marine lubricants

lubricating dual-fuel auxiliary engines: a practical approach

As an increasingly diverse marine fuels market adds complexity for ship operations, owners are looking for simplified solutions to optimise engine performance. Chevron Marine Lubricants' recent work with dual-fuel four-stroke engines highlights a practical approach to these challenges.

Dual-fuel LNG engines are being installed on more and more vessels, driven by an expanding fleet of LNG carriers as well as the rise of LNG-powered propulsion in other vessel segments. Along with emissions benefits in gas mode, these engines provide fuel flexibility, with the ability to run on either LNG or fuel oil dependent on availability. That flexibility means that lubrication requirements for the same engine can change depending on how the fuel is used.

"In dual-fuel auxiliary engines — as with all engines — there is no one-size-fits-all solution," says Ian Thurloway, Brand, Marketing & Business Development Manager for Chevron Marine Lubricants. "Lubrication is usually dictated by the fuel used and its operating profile. The flexibility of dual-fuel engines means that this can be a more challenging environment than other applications."

The rise of LNG as marine fuel

The use of LNG engines has increased dramatically in the past decade. Initially deployed on gas carriers, the engines are now being installed on merchant vessels; according to DNV GL's Alternative Fuels Insight[1], the gas-fueled fleet (excluding LNG carriers) grew from just 21 vessels in 2010 to 168 in 2019. It is expected to more than double by 2022. Meanwhile, the gas carrier fleet — as well as the number of offshore facilities including floating storage regasification units (FSRU) and floating LNG (FLNG) installations — is also set to expand as demand for LNG around the world rises.

The growth of LNG as a marine fuel coincides with increasing global production of natural gas and the emergence of environmental legislation in the shipping sector. The fuel was initially pioneered in small Norwegian ferries to

1. https://afi.dnvgl.com/Statistics?repId=1

reduce harmful nitrogen oxide (NOx) emissions and was also touted as a means of complying with fuel sulphur (SOx) limits when IMO introduced sulphur emission control areas (ECAs) in January 2015.

LNG is an attractive option for shipowners looking to comply with IMO's global sulphur cap. LNG is currently one of the few readily available fuels which can offer lower carbon dioxide emissions, meaning that it is being considered by some ship owners and operators as a step in the path to decarbonising shipping, in line with IMO's greenhouse gas emission reduction strategy.

Dual-fuel engines mean that operators have the versatility to switch between LNG and residual or distillate fuels, for example if LNG is unavailable or is only required in a specific area such as an ECA or in port. It is a particularly practical option while global LNG bunkering infrastructure is being developed, or when a ship's trading pattern means that it does not necessarily have fixed bunkering locations.

The challenge of lubricating four-stroke, dual-fuel engines

Around three quarters of ships using LNG as fuel have dual-fuel, four-stroke engines. When running continuously on LNG these engines require an oil formulated to minimise ash deposits, which can adversely affect the performance of gas engines by encouraging premature ignition or pre-ignition. However, these oils will not always be appropriate when dual-fuel engines are operating on residual or distillate fuels.

"The challenge for some operators is that they may not know what fuel their vessels will use on a long-term basis," explains Chevron Marine Lubricants marine technical service engineer Rik Truijens. "They could shift from operation on gas to using marine diesel oil, right up to full operation on heavy fuel oil. This means operators also face uncertainty about which lubricant they should be using with which fuel."

Like two-stroke engines, four-stroke engines require lubricating oil to ensure smooth running and engine cleanliness. But while two-stroke engines have separate lubrication systems for the cylinders and the crankcase, four-stroke engines have a common sump serving both cylinders and crankcase. Rather than two oils (cylinder oil and system oil), four-stroke engines are therefore lubricated by a single trunk piston engine oil (TPEO).

Another important difference between lubricating two-stroke and four-stroke engines is how the oil is replenished. While fresh cylinder oil for two-stroke engines is injected into the cylinders continuously, in four-stroke engines trunk piston oil is recirculated from the sump, so only needs to be topped up.

