New Cylinder Lubrication Requirements post the 2020 Sulphur Cap

Content:

Abstract

The global 0.5% sulphur cap will be introduced in 2020 with the revised Marpol Annex VI 2020, and up to 70,000 ships may be affected by the regulation according to IMO estimates.

Under the new global cap, ships will have to use fuel oil on board with a sulphur content of no more than 0.50% m/m, against the current limit of 3.50%, which has been in effect since 1 January 2012.

This change will have important and far-reaching influence on cylinder lubrication of the main engine including the oil consumption, liner and piston ring condition.

It is a common perception that when the sulphur in the HFO is reduced, the cylinder lube oil consumption can "just" be reduced. However, the lubrication technology installed on most 2-stroke marine engines today, are not designed to operate under these new regulations hence typically not capable of ensuring the continuous presence of a stabile hydrodynamic oil film. It is well known, that a stabile hydrodynamic oil film is essential to control the abrasive and adhesive wear and - at the end - avoid abnormal wear of liners and rings, scuffing, engine down time, Lost Time Injury, exchange of liners etc.

It is clear to anyone involved in technical marine operations, that many changes in recent years, as well as changes in the years to come have influence on cylinder lubrication hence the engine condition. A few examples are the 2020 global sulphur cap, the continuous slow steaming as the "new normal", low sulphur fuels and other new fuels (some with degreasing effects like Ethane), new engine designs with higher pressure that are more corrosive than ever before, new cylinder oil types etc.

Constant changes require that the technologies installed onboard are flexible and able to cope under various conditions. **Therefore, ship owners demand flexibility.**

At Hans Jensen Lubricators, we work dedicated and focused to offer ship owners the very best and most flexible lubrication systems in the world, no matter what the specific situation requires.

This document presents Hans Jensen Lubricators' opinion on the matter and can be seen as our contribution to the ongoing discussion. Our opinion is based on extensive experience for more than 100 years dealing with marine cylinder lubrication in corporation with ship owners, engine designers and engine makers, oil suppliers, research institutes and other industry experts.

Purpose of Cylinder Lubrication

Cylinder lubricants are specially formulated to perform in the specific environment of the two-stroke combustion chamber. The generic purposes of a cylinder lubricant are to protect the cylinder liners, pistons and piston rings from the harmful effects of combustion residues and provide an oil film between piston rings and cylinder liners.

To achieve this, the cylinder lubricant is required to:

- Spread uniformly over the cylinder liner surface and form a stable oil film, to eliminate metal-to-metal contact between moving objects.
- Neutralise acids formed during the combustion process.
- Prevent corrosion of the cylinder liner and piston rings.
- Keeping the piston surfaces, ring grooves and cylinder liner wall clean and free of deposits which can lead to ring sticking or breakage.
- Flush out particles formed during combustion from the combustion chamber as well as wear particles.
- Have the necessary thermal stability, this, in order to be able to lubricate efficiently also at high cylinder liner temperature.
- Be compatible with the different methods used by engine manufacturers to introduce lubricant into the cylinder liner.
- To assist in providing a gas seal between the liner and the piston rings.

Improved Fuel Efficiency leading to increased corrosive level

New engines coming into the market, such as ME/ME-B/ME-C/RT-Flex/X type, are designed to consume less fuel oil compared to older engines. While the engine designers have been successful in achieving reduced fuel consumption, the cylinder liners of modern engines are more exposed to a corrosive environment compared to the older MC/MC-C and RTA engines, due to longer stroke lengths, lower combustion temperature and higher pressure:

"In order to improve the specific fuel oil consumption, the pressure in the combustion chamber has been increased on the newest engine designs. This pressure increase, together with the increased operating time at part load, has led to increased water and acid condensation on the cylinder walls, which leads to cold corrosion in the combustion chamber."[1]

"Recently, cold corrosion of cylinder liners has grown to become a major issue for the latest generation of MAN B&W two-stroke engines."[2]

