A global 0.5% sulphur limit comes into force from 1 January 2020

Engine injection equipment must be checked and, where required, reconditioned or upgraded

Converting a vessel to run on LNG ensures compliance while also lowering particulate matter, NOx and CO2 emissions
1. Introduction

The maritime industry is currently facing an increasing amount of legislation aimed at safeguarding marine life and reducing emissions – as well as helping to ensure a sustainable future for our planet. The reduction of sulphur oxide (SO\textsubscript{X}) emissions from marine vessels has been a priority for some time due to the harmful impact they have on both human health and the environment.

The IMO global 0.5% limit on sulphur in marine fuels comes into force from 1 January 2020. The global sulphur cap will bring about significant changes in the type and quality of fuels used in the industry, impacting both vessel operations and supply chains.

There are three broad strategies available to ensure compliance with the 2020 sulphur legislation:

- Use compliant fuels based on marine distillates, low-sulphur residual fuels and/or blended fuels
- Convert vessels to run on liquefied natural gas (LNG)
- Install SO\textsubscript{X} scrubbers to clean exhaust gas

2. Options for ensuring compliance

**RUN DIESEL ENGINES WITH LOW-SULPHUR FUELS**

Marine distillates, low-sulphur residual fuels and blended fuels will have a sulphur content between 0 and 0.5%, thus lowering emissions to comply with the 2020 global sulphur cap.

**CONVERT THE VESSEL TO RUN ON LNG**

LNG, with its negligible sulphur content, qualifies as a compliant fuel. Converting an existing vessel to run on LNG is possible and involves retrofits to combustion chamber components, fuel injection components and the control system. Whether a vessel can be converted depends mainly on the space available to install the LNG tanks and the associated additional equipment.

**CLEAN THE EXHAUST GAS**

Marine SO\textsubscript{X} scrubbers are typically wet scrubbers that use water as a cleaning medium to wash or “scrub” the gas. There are three main scrubber types:

- In an open-loop model, scrubbing water is fed once through the scrubber unit and then discharged into the sea. Plain seawater is used as scrubbing water and no additional chemicals are needed.
- In a closed-loop model, the scrubbing water is recirculated and alkalinity is maintained at the correct level with the addition of alkalis.
- A hybrid system includes both open and closed-loop equipment. Open-loop operation can handle compliance in all areas except where discharge overboard is not allowed or where the alkalinity of the water is too low (for example in freshwater areas). In these situations the system can be operated in closed-loop mode. In non-discharge areas, bleed-off water taken from the scrubbing-water circulation is stored on board.

In this business white paper, we will focus on a compliant fuel strategy as a practical and cost-effective way to ensure compliance for WinGD, Wärtsilä and Sulzer branded two-stroke engines.
3. Preparing an engine to run on marine distillates, residual fuels and/or blended fuels

The quality and grade of compliant fuel varies, and both factors can have an impact on the reliability of a vessel’s engine and the time between overhauls (TBO) for the fuel-injection system.

Furthermore, the quality of the fuel treatment on board has a direct impact on the wear of fuel injection system components. Operating with heavy fuel oil (HFO) results in wear of running parts, while switching between fuels and mixing incompatible fuels can impact component lifetime. Continuous operation with HFO will result in the standard TBO being achieved. When switching to clean low-sulphur fuels with low viscosity, the efficiency or the function of the injection components might be affected.

**THE INJECTION CONTROL UNIT (ICU)**

The ICU delivers a metered quantity of fuel into the cylinder at timed intervals to ensure efficient combustion. The accuracy of the metered fuel and injection timing is affected by leakages in the fuel quantity piston and the performance of the injection control valve and rail valves.

The amount of leakage is affected by fuel viscosity, pressure differential and clearances. The leakage rate can be five times higher with a reduction in fuel viscosity from 15 to 3 CentiStokes (cSt). Excessive fuel leakage due to worn parts can lead to bad starting behaviour, especially when low-viscosity fuels are used.

Earlier-generation ICUs are designed for continuous operation on residual fuels, with operation on low-viscosity fuels limited to a few hours during shop tests and major overhauls. In today’s operating environment, engines switch over to gas oil when entering emission control areas (ECA) or zones where local emissions legislation is in force. Operating on distillates may result in components wearing out earlier compared with operating on residual fuels.

**THE SOLUTION**

It is recommended to check the ICUs’ condition on the engines to evaluate their capability to operate on distillates. If the ICUs need to be overhauled to ensure efficient engine operation and reduced maintenance costs, the latest ICU technology – which is more robust and exhibits improved leakage behaviour under multi-fuel operation – can be installed during reconditioning of ICUs, or in the case of larger bore RT-flex engines, as a retrofit.
**THE COMMON RAIL FUEL OIL PUMP**

The fuel pump on Wärtsilä RT-flex and X-generation engines is a delivery pump that supplies fuel to maintain a pre-set pressure level in the common rail. The design is a special jerk pump with a control helix on the plunger for flow regulation by suction control.

There is always fuel leakage between the plunger and barrel, which acts as a lubricating film. The rate of leakage is dependent on the viscosity of the fuel: there will be a higher rate of leakage with lower-viscosity fuels such as distillates.