The recirculating of oil in four-stroke engines has two important implications. First, it means that contaminants from fuel and/or engine wear can accumulate in the sump, making the oils' ability to handle these contaminants particularly important. Secondly, it can make fuel switching more complicated. While two-stroke engines can simply switch the lubricant they are injecting into cylinders to match the new fuel type, in four-stroke engines the entire reservoir of oil in the sump needs to be replaced. Ideally, operators need a practical approach to lubrication that will prevent this costly and time-consuming task.

"If you choose a gas engine oil, then you will need to change the sump as soon as the engine runs for any length of time on distillate fuels, because the oil will not be able to handle those contaminants," says Truijens. "Likewise, oil designed for gas operation will not cope with prolonged use of residual fuel."

Different oils for different fuels

There are many reasons why different fuels need different lubricating oils. A major factor is sulphur content. The higher the level of sulphur in a fuel, the greater the risk of acidic corrosion in the engine. To counter this, lubricants include alkaline material, quantified by their base number (BN). More sulphur in fuel requires greater alkalinity (i.e., a higher BN) in an engine oil.

However, if the alkalinity in oil is too high for the fuel sulphur level, ash deposits can be formed in engines. This is a particular challenge in gas engines, where the ash embers can settle on pistons and potentially cause pre-ignition of gas fuel — also known as 'knocking' — with a negative impact on engine performance.

According to lubrication advice from many leading dual-fuel four-stroke engine OEMs, engines running constantly on LNG should be lubricated with a low-ash engine oil. These low ash oils — such as Chevron Marine's HDAX 5200 —

help to ensure that the formation of deposits on the piston and ring belt remain under control. Reliable oxidation and nitration resistance can also reduce build-up of insoluble contaminants and promotes long oil and filter service life.

For dual-fuel engines running primarily on distillate fuels — including marine gas oil and marine diesel oil — alternating with LNG, more alkalinity is needed in a lubricating oil to handle the sulphur present in these fuels. To achieve the right balance between oil alkalinity and detergency, while helping protect valves from excessive wear and keep the engine clean, Chevron Marine Delo 1000 Marine 40 can provide the solution. The selected additives in the oil promote engine cleanliness and replenishment intervals can be extended with the use of separation and filtration.

Even more protection is needed for dual-fuel engines running mainly on residual fuels such as heavy fuel oil. Residual fuels typically contain asphaltenes which can drop out of solution and form sludgy deposits. For continuous operation on this type of fuel, alternated with natural gas and/or distillate fuel, a lubricating oil designed to handle these asphaltene contaminants is needed, such as the Chevron Marine Taro DP and XL series.

Many residual fuels have a high sulphur content and therefore require lubricant oils with a high BN, with enough alkalinity reserve to help protect the engine from corrosion. Chevron Marine Taro DP and XL are available in a range of BN levels, allowing operators to select the level they require. Chevron Marine recommends that operators determine the required BN through used oil analysis. It is Chevron Marine's experience that, in case of operation on residual fuels, the best results are obtained with Taro DP and XL maintaining the BN in the sump around 25, with a minimum of 20.

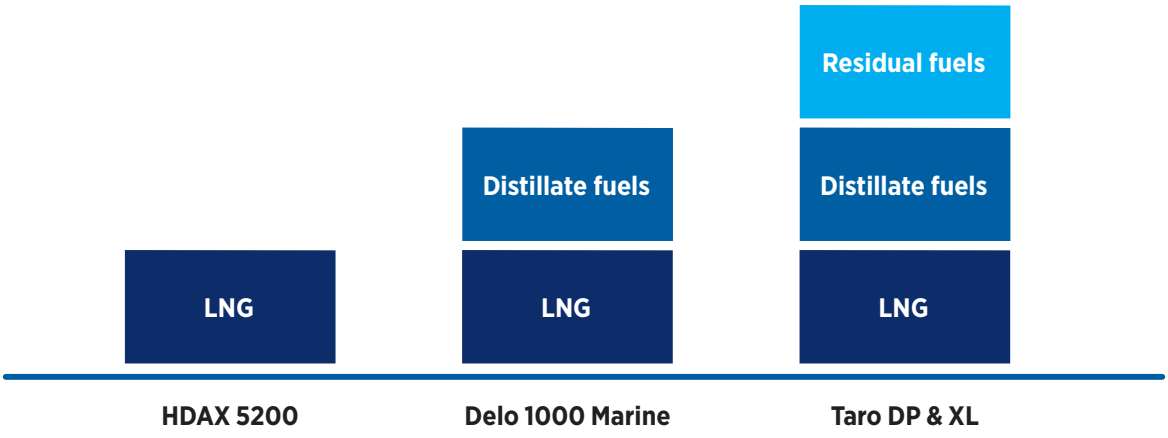
The advice above highlights the different types of trunk piston engine oils used with LNG, distillates and residual fuels. Get it wrong and there can be both operational and financial consequences — increased topping up of engine oil due to contaminants in the sump; the cost and time of replacing the entire sump; or, in extreme cases, engine damage.

