Market Update Note

MUN2017-11-24

Two-Stroke Engines Under the 2020 IMO Sulphur Cap and the Impact on Engine Design

Global 0.50% sulphur limit from 2020

On 1 January 2020, the global sulphur (S) limit on marine fuels will be reduced from 3.50% to 0.50% S (Fig. 1). This landmark decision, which will have a major impact on the marine industry, was taken in 2016 at the 70th session of IMO's Marine Environment Protection Committee (MEPC 70).

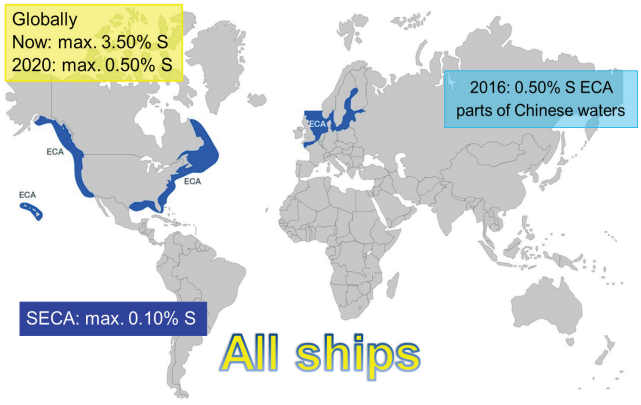

Fig. 1: World map illustrating major sulphur emission controlled areas (SECAs) and the sulphur limits in force

Operators have the following three options for operation in global waters:

- operate an electronically-controlled ME or mechanically-controlled MC type engine on 0.50% low-sulphur fuel oils (VLSFO)
- operate a dual fuel ME-GI or ME-LGI type engine on LNG, ethane, methanol or LPG
- continue operation on high-sulphur fuels and apply an approved SO_x reduction method, for example an exhaust gas scrubber.

It is up to the owner to decide on which option is the most favorable.

The current 0.10% SECAs will remain unchanged. The 0.50% S emission-controlled areas in China will increase and are scheduled to be fully implemented by 1 January 2019.

Current and future fuel pool

The current fuel pool is dominated by high-sulphur residual fuels (HFO), distillates, and the 0.10% S ultra-low-sulphur fuel oils (ULSFO). This will change in 2020, when the refineries and blenders will produce and blend fuels that can also meet the 0.50% S limit.

This will require different refining processes and utilisation of oil streams not currently used for marine fuels. The future fuel pool for 0.50% S fuel will include heavily cracked streams, paraffinic fuels, distillates, desulphurized oil, HFO originating from sweet crudes already meeting the sulphur limit, and other types.

The challenges of the new 0.50% S fuels could include:

- instability within the fuel (some)
- compatibility between fuels (some)
- high cat fines content (rare cases)
- unfavorable combustion characteristics (very rare cases).

Accordingly, handling of these new fuels becomes a very important issues for all operators. One way to prepare for the future is to learn how to handle the current ULSFOs, which face similar challenges. Recommendations on how to handle ULSFOs are given in our service letter SL2014-593.

It is impossible to know exactly which properties the 0.50% VLSFOs will have, as they are not yet available. However, the fuels must comply with the ISO 8217 Specifications for Marine Fuels, if ordered as such. MAN Diesel & Turbo is rep-

resented in the working group of ISO 8217 and in the CIMAC working group 7, where we are closely involved in the development of marine fuel specifications.

The majority of the world fleet outside SECAs will probably start operating on 0.50% S VLSFO and the rest will operate on high-sulphur HFO and remove the SO_x by using a scrubber. We believe that the interest in LNG, methanol, ethane and LPG as a main fuel for the engine will grow at a steady pace. How it continues to develop will depend on the price and availability of the different fuels.

Engine design

The engine design will depend on the type of fuel and sulphur content the engine is going to operate on. This means that the engine design can be optimised with regards to both cost and performance.

The sulphur level in the fuel is decisive for the corrosion level in the combustion chamber. Reducing the sulphur content from 3.50% S to 0.50% S will decrease the corrosion considerably.

Our computerised engine application system (CEAS) now offers the possibility to specify the fuel sulphur content and in this way order a suitable engine design. We have grouped the operation and choice of fuel into the following three engine design categories:

- engines for max. 0.50% S VLSFO
- engines for high-sulphur fuel (the base engine as of today)
- engines prepared for future flexibility to change between high-S and low-S fuel.

