WinGD Winterthur Gas & Diesel

2020 IMO global 0.50 percent fuel sulphur regulation

WinGD operation guideline

Date:	2019-05-20
Reference No.:	21336/TFL/TIN011

Contents

Summary

On 1st January 2020, th maximum permissible global sulphur content of marine fuels is reduced from 3.5 % to 0.5% according to MARPOL Annex VI.

New fuels, compliant with this 0.5 % S limit, are likely to display a wide variability of physical and chemical properties even between fuel batches of the same ISO specification.

This document informs of the possible consequences of this wide variability, and provides guidance on important factors to consider when purchasing, bunkering and handling on board of these fuels.

Specifically, in addition to standard fuel management guidelines, due consideration should be given to the compatibility of different batches of fuel, and the resultant stability.

1 Introduction

In May 2005, MARPOL Convention Annex VI [1] came into force which aims at reducing the air pollution from ships. Regulated pollutants include, besides nitric oxide emissions (NOx), Sulphur Oxides (SOx) as well as particulate matter (PM). In order to control emissions of SOx and PM the International Maritime Organization (IMO) introduced regulations limiting sulphur content in marine fuels.

Such limits were defined both for specifically designated emission control areas (ECA) and globally. The ECA limit was gradually reduced from its initial value of 1.5% to 1.0% (2010) and finally to 0.1% (2015). The global limit was set to 3.5 % in a first step (2012). In the context of the 2008 revision of MARPOL Annex VI [1], the new 0.5 % S limit for fuels was introduced, which will be in force from 1st of January 2020 (Figure 1).

Note that the utilisation of approved alternative means of emissions reduction, which are at least as effective as using compliant fuels, is also permitted. An exhaust scrubber designed for reducing the SOx content to the level required is hence considered equivalent, and fuels with higher sulphur content may still be used on vessels equipped accordingly.

The considerable decrease of fuel sulphur content in 2020 will have a substantial effect on the marine industry. The changes in fuel production are expected to result in a different nature and quality of fuels, which will most likely not influence engine performance. However, these changes may be associated with challenges for fuel characteristics (Chapter 2) and on board fuel handling (Chapter 3). Additionally, the cylinder lubrication oil base number (BN) must be selected according to the sulphur content of the fuel in use (Chapter 4).

This guideline will present information on the expected changes in fuel properties and provide guidance for ship operators using these fuels after 1st of January 2020.

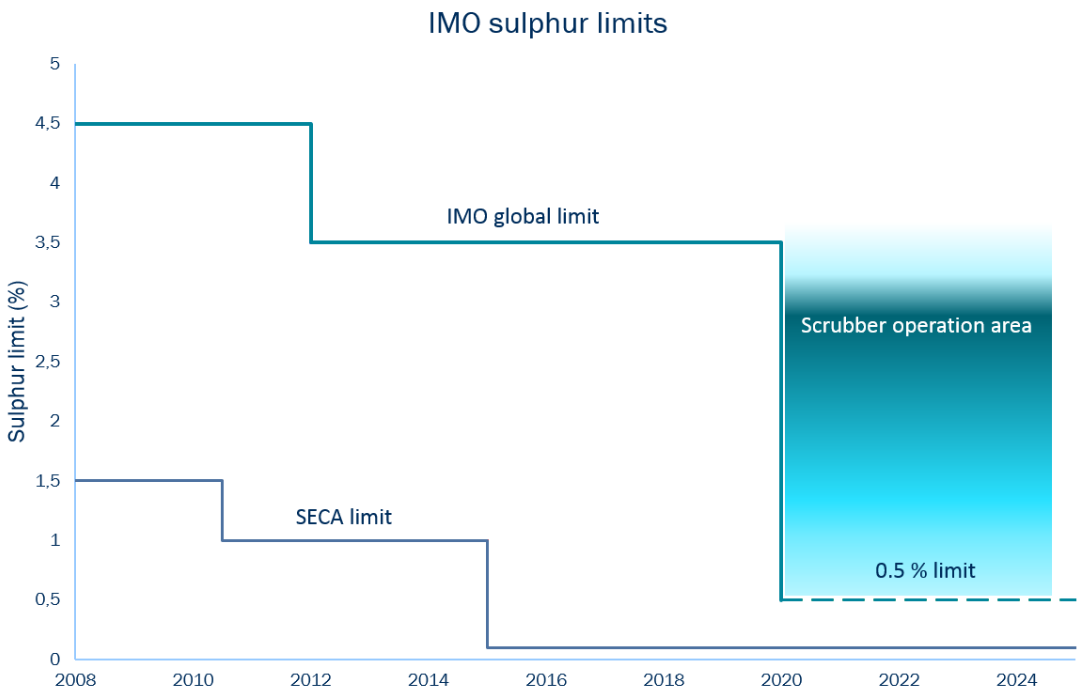


Figure 1. Sulphur limits introduced by IMO according to MARPOL Annex VI [1]