Real-world lubrication challenges

On vessels in service, sometimes operating cases are not quite so clear-cut. Some dual-fuel engines might operate on an unpredictable mix of all three fuel types, bunkering either residual or distillate fuels where they can and using LNG as it is available or allowed. With such a varied operating profile, it would not be feasible or economical to switch the lubricating oil in the sump to the optimum product for each different type of fuel. Instead, Chevron Marine has identified a more realistic way to manage the lubrication of dual-fuel auxiliary engines.

"A practical approach can be to assess up front what type of fuel will be applied predominantly, then select the lubricating oil according to which fuel has the most potential contaminants," explains Rik Truijens. "This means residual fuel, followed by distillate fuels and then LNG."

In Chevron Marine's portfolio, the selection — depending on the fuel used by the vessel with the highest potential for contaminants — would be between:



This approach allows for practical protection of the engines without switching oil every time a new fuel is used. Thanks to Chevron Marine's investment in developing a wide and flexible portfolio of trunk engine piston oils, the approach can be further simplified.

Chevron Marine's Taro DP and XL series of trunk piston engine oils for medium-speed engines comprise four products designed specifically to handle contamination of the sump with asphaltenes originating from residual fuel. But according to Rik Truijens, it also offers the ideal platform for lubricating all cases of dual-fuel auxiliary engine use.

"If we use a gas engine oil, as soon as the engine runs for a long time on distillates, we will need to change the sump because of contaminants and oil degradation," he says. "Likewise, for residual fuel with oil meant for distillates, you could experience issues with asphaltenes and corrosive wear."

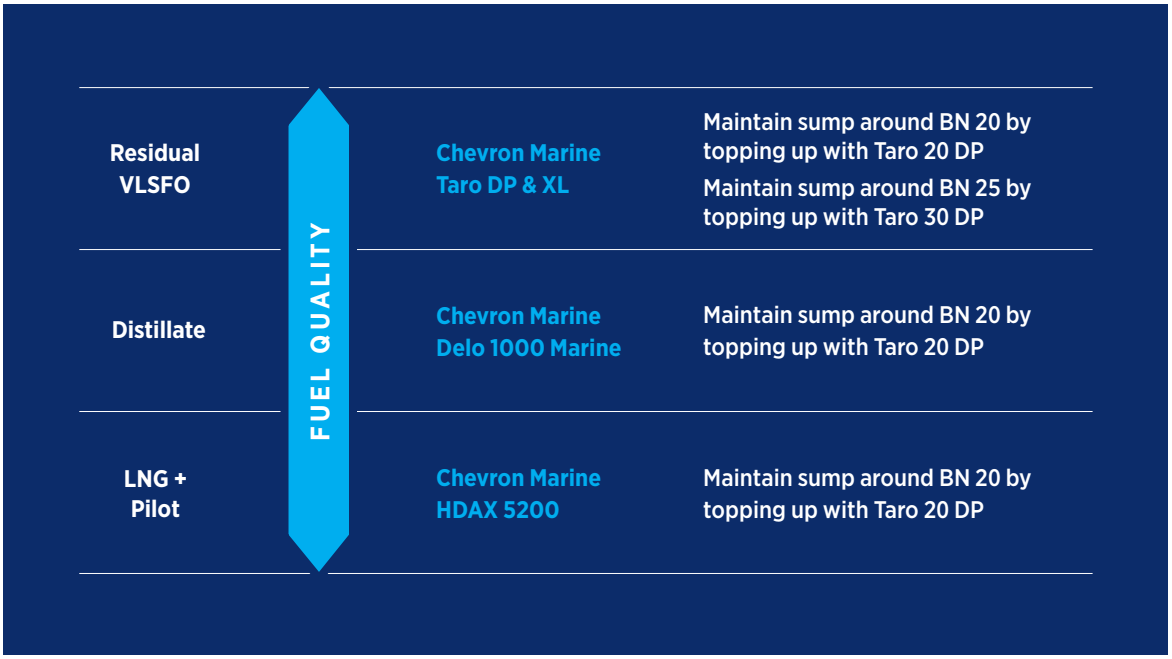
A practical approach to multi-fuel lubrication