Engines for max. 0.50% S VLSFO

These vessels will operate on fuels with a sulphur content of less than 0.10% S and 0.50% S. The design is optimised as follows, see also Fig. 2:

- cermet-coated ring pack will be the standard design
- LDCL system and RDL concept can be omitted as cylinder liner cold corrosion will be low
- cooling water outlet set point on engine outlet will be 80°C, which must be taken into account for other components in the cooling water system, such as the fresh water generator.

For engines already ordered, make sure that they will follow the recommendations above.

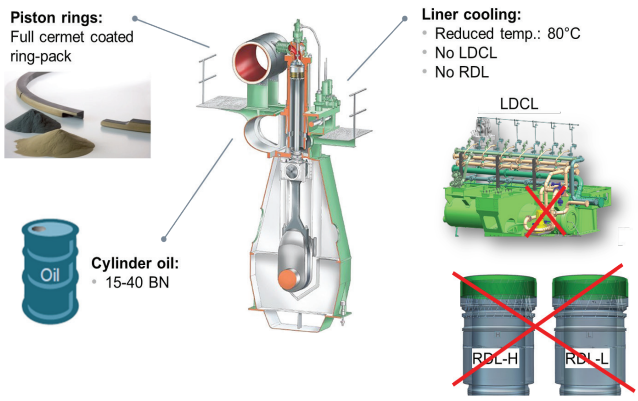

Fig. 2: Design optimisation depending on operation on <0.50% S VLSFO

Engines for high-sulphur fuel

Vessels equipped with an exhaust gas scrubber, and thereby an engine as known today, are capable of operating on high-sulphur fuel. The engines for these vessels will follow the current design. Our standard design covers up to 3.5% S fuels, but higher-sulphur fuels can be handled on request, see also MUN2017-06-28 on ACOM (automated cylinder oil mixing).

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Engines prepared for retrofit of exhaust gas scrubber and shifting between high-S and low-S fuel

The initial design is aimed at operation on fuels with max. 0.50% sulphur content and is prepared for operation on high-sulphur fuel, which means the following design features are also added:

- cermet-coated ring pack will be the standard design
- RDL (rating dependent liner) is included as standard but may be omitted on special request
- LDCL installations are covered on a case-by-case scheme depending on the owner's preference
- vessels must be designed with 0.50% S VLSFO fuel tanks in addition to high- and low-sulphur fuel tanks
- preparations for later installation of exhaust gas scrubber.

For engines ordered already, make sure that they will follow the recommendations above.

Tier III equipment for future fuel

The design of the Tier III equipment will depend on the fuel that is to be used. For example, a high-pressure selective catalytic reduction (HPSCR) system can be ordered for both high-S and low-S fuel. The high-S version can operate in the full range of 0-3.50% S, whereas the low-S version can operate on max. 0.10% S fuel. Fig. 3 illustrates the possible combinations of fuel-S and Tier III equipment.

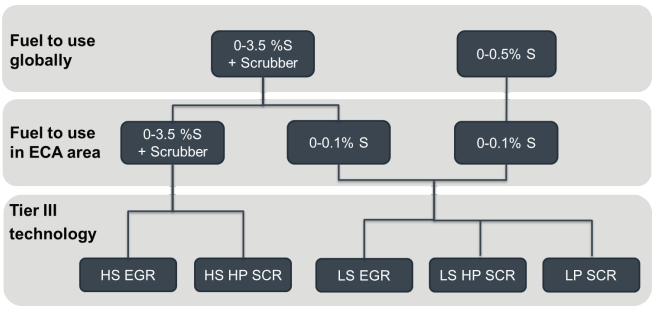

Fig. 3: General fuel and Tier III technology combinations

Cylinder lube oil for <0.50% S fuels

Our general strategy for cylinder lubrication is:

- use low-BN cylinder lube oil for low-S fuel
- use high-BN cylinder lube oil for high-S fuel.

The corrosive level in the engine will determine the specific requirement for BN in the oil. Investigations are ongoing, and we expect that the recommendation will be:

- 15-25 BN cylinder lube oil for engines operating on fuel with less than 0.10% S.
- 25-40 BN cylinder lube oil for engines operating on fuel with 0.5% S fuel.

Nomenclature confirmed with ISO and CIMAC

■ ultra-low-sulphur fuel oil	ULSFO	max. 0.10% S
■ very-low-sulphur fuel oil	VLSFO	max. 0.50% S
■ low-sulphur fuel oil	LSFO	max. 1.00% S

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