1.1 Names of fuels after 1st January 2020

The consensus of the marine market is a simplified terminology for fuels used in the market after 1st January 2020, in accordance with the most relevant characteristics. All fuels basically fall under the same category: Fuel oil (FO). The key differentiator is whether the fuel needs to be heated or not; the second criterion is its sulphur content. Grade designations according to ISO 8217:2017 [2] will remain applicable; however, using the simplified terminology as listed in Table 1 allows a straightforward determination if a fuel is fit for the purpose at hand.

Definition of fuel abbreviations:

- HFO: Heavy Fuel Oil
- MGO: Marine Gas Oil
- DM: Distillate Marine (fuel that does not need heating)
- RM: Residual Marine (fuel that needs heating)
- MDO: Marine Diesel Oil
- ULSFO: Ultra Low Sulphur Fuel Oil
- VLSFO: Very Low Sulphur Fuel Oil
- HSFO: High Sulphur Fuel Oil

Table 1. Naming of fuels after 1st January 2020

Sulphur content	HFO (RM-grades)	MDO (DMB, DFB)	MGO (DMA, DFA, DMZ, DFZ)
S ≤ 0.10 %	ULSFO RM	ULSFO DM	
0.10 % < S ≤ 0.50 %	VLSFO RM	VLSFO DM	
0.50 % <S	HSFO RM*	HSFO DM*	

* fuels allowed only for ships with exhaust abatement technologies yielding sulphur oxide reductions equivalent to using fuels compliant with the respective sulphur limit

2 Characteristics of 2020 Compliant Fuels

2.1 Introduction to fuel characteristics

The above-mentioned regulations will result in the introduction of new fuels in the market. The fuel sulphur content will be within two ranges:

- VLSFO up to 0.50 % S content; and
- HSFO for scrubber operation with a sulphur content up to 3.50 % (or even higher).

Most fuels used in the market after 1st January 2020 will be VLSFO, as only a small percentage of the fleet is expected to be equipped with scrubbers and therefore able to operate on HSFO. The switch to VLSFO will affect refineries' production as it is unlikely that HFO products in use today will simply be desulphurised to create compliant fuels. Instead, VLSFO will consist of blends of fuels produced from different refineries' streams. These blends are expected to contain higher fractions of paraffinic products, which will affect the properties of VLSFO.

It is important to state that VLSFO must be compliant with ISO 8217:2017 [2] and fit within the same RM grades as used before 2020. However, fuels of the same ISO grade may show a high variability in other characteristics.

It is expected that VLSFO will have similar properties to ULSFO. For more details regarding ULSFO usage and associated operational considerations, please refer to the WinGD information letter "Statement: Ultra Low Sulphur Fuel Oils" [3].

The following parameters might change with new VLSFO fuels:

- Compatibility and/or stability
- Viscosity
- Cold flow properties
- Calculated Carbon Aromaticity Index (CCAI)
- Catalytic fines concentration

2.2 Compatibility and/or stability

Depending on the origin and production process used, VLSFO can be predominantly aromatic or paraffinic in nature. This could lead to compatibility problems between different fuel batches even if they are within the same ISO 8217:2017 [2] fuel grade.

Blending of aromatic with paraffinic fuels on board might result in sludge formation (after prolonged time in a tank, even if initially stable) due to a change in solubility properties of the resultant blend in comparison to original fuel batches.

2.3 Viscosity

The viscosity of fuel oils must be in accordance with ISO 8217:2017 [2]. The VLSFO fuels are expected to have a broad range of viscosities even within the same grade. Some types of VLSFO will have low viscosity levels similar to DM. However, these types of VLSFO are not distillate fuels, and if sold as VLSFO RM, all the procedures for typical HFO treatment must be applied.

