Lubricants.

Example of a piston with scuffing and deposits. Photo courtesy of Chevron Marine Lubricants, 2020

Managing the shift to low-BN oils

In the run-up to the sulphur cap, Chevron Marine Lubricants renewed its range of cylinder oils to cover the entire spectrum of fuels that would be used after 2020 — from near-zero sulphur fuels such as LNG or methanol to HSFO with a sulphur content possibly even higher than 3.5%. The Taro Ultra range was formulated to offer flexibility and to ensure global supply. It was rolled out across Chevron Marine Lubricants’ existing supply network of over 573 ports during 2019 to ensure readiness to meet the demands of the post-2020 landscape.

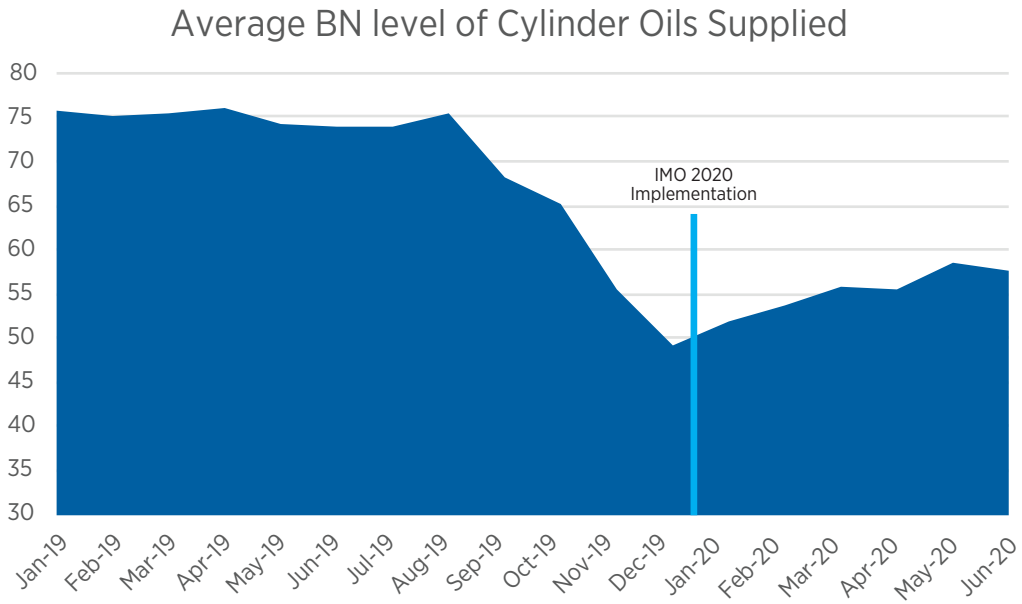
The BN40 product Taro Ultra 40 is an example of that flexibility. It was rigorously tested with VLSFO blends and is also suitable for intermittent operations that vary between the use of LSFO, blends and distillates — such as when switching fuels when sailing through SECAs. This removes the use of multiple cylinder oils, reducing on-board complexity.

In the run-up to the end of December, Chevron Marine Lubricants took a survey of customers' plans for the fuel switch. This was designed to help manage the changing lubrication requirements and BN levels; the move from high- to low-BN product in general represented a complex shift in the supply chain of lubricants.

"We were quite surprised how late a lot of the industry left the switch," says Ian Thurloway. "Some did change over as early as September to gain more experience before the regulation came into effect. But we noted a very late run on low-BN product in December."

For Chevron, ensuring supply and availability of products was a huge priority. The global switch to lower BN oil meant dramatically different product was needed across the world. According to Simon Chung, Team Lead — Global Marine Product & Technology Support, Chevron Marine Lubricants, it was a question of getting the right products in place in the right package for customers. But swings in demand made the big transition even more problematic.

"Earlier in the year we saw volumes of high-BN marine cylinder oils drop off because ship operators did not want to be left with excess stock," he explains. "The volume didn't pick up again until very late in the year, and then it was for low-BN oils. So, there was a lot of uncertainty in demand and the shift in product meant that we also had to plan for several different scenarios, as well as helping customer manage their transition."



VLSFO, ECA and scrubber operation data included. Chevron Marine Lubricants, 2020.