This leaking fuel is collected in the spring housing and drained through a bore connected to the fuel-leakage drain line. It is important to ensure the bore is not clogged to avoid spring failure due to the hydraulic impact of leakage.

Fuel leakage also occurs from the pressurised area above the plunger through the control bores back into the low-pressure area. This leakage reduces the volumetric efficiency of the pump and, as a direct consequence, its maximum delivery capacity, which may limit the power output of the engine.

**THE SOLUTION**

In general, there is sufficient overcapacity in the fuel pump to cope with the excessive leakage at a continuous service rating; however, there may be engines where this overcapacity is not sufficient in the case of worn components. Earlier overhaul is the preferred solution. Instead, in some cases, a bigger plunger diameter can be fitted if feasible.
### CYLINDER LINERS
As the sulphur content of compliant fuels varies between 0% and 0.5%, there needs to be an adequate base number (BN) in the cylinder oil to neutralise the acid from combustion and optimise the feed rate. An adequate corrosion protection with a 25 BN cylinder oil or excessive deposits with a higher than 40 BN oil.

### THE SOLUTION
The right matching of cylinder oil BN with the fuel type and adjustment of lubrication feed rate based on findings from regular checks in line with the operating instructions and service bulletins will ensure piston running reliability. Alternatively, a blend-on-board system provides the optimal BN at a fixed feed rate by blending system oil with additives or with a high BN cylinder lube oil or by blending two different cylinder lube oils, which helps to provide the required levels of dispersants, detergents and viscosity.

For dark grey areas, it is recommended to:
- carry out regular piston underside drain oil sampling, as well as analysis and interpretation of the results
- carry out regular checks of the piston and piston ring conditions through scavenge port inspections.

For the hatched area (001), there are some products that are validated for < 0.1% S ECA fuel.
4. Converting a vessel to run on LNG

For many operators, converting vessels to run on LNG is a viable alternative to ensure compliance with sulphur legislation. A key consideration in any gas conversion project is the availability of sufficient space for storing the gas onboard the vessel.

Daily gas consumption should be calculated based on the operating profile. The existing liquid fuel storage system can continue to work as a backup system if necessary.

For LNG storage, either vertical or horizontal tanks on deck or below deck are possible. When storage is above deck, the requirements set by the classification societies are slightly lower and installation is more straightforward.

Generally speaking, converting existing engines to run on LNG is more economical than installing new ones. Since most vessels are in some way unique, LNG conversion projects should always start with a feasibility study to determine the suitability for conversion.

THE BENEFITS

Switching to LNG not only ensures compliance with the 2020 sulphur legislation, it can also significantly reduce fuel costs and help you meet future legislation on greenhouse gases and black carbon. This means that the total lifecycle cost of LNG-fuelled engines can be lower than that of oil-fuelled ones – even when taking into account the higher initial investment costs and maintenance costs.
Vessel owners have three main paths available to ensure compliance with the 2020 global sulphur cap: use low-sulphur liquid fuels, convert the engine for operation with LNG or clean exhaust gas with scrubbers. With WinGD, Wärtsilä and Sulzer branded two-stroke engines, implementing a compliant fuel strategy – either by retrofitting engines to use compliant liquid fuels or converting a vessel to run on LNG – ensures compliance with the 2020 global sulphur cap and can also bring cost benefits.

If an engine has been operated over longer period with HFO and depending on the quality of the fuel treatment system, some injection equipment components might require an earlier overhaul to be able to cope with low-viscosity fuels. For RT-flex engines, a scheduled overhaul may be combined with an upgrade to the latest available technology, extending the next component lifetime cycle and reducing the cost of the retrofit.

As the lifecycle partner for vessel owners and operators, Wärtsilä can help to ensure compliance and a reduced environmental footprint in the most efficient way. In order to comply with regulations while ensuring vessel performance, a holistic approach that takes into account the whole life cycle of the vessel is needed, from feasibility studies to installation and maintenance. The goal is to ensure compliance with sulphur legislation while simultaneously ensuring best performance and limiting downtime and costs.

**5. Conclusion**

**HOW WÄRTSILÄ CAN HELP SUPPORT PREPARATION FOR COMPLIANCE WITH THE 2020 SULPHUR CAP**

**MAKE ENGINES FIT FOR MULTI-FUEL OPERATION**

Where injection equipment is worn out, Wärtsilä can offer reconditioning or retrofits with the latest injection component technology that can cope with compliant fuels based on marine distillates, residual fuels and/or blended fuels. The Wärtsilä Blendin on Board system provides the optimal BN value of the cylinder lubricating oil, allowing a fixed feed rate with different fuels by blending system oil with additives.

**LNG CONVERSIONS**

In order to convert to LNG, Wärtsilä is now conceptualising a two-stroke dual-fuel gas retrofit solution for Wärtsilä and WinGD engines in service. This concept will be supplied as an engineering, procurement and construction (EPC) project and include hardware modifications to the engine, an LNG storage and supply system as well as safety systems.

**LEARN MORE:**

https://www.wartsila.com/marine/maintain/2-stroke-engine-services
Wärtsilä is a global leader in smart technologies and complete lifecycle solutions for the marine and energy markets. By emphasising sustainable innovation, total efficiency and data analytics, Wärtsilä maximises the environmental and economic performance of the vessels and power plants of its customers.