2.4 Cold flow properties

In VLSFO containing high fractions of paraffinic components, exposure to prolonged cold conditions may lead to wax formation, which in turn could affect the cold flow properties of the fuel. Therefore, before obtaining a fuel, it is recommended to make sure that the fuel cold flow properties comply with the fuel system design and the planned ship routing. Additionally, for residual fuels with low viscosity it is recommended to keep the fuel at 15 °C above the pour point.

2.5 Calculated Carbon Aromaticity Index (CCAI)

The CCAI provides an indication of the ignition properties or ignition delay of the fuel on the basis of fuel viscosity and density. In view of the broad range of density and viscosity values of VLSFO, resulting CCAI values can also vary considerably. However, as long as the CCAI limits as defined in ISO 8217:2017 [2] are fulfilled, WinGD engines can be operated without any limitations.

2.6 Catalytic fines (cat fines)

The level of cat fines in VLSFO is unknown and might vary depending on the refinery streams from which the fuel was produced. It is highly recommended to follow ISO standards [2] and WinGD recommendations [4] regarding cat fines, which includes running the fuel purification system at high efficiency level.

3 Operational Considerations for 2020 Compliant Fuels

3.1 Purchase and bunkering of fuels

WinGD recommends the use of ISO 8217:2017 [2] for purchasing of fuel. Make sure that all the fuel parameters are within the limits given by this standard. It is also advised to follow a proper fuel management plan which includes all steps prior to bunkering and until the fuel is used.

All relevant properties of the fuel including (but not limited to) viscosity, pour point, cat fines concentration as well as total sediment potential, should be requested at bunkering. If sufficient information is not available, a fuel sample should be sent to an accredited laboratory for analysis.

Optionally: Perform on board “Cleanliness Procedure” according to ASTM D4740 [5] to check potential of sludge formation of the fuel.

Prior to bunkering, special attention must be given to the fuel cold flow properties to ensure that these are suitable for the fuel system design and the planned ship routing.

3.2 Storage

Ship operators should have a suitable plan for the storage of different fuel batches. Deliberate blending of these different fuels in the storage, settling or service tanks, should be avoided; that is, each newly bunkered fuel batch should be stored in a separate storage tank.

In addition, it is recommended to check the fuel installation and prepare fuel management procedures which will ensure minimal mixing of different fuel batches during operation in the fuel system.

In general, the temperature of the fuel in storage should be kept at least 5-10 °C above the pour point to ensure proper flow properties. However, to avoid potential wax formation with low viscosity VLSFO RM fuel grades, this fuel should be maintained at 15 °C above the pour point.

Figure 2 shows the optimum arrangement for maximum fuel flexibility in multi-fuel operation: it is drawn for two or more different types of residue based fuel oils, MDO and MGO. Figure 3 shows the minimum tank arrangement for the same fuel setup. Should fewer fuel types be intended for multi-fuel operation (e.g. no MDO needed), the tank arrangement can be simplified.