[1] MAN Service Letter: "Service Letter SL2014-587/JAP

[2] MAN "Service Experience – MAN B&W Two-Stroke Engines"

Low sulphur Fuel – The Challenge

If owners opt for low sulphur fuel (instead of scrubber technology) the need to neutralize sulphuric acid is reduced. However, the need for lubrication to reduce the abrasive wear is increased:

Operation with low sulphur fuel, reduces the need for base (BN) to neutralize the sulphuric acid formed during the combustion process leading to a reduced feed rate. When the feed rate is reduced, most lubrication systems (not the Hans Jensen Lubtronic SIP) increases the number of engine revolutions between injections of cylinder oil, referred to as the "Effective Lubricant Refreshment Rate" (ELRR). This is because most lubrication systems, fitted from new building stage, operates with a fixed oil volume/quantity that is injected, when the lubricator pump is activated.

"the Alpha Lube is designed to supply cylinder oil every 2-15 engine revolutions"[3]

This leads to an increased "Cylinder Oil Stress" (acid stress + thermal/oxidative stress + asphaltene stress[4]). A high oil stress increases the wear of liners and pistons that reduces the lifetime of the components. Ensuring a low Cylinder Oil Stress level is crucial:

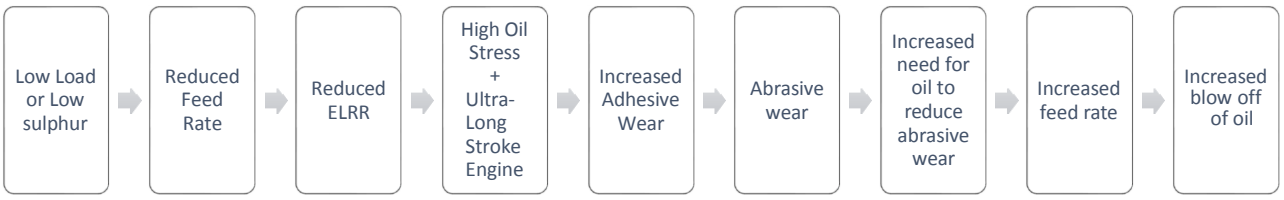
"Cylinder oil performance in terms of its properties and ability to deal with oil stress on the liner surface is a key factor to enable a longer life of cylinder liners and piston rings by establishing and promoting optimal running conditions"[5]

Higher oil stress in itself will lead to increased abrasive wear. Many newer engines are designed with longer stroke length (for example the so-called "Ultra-Long-Stroke" like the G-type or X-Type engines) which usually means longer distance from oil injection level to TDC. This design change makes it challenging to lubricate the liners evenly and to lift the oil to where it is mostly needed; on the upper part of the liner.

The high oil stress and the challenged distribution leads to increased abrasive wear.

Increased abrasive wear leads to an increased feed rate where more oil will accumulate in the ring pack. Some of the oil will be lost due to blow off and some will accumulate in the form of burnt residues behind the rings with the risk of piston rings sticking or even breaking.

Cylinder lube oil lost due to the ring pack spray through the inlet ports is in the range of 15 - 30% of the refreshment oil[6]



[3] MAN Service Letter: "Service Letter SL2014-587/JAP

[4] Read more in: CIMAC 2004, Paper No. 21: "Oil stress investigations in Shell's medium speed laboratory engine"

[5] CIMAC 2010 Paper No. 24: "Cylinder Lubrication – Understanding Oil Stress in the Low Speed 2-Stroke Diesel engine"

[6] CIMAC 2010 Paper No. 24: "Cylinder Lubrication – Understanding Oil Stress in the Low Speed 2-Stroke Diesel engine"

Note: Under low load conditions, the liner surface will become colder, which increases the risk of corrosion.

Note: Engines today generally have a higher corrosive level than older engines. Therefore, even though the sulphur content of the fuels in the future is reduced, this smaller amount will be more "aggressive" than before. This is mainly due to different pressure and temperature conditions as well as the different dimensions of the Ultra Long Stroke (and "X-type") engines.