Monitoring the new regime

Another critical element of managing the transition with ship operators was to reinforce the importance of testing drip oil. While lower sulphur in fuels may mean fewer harmful emissions, the loss of lubricity that sulphur brings can also make engine operations more challenging. And with little experience using 0.50% sulphur fuels, operators needed to verify that they were taking the right steps to safeguard their engines.

As Luc Verbeeke explains, "In the traditional high-sulphur world there was a buffer zone against engine damage. As you reduce feedrates, you enter first a corrosive wear zone before reaching the more damaging adhesive/ abrasive wear. The engine operates best in the corrosive wear zone if you manage that. But with sulphur levels

in fuels coming down, that safety margin has become much smaller and you can end up getting to the damaging adhesive/abrasive wear much faster — potentially towards the sudden severe wear that affects the engine immediately and cannot be recovered."

Total iron levels remain important for indicating when engines are in a corrosive regime, but the magnetic particles are also needed to alert ship operators to abrasive wear. Chevron's DOT.FAST® service uses an onboard test that looks at total iron. The onshore laboratory service goes further, using inductively coupled plasma (ICP) mass spectrometry to identify not only total iron, but also a particle quantification (PQ) analysis to detect magnetic particles.

"The DOT.FAST laboratory analyses now provide a reading of both total iron and magnetic iron," explains Luc Verbeeke. "If you see total iron increasing without magnetic particles rising, you know you have corrosion. But if you see magnetic particles also rising, you have adhesive/abrasive wear."

Looking beyond 2020 fuels

This monitoring and analysis will be critical as the industry adapts to even more fuel changes in the future. The amount of sulphur in marine fuels is likely to decrease further in response to future regulations, reducing the safety barrier between normal engine operation and damaging cylinder wear. But there is much more than sulphur on the future fuel agenda.

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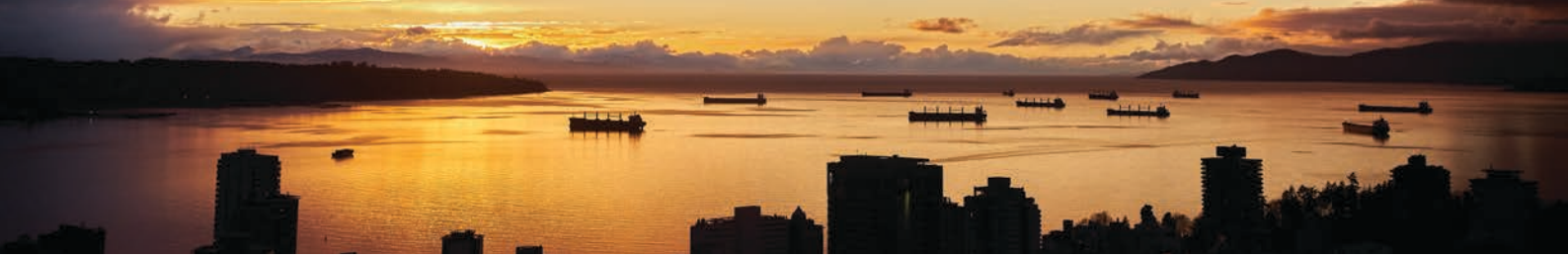
"Looking beyond 2020 there are still a lot of big changes to come," says Simon Chung. "IMO has further regulations on the horizon, OEMs are still looking at certifications and approvals as well as other engine designs and fuels. Therefore, the picture will likely only become more complex. We are continuously looking at our product range and making sure we address any gaps that emerge."

Having navigated the sulphur cap, IMO is now turning its attention to other areas. In the longer term, this means decarbonisation in line with its target of reducing greenhouse gas emissions per transport work by 40% by 2030, then reducing total greenhouse gas (GHG) emissions by 50% by 2050 (based on 2008 levels). More immediately, other emission reductions will take the focus — namely particulate matter and nitrogen oxides (NOx). Luc Verbeeke expects that the IMO's hitherto limited Tier III NOx regime will be expanded rapidly.