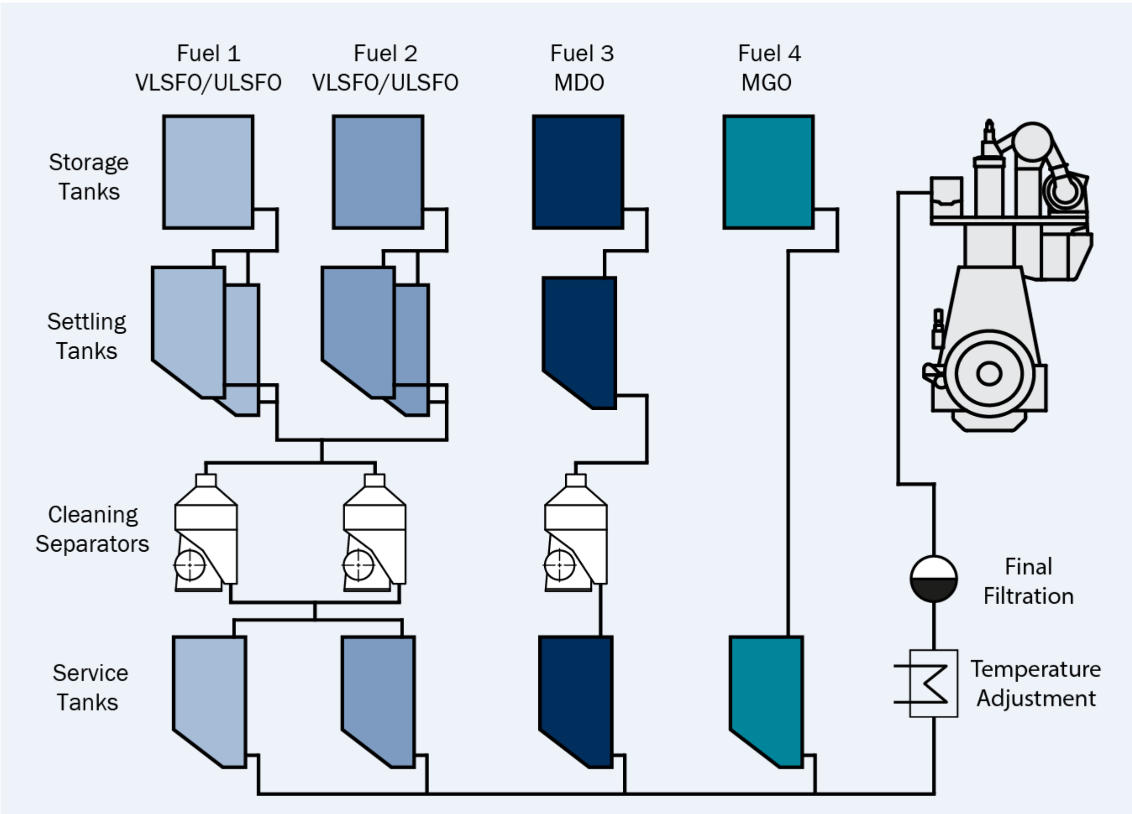


Figure 2: Recommended optimum fuel tank arrangement for multi-fuel operation

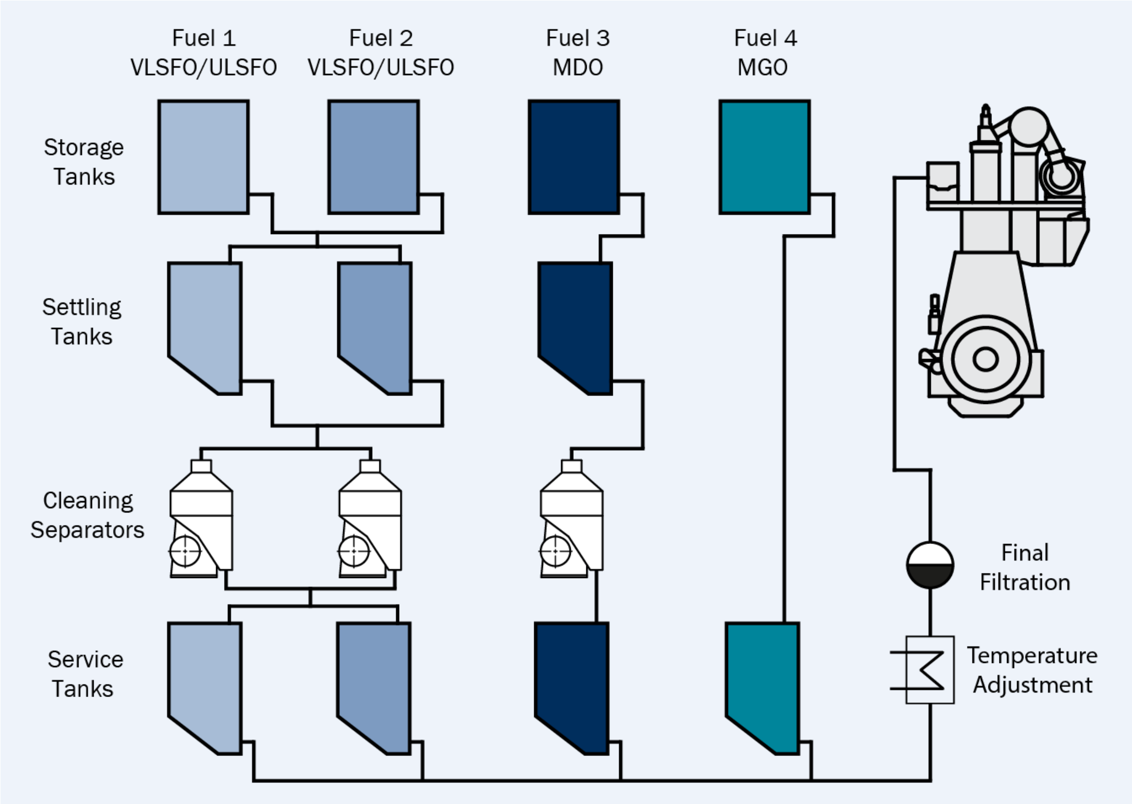


Figure 3: Recommended minimum fuel tank arrangement for multi-fuel operation

3.3 Blending of fuels on board

Due to the potential risk of incompatibility of different batches of VLSFO, WinGD do not recommend blending of such fuels on board. Deliberate blending of these fuels on board should be avoided, and this also applies to two or more fuels having the same ISO grade.

3.4 Compatibility check of fuels

If the situation exists where the ship operator considers blending of fuels on board, the following WinGD procedure may be used for checking the compatibility of those fuels (Figure 4). Note however, that the result of this procedure only provides an indication of the compatibility of the fuels in question. This procedure is an extended version of ASTM D4740 [5]. For this procedure, the only acceptable cleanliness level is Rating 1 (Figure 5).

The compatibility check procedure may be summarised as follows (Figure 4):

- Determine or clarify the intended blend ratio of the two fuels in question
- A two-stage procedure should be followed:
    - Stage 1 involves individual spot tests at either two or three (depending on the intended blend ratio) different blend ratios. All tests must be passed to progress to Stage 2.
    - Stage 2 involves two additional spot tests which further determine potential compatibility and provide a suggested blend direction of the fuels.

A graphical representation of possible outcomes from using the above procedure is shown in Figure 6.