Definition

1. Adhesive Wear[7]

   This phenomenon is caused by frictional contact between asperities on opposing surfaces at a high enough load, that plastic deformation or solid-phase welding occurs in the contact (see figure 1). When this results in transfer of material from one surface to another, adhesive wear occurs. Wear debris can also be formed. In a low speed engine this wear mechanism is generally observed when insufficient oil film is present to achieve hydrodynamic lubrication.

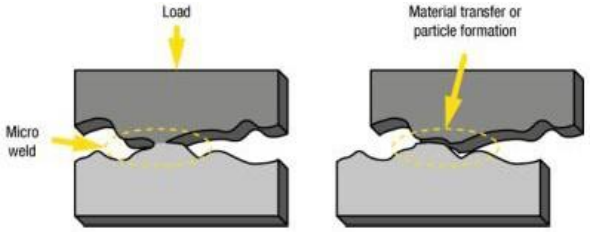


Figure 1 Schematic Representation of Adhesive Wear

2. Abrasive Wear[8]

   Abrasive wear occurs when a harder material is rubbing against a softer material resulting in loss of material (see Figure 2).

   When only two surfaces are involved and the wear is caused by asperities on the harder surface, the wear is called two body abrasion. If the wear is caused by a hard particle trapped (either free or partially embedded in one of the surfaces) between the sliding surfaces, the wear is called three body abrasion. Abrasive wear occurs when the oil film thickness allows contact and results in scratches, embedding of particles or formation of new particles.

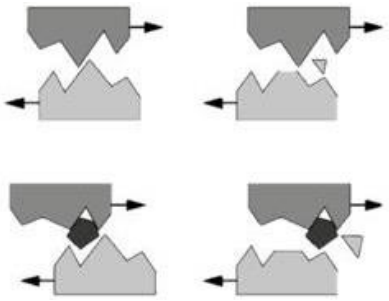


Figure 2 Schematic representation of abrasive wear

3. Corrosive Wear[9]

   The rate of material loss can be very high; much higher than the sum of the individual contribution of wear and corrosion. This is because loose corrosion products are easily removed by wear to continually reveal fresh metal beneath, which in turn can corrode quickly. (See figure 3)

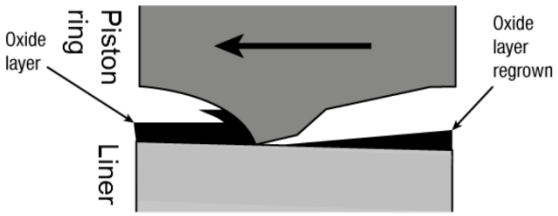


Figure 3 Schematic representation of oxide layer removal – exposing the surface to corrosion

[7] CIMAC WG8 Lubrication of Two-Stroke Crosshead Diesel Engines, 2016-04 (1st edition)
[8] CIMAC WG8 Lubrication of Two-Stroke Crosshead Diesel Engines, 2016-04 (1st edition)
[9] CIMAC WG8 Lubrication of Two-Stroke Crosshead Diesel Engines, 2016-04 (1st edition)

MGO, Ultra-low sulphur HFO/hybrid fuel, LNG or scrubbers?

No matter what solution you choose, the HJ Lubtronic SIP system is the most flexible cylinder lubrication system in the market. Our lubrication system can adapt to almost any situation you can imagine. This is due to our patented injection principle and our step less stroke adjustment function in the HJ Lubtronic.