"The first NOx regime was in place in the US in 2016 and we now expect several other parts of the world to follow shortly," he says. "It will be adopted in the North Sea and Baltic Sea in 2021. So today when you build a new ship you could say that you will avoid the US, although this would be limiting and reduce vessel flexibility. But can you afford to say you will avoid the US and Europe for the lifetime of your vessel?"

From the cylinder lubrication perspective, lower NOx limits will require changes from the oils generally used today. Most vessels are likely to meet Tier III NOx by means of exhaust gas aftertreatment — either selective catalytic reduction (SCR) or exhaust gas recirculation (EGR). When using these devices, maintaining engine efficiency is critical to make sure that emissions limits can be maintained while engines run smoothly and efficiently. Cylinder lubricants can contribute to this efficiency by altering factors such as ash formation — which can have a detrimental impact on aftertreatment — and viscosity.

When it comes to decarbonisation, any contributions to efficiency that cylinder lubricants can provide will be useful as ship operators look towards IMO's 2030 target. This target — essentially reducing the GHG emissions of each ship by 40%, although specific regulations have yet to be formulated — will also need to be met by ships already in service.



Future fuels for 2050

Meeting the 2030 target may not require a change of fuel, but the more ambitious 2050 target certainly will. To reduce GHG emissions by half compared to 2008 levels after 42 years of growth in shipping volumes is a daunting task. Some observers believe it is a task that the internal combustion engine is unable to achieve. But a range of new carbon-neutral fuels stand against that viewpoint.

"Ship propulsion will not likely change radically by 2050," says Luc Verbeeke. "It has now been proven that ship engines can run on a wide range of new fuels including the e-fuels like methanol and ammonia that are produced by renewable electricity. We see a lot of projects investigating how to store excess electricity as e-fuels and some of these make sense as shipping fuels. We believe that the diesel engine will still have a role, although the fuels will have to change."

The range of carbon-neutral fuels currently under consideration by the shipping industry includes ammonia, methanol and synthetic LNG. Each of these will bring specific challenges to maintaining engine condition. Chevron Marine Lubricants already has a wealth of experience in two of these areas.

The company has been lubricating the methanol-fuelled two-stroke engines of Marinvest Shipping for more than four years now, supplying 40BN product with positive feedback. And it has long experience in lubricating dual-fuel LNG engines on the gas carrier fleet and across a growing number of merchant vessels.

Ammonia as a marine fuel has yet to emerge, although it has strong potential and is currently the subject of several engine and vessel pilot projects. Chevron is monitoring these developments and assessing the impact and requirements this fuel will place on cylinder lubrication.

Conclusion

As the industry heads into a future of new fuels, the switch to low-sulphur fuels at the beginning of 2020 provides a useful indicator of what might come.

Perhaps the clearest observation is that the most frequent issues may not be attributable to inherent quality problems with the new fuels themselves. It is the correct handling of the fuels, good preparation for any new regime and the adherence to OEM guidance that most often safeguard engines from damage while optimizing performance. While it is too early to assess the characteristics of many future fuels, these factors will remain crucial.

It is also apparent that cylinder lubrication will need to continue to evolve in line with the shifting marine fuel landscape. As the IMO has mandated reduced sulphur content, cylinder lubricants have been reformulated to cope with new, lower sulphur fuels. Future regulations — whether governing particulate matter or ultimately the use of carbon-based fuels — will see an even more diverse range of fuels and fuel characteristics come into play. Cylinder lubricants will have to address these new characteristics and the challenges they pose for engines.

Finally, any new regime will need to be monitored carefully to ensure engines are not subjected to unacceptable wear. Low-sulphur fuel running reduces the safety margin between normal operation and abrasive/adhesive damage, and it is likely that new fuels will add other challenges. Regular and detailed drip oil analysis — able to measure magnetic and non-magnetic iron — will be essential to provide a clear picture of what is happening inside the engine. Onboard and onshore testing with these capabilities such as that deployed by Chevron's DOT.FAST service will help to spot issues before they become problems and inform ship operators how to adapt and optimize cylinder lubrication.

The switch to low-sulphur fuels has been largely successful, supported by good preparation from ship operators, strong support from OEMs, fuel and lubricant providers and careful monitoring of operations using the new fuels. With similar care there is every reason to believe that the shipping industry can also navigate the fuel changes that lie ahead.