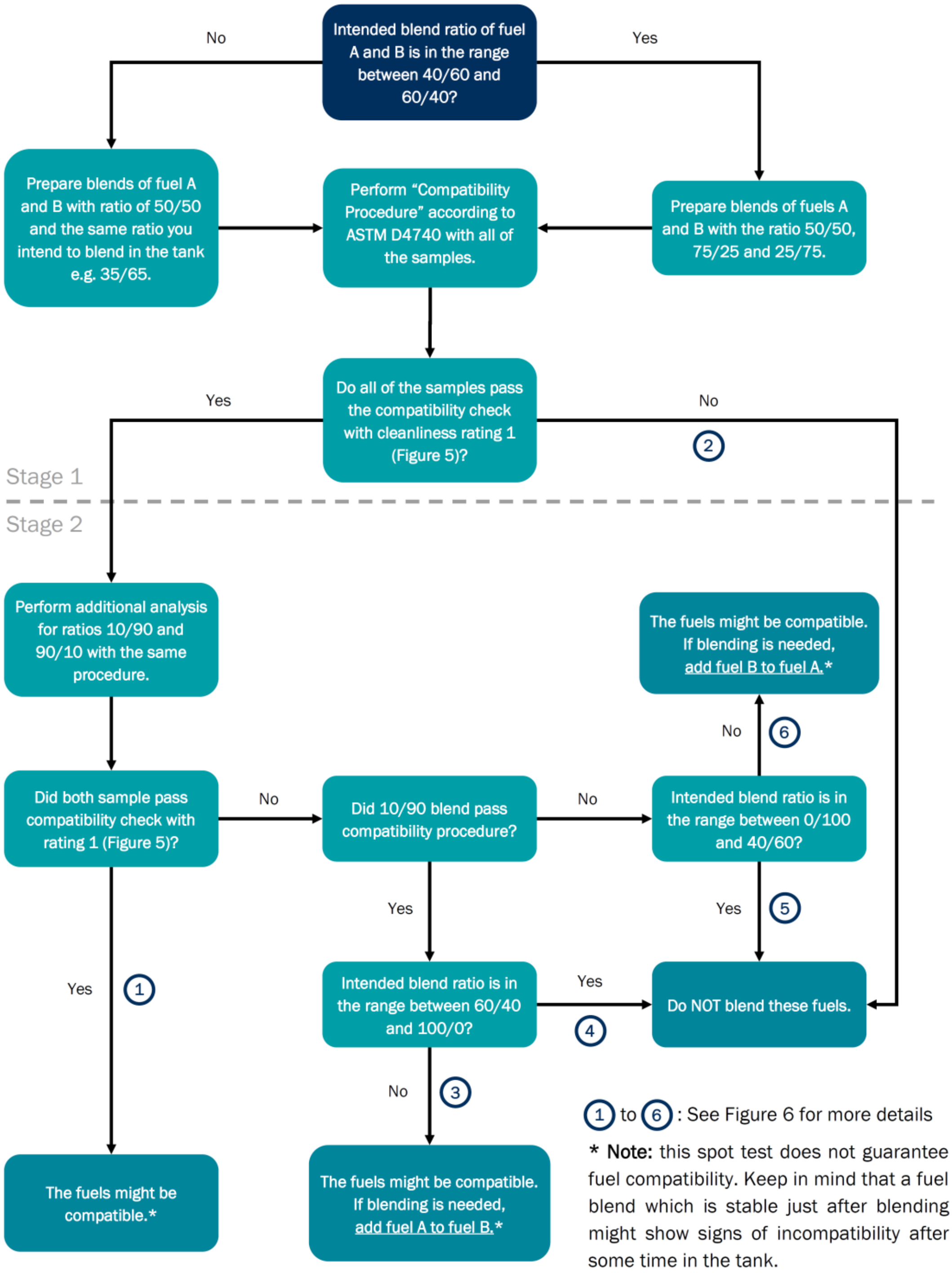


Figure 4: Recommended procedure for checking compatibility of fuels before blending

Figure 5: Cleanliness rating according to ASTM D4740 [5]. For passing the test in this document, only Rating 1 is considered acceptable

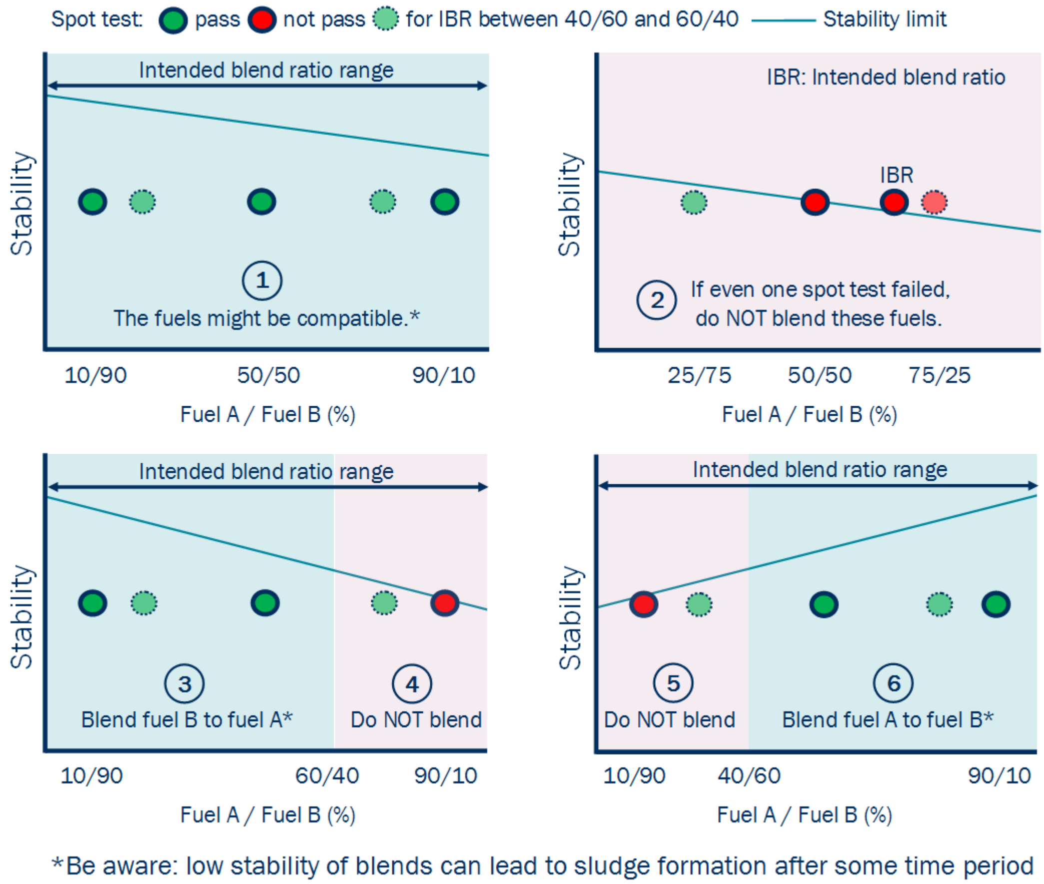


Figure 6: Graphical representation of possible results obtained from procedure in Figure 4

If the blended fuel passes the compatibility check procedure and blending is carried out, the fuel should be consumed as soon as possible, prior to other fuels on board. A fuel blend might be stable initially, but form sludge after prolonged time in a tank.