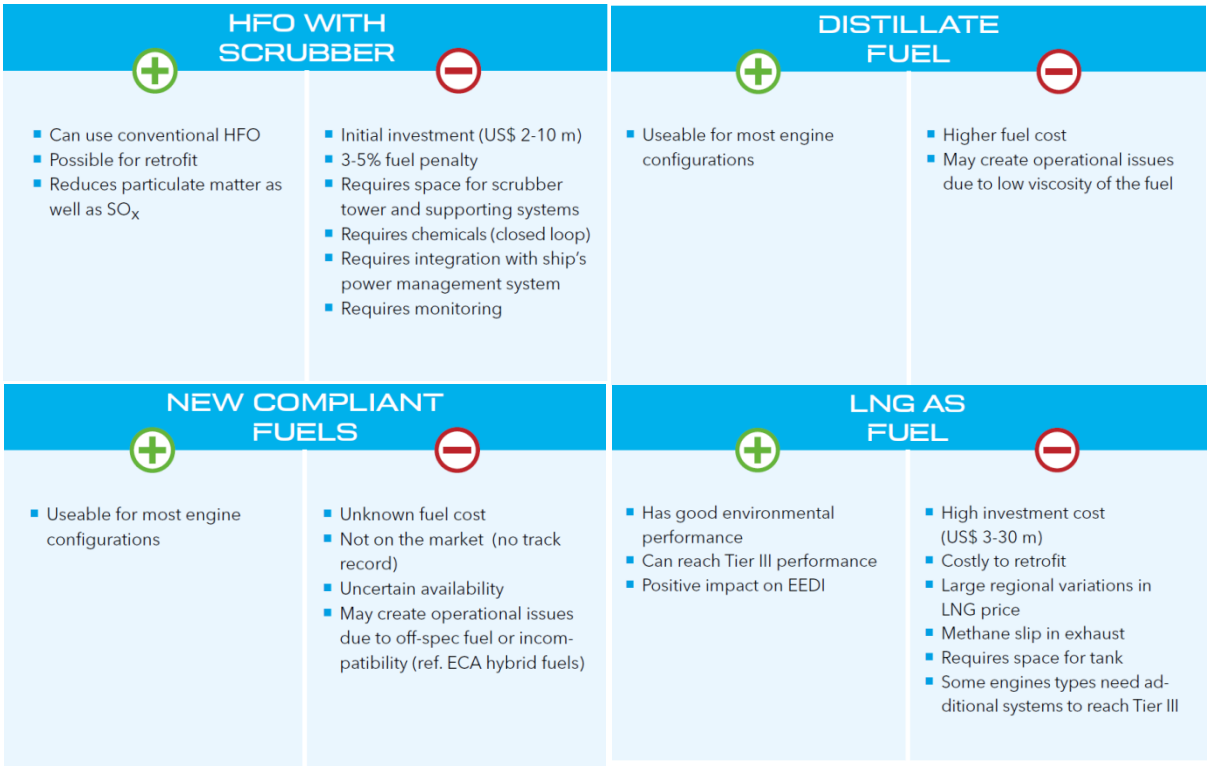


Figure 4 Pros and cons of various fuels[10]

No one knows what regulations with effect on cylinder lubrication will impact the shipping next, after the 2020 regulations.
No matter what the future will bring in terms of regulations or other changed parameters, you are in good hands teaming up with the leading industry expert with more than 100 years of experience, with the best and most flexible products available ensuring:

1. Fresh oil injection more frequent than others for fresh alkalinity.
2. Optimal distribution of the oil in the upper part of the liner.

Whatever your requirement is, HJ Lubtronic SIP is the most flexible system to meet your individual needs.