Initially using Taro 20 DP is the ideal solution for total flexibility. From this base, all three fuels can be used. The oil is designed for residual fuels but is also acceptable for gas operation with pilot fuel and for distillate fuels — at BN 20 its alkalinity is high enough to adequately neutralise acids and help prevent corrosion. Although the ash content is higher than HDAX 5200 and Delo 1000, it is within acceptable limits.

The Taro DP and XL series is fully compatible across the different BN products. This means that when starting with BN 20 (Taro 20 DP), the sump can be topped up with BN 30 oil or BN 40 oil to replenish the BN level depending on the requirements of the fuel in use. For example, if mainly using low-sulphur (<0.5%) residual fuel — such as the new very low sulphur fuel oil (VLSFO) blends coming to market with IMO's 2020 global sulphur cap — an operator could top up the sump with Taro 30 DP to reach the required BN 25. If using a traditional high-sulphur residual fuel, topping up with the higher BN Taro 40 XL 40 would help to replenish the more rapid depletion of BN from the sump oil.

Using this strategy, operators of dual-fuel engines that could burn any type of fuel alternating between distillate, residual and LNG with pilot fuel can apply Taro DP and XL lubricants only, adjusting the sump oil to counteract BN depletion by topping up with the appropriate grade of engine oil.

If alternating distillate and residual fuel with LNG, this strategy would entail the following recommendations depending on the primary fuel.