Notes:

- The Stage 2 tests are performed to establish any potential limitations in terms of the direction of blending i.e. Fuel A added to Fuel B or vice versa. This is important as different fuels can have a higher or lower capacity to keep asphaltenes dispersed in solution. Therefore, the stability of the resulting blend will increase or decrease gradually as the fuels are added to one another (Figure 6). In some cases, this may result in sludge formation as early as the beginning of the blending process.
- Certain highly paraffinic/waxy fuels might yield a false negative result during the compatibility check procedure. However, to avoid mistakes in the interpretation of the results, WinGD recommends disregarding this possibility.

3.5 Fuel oil treatment

When using VLSFO, the following standard procedures, as outlined in relevant documents, must still be applied:

- Check every bunker delivery note for fuel density, water and cat fines concentration.
- Adjust separator gravity discs to fuel density if no self-adjusting separator is installed.
- Run your purification system at the efficiency required to reduce any cat fines to below the specified maximum engine inlet levels.
- If any sign of sludge formation in the separators appears, switch to distillate grade fuels and follow separator manufacturer instructions.

3.6 Fuel change-over

A fuel management procedure (suited to the specific fuel system in use) should be prepared in order to minimise the mixing of fuels from different batches during fuel changeover:

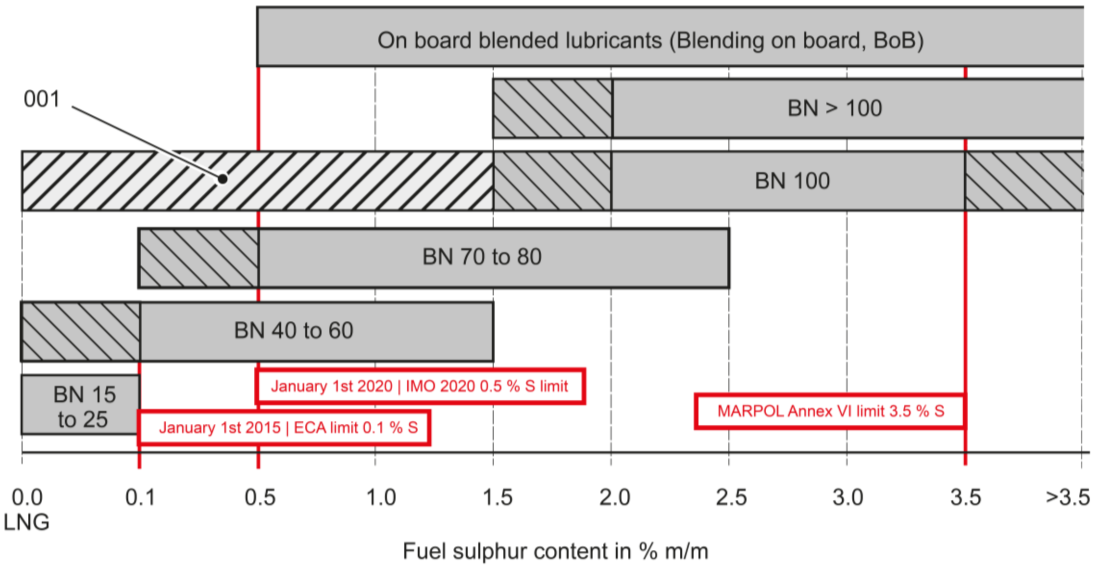
- Before filling the settling tank with a new batch of fuel, ensure that the tank is empty.
- If a settling tank contains unused fuel when filling it with a new batch of fuel, frequently drain this tank to check for possible sludge accumulation.
- The service tank should be empty before filling it with a new batch of fuel.
- If it is not possible to empty the service tank completely, ensure that the quantity of previous fuel remaining is kept to an absolute minimum.