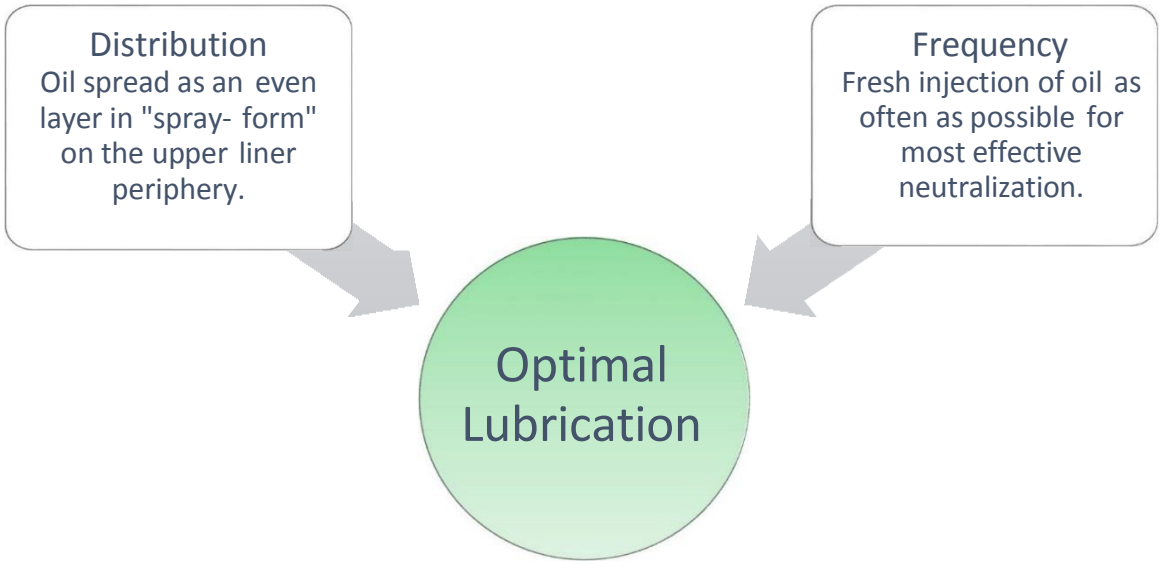
[10] DNV GL – "Global sulphur cap 2020"

Use Hans Jensen Lubricators for highest flexibility

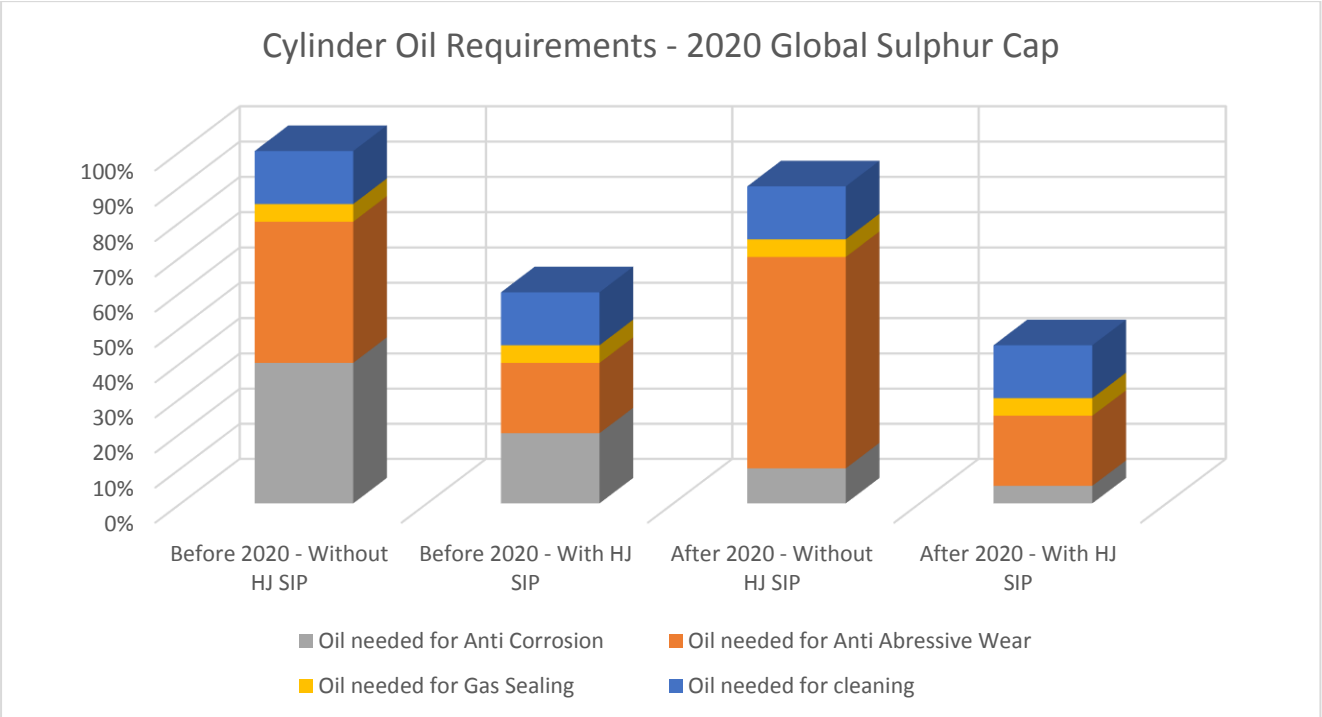
Hans Jensen Lubricators have 100 years of experience in cylinder lubrication of marine engines including all types of engine makes and almost all engine types running under any condition you can imagine. Our experience includes the introduction of the introduction of the SECA zones under MARPOL Annex VI and the later revisions.