Keeping an eye on oil condition

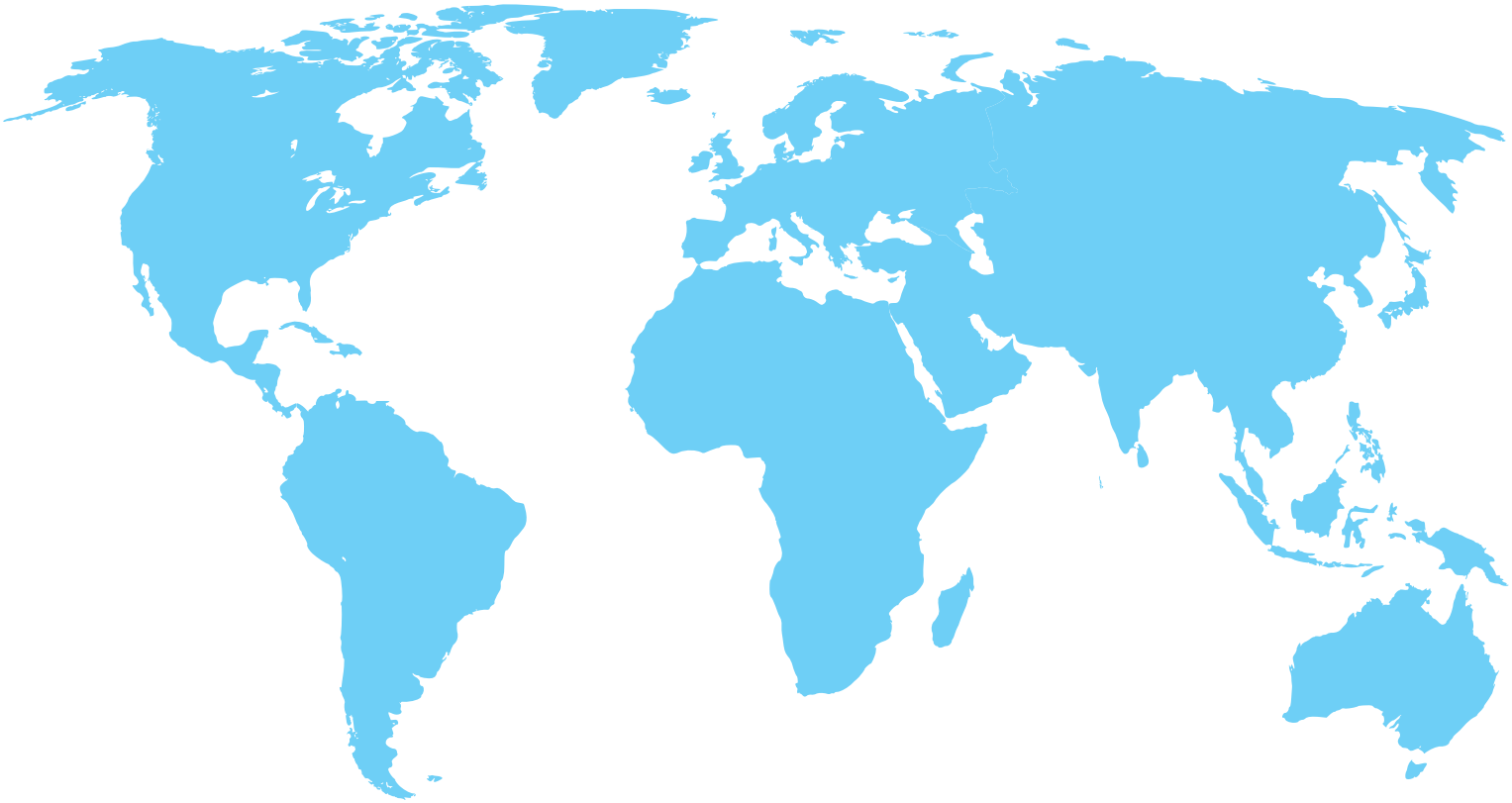
In order to maintain the correct alkalinity in the sump and to ensure that the oil is handling other contaminants adequately, regular monitoring of the engine oil is essential. Chevron Marine's FAST analysis program provides reliable results within 48 hours via its online service. Laboratories in Ghent and Shanghai test several critical variables — including BN, iron and wear metal content, viscosity, insoluble materials and acid number — and deliver actionable recommendations that can help to extend the service life of oil.

"As always with lubrication, we believe that there is no single approach to lubrication needs," explains Ian Thurloway. "The precise needs of each engine will depend on factors including the operating profile and the fuel chemistry. Monitoring with FAST enables early detection of potential issues and provides recommendations for the necessary adjustments, which prevent downtime and limit the potential for costly damage to occur."

Fleet-wide clarity and flexibility

The result of this approach is flexibility, clarity and uniformity for operators, helping to reduce the different engine lubricants required across their gas-fueled fleets. Where vessels can be certain that they will only be using distillate fuels with LNG, they are still using the Chevron Marine Delo 1000 oil, designed for distillates. Where residual fuels are in play, the strategy of maximising flexibility by using Chevron Marine Taro 20 DP 40 as a base ensures that engines are protected whether they are running on LNG, distillates or residual fuel.

Thurloway concludes: "The challenge of lubricating dual-fuel auxiliary engines is just one example of how the widening marine fuel mix is adding complexity to ship operators' lubrication choices. Chevron Marine's work in developing a practical strategy — and the flexibility offered by deploying the Taro DP and XL range — highlight the way Chevron Marine is providing solutions to help ship operators navigate these challenges."



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