For any actions to be taken on the engine side during fuel changeover, please refer to Chapter 3 of the “Diesel engine fuels” guideline [4]. Careful attention should be given to the following:

- Make sure that the viscosimeter is working properly.
- Adjust the temperature accordingly to reach the specified engine inlet viscosity. The fuel viscosity temperature relationship can be found in Chapter 2.3.1 of the “Diesel engine fuels” guideline [4].
- This temperature adjustment should be carried out at a maximum rate of 2 °C/min.

4 Recommendations for Cylinder Lubrication

To assist in choosing a suitable cylinder lubricant, the base number of the lubricant must follow the sulphur content in the fuel to ensure sufficient protection of combustion chamber components against corrosion. As mentioned previously, the sulphur content of fuels can be either very low (below 0.5 %) to comply with new regulations, or high for ships equipped with scrubbers. Therefore, based on extensive experience and a robust oil validation program, WinGD recommends oil selection as follows (Figure 7):



- Hatched area: For hatched areas WinGD recommends as follows: 1) Do a regular piston underside drain oil sampling and an analysis and interpretation of the results according to WinGD Lubricant guideline [6]. 2) Do regular checks of the piston and piston ring conditions through scavenge port inspections.
- 001 area: some of the BN100 products are validated for limited use with ECA fuels (< 0.10 % S). Refer to list of validated oils in WinGD Lubricant guideline [6].

Figure 7 WinGD recommendation for lubricant selection; Base Number vs. Fuel sulphur content [6]

5 Engine Design

WinGD has years of field experience in the use of different fuel types including LNG and a broad range of liquid fuels with sulphur contents ranging from near zero to > 3.50 %. This experience includes the use of a large variety of cylinder lubricating oil formulations with these fuels.

This concept consists of the following main elements:
- Cylinder liners with optimised temperature profiles to prevent cold corrosion
- Fully plateau honed cylinder liner running surface enables shortest running in times and reduced friction
- Chromium ceramic coated piston ring pack with 3 piston rings and, on latest engines, 2 piston rings. Top ring in gas-tight execution and lower ring(s) with straight-cut ring gap. These ring packs offer an excellent seal between combustion chamber and piston underside. This allows for rapid running in (72 hours) and long overhaul intervals in the 40'000 running hours range.
- The Pulse Jet lubricating system. This system, in combination with patented lubricating oil grooves on the cylinder liner, results in an excellent oil distribution to prevent uneven component wear.
- Very low wear rates of cylinder liners and piston rings.
- Our cylinder lubricant guidelines including the large list of validated cylinder oils support user to select the correct oil and to optimise the feed rates.

It has been clearly demonstrated that WinGD's tribology concept and engine design is well suited to the operating conditions expected into 2020 and beyond.

6 Outlook

WinGD will closely monitor all possible developments as a result of the 2020 IMO 0.5 % fuel sulphur limit. Due consideration will be given to any new information based on WinGD experience, or that provided by regulators, fuel suppliers or studies carried out by responsible bodies.

In the third quarter of 2019, ISO plans to release a publicly available specification (ISO/PAS 23263) on the topic of post 2020 marine fuels entitled: "*Considerations for fuel suppliers and users regarding marine fuel quality considering the implementation of max. 0.50%S in 2020*". Additionally, CIMAC WG-7 "*Fuels*" intends to publish its own guidelines around the same date.

7 References and bibliography

[1] International Maritime Organization, «Revised MARPOL Annex VI,» London, 2016.

[2] ISO (International Organization for Standardization), «ISO 8217:2017 (E) Petroleum products - Fuels (class F) - Specifications of marine fuels,» Geneva, 2017.

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[4] Winterthur Gas & Diesel Ltd, "Diesel engine fuels," December 2018. [Online]. Available: https://www.wingd.com/en/documents/general/papers/wingd-diesel-engine-fuels-issue-2-december-2018.pdf/.

[5] American Society for Testing and Materials, "Standard Test Method for Cleanliness and Compatibility of Residual Fuels by Spot Test," 2014. [Online]. Available: https://www.astm.org/Standards/D4740.htm.

[6] Winterthur Gas & Diesel Ltd, "Lubricants," March 2019. [Online]. Available: https://www.wingd.com/en/documents/fuel-lubricants-water/lubricants.pdf/.

Track Changes

Date	Subject	Description
2019-05-20	Document	First release