Today, the need for a flexible lubrication system is more important than ever before, given the complexities put forward in this white paper as well as the uncertainty of the future.

According to our experience, the key to optimal cylinder lubrication, meaning best possible liner and piston ring condition with the lowest consumption of oil possible, is:



As it can be seen on this graph (used for illustration purposes only as the proportions may be different from engine to engine, cylinder oil type, sulphur content etc.) HJ SIP will always be the most economic lubrication system and will at the same time ensure your liners keep the wear to a minimum.



Conclusion

Removing the sulphur from the fuel requires a more flexible lubrication system. The combination of HJ Lubtronic and HJ SIP will safe guard the engine operation because:

1. HJ SIP system will distribute the cylinder oil where it is needed; In the upper part of the liner in the combustion area to ensure effective neutralization of the sulphuric acids and evenly distributed on the entire periphery of the surface to ensure a reduced and even wear on the entire liner surface
2. HJ Lubtronic system can inject fresh oil in smaller quantities more often than any other lubricator - also at very low loads and with very low sulphur.
   It has flexible adjustment options depending on the type of cylinder oil, sulphur level, load, engine type etc.

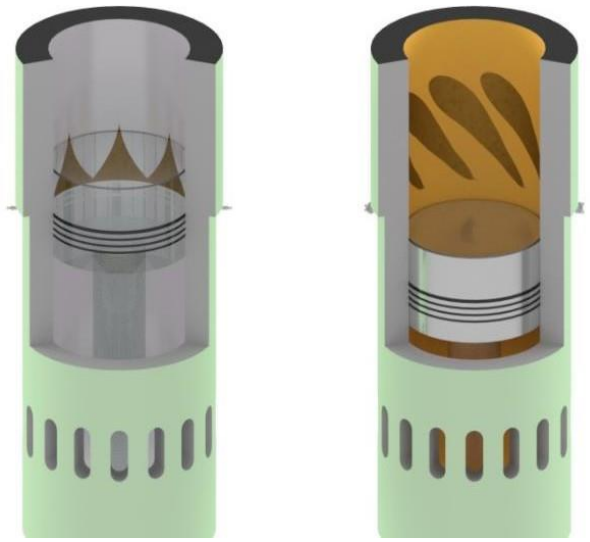


Figure 5: Left: Ring Pack Lubrication, Right: HJ SIP Lubrication

By installing HJ Lubtronic SIP on your new building or on retrofit basis, you have the optimal solution to meet the future lubrication demands and to ensure stable operation of the engine in the years to come. *The revised Marpol Annex VI (prescribing the marine fuel sulphur content to go down from 3.50 mass% (outside the ECA's) to 0.50 mass% (outside the ECA's), or to take measures to ensure an equivalent reduction of SOx and particulate matter) is set to take place on January 1st 2020, or five years thereafter should a review in 2018 conclude the former date is not feasible.*