Sulphur 2020: What's your plan?

Guidance for shipowners and operators on MARPOL Annex VI Sulphur Regulation.

Lloyd's Register

Contents

Foreword

The MARPOL Annex VI Reg. 14 regulation seeks to control SOx emissions from ships, leaving the option for ships to make the choice as to how they will meet the limits being set. Shipowners today essentially have the option to either use a compliant fuel oil to meet the regulation, or to use high sulphur fuel oil (HSFO) in conjunction with exhaust gas cleaning systems (EGCS) to achieve an equivalent SOx reduction, provided the arrangement has been approved by the ship's flag state. It is anticipated that over 85% of the world's fleet will enter 2020 using compliant fuel as their chosen option. The IMO fuel availability study predicted that around 3,800 ships with EGCS will be in use by the implementation date; however, the figure is looking more likely to be about 1000-1500 ships; this equates to a demand of about 10–15 Mt, leaving a projected demand of over 260 Mt for 0.50% fuel oils.

It is being widely emphasised that the reduction in the fuel oil sulphur content will inevitably cause a change in the fuel oil formulation and its characteristics, when compared to that being used today. This will require greater awareness from the ship's crew, with regards to the variety of fuel oil formulations that may be delivered from one bunker loading to the next. They might expect to have to manage with a specific being required on the compatibility between the different fuels.

There is also the option to fuel ships with a non-conventional fuel oil with zero sulphur content; for example, liquefied natural gas (LNG) or methanol. The perception, however, is that these alternatives will make no significant impact on reducing the demand for conventional compliant 0.50% fuel oil by 1 January 2020 or in the early years thereafter.

We recognise that the change in the sulphur content will have a significant impact on the management of ship's bunkering operations, both around the lead up to the implementation date and thereafter. However, it is considered that, with due preparation, not only can these changes be effectively managed but they will also open up a number of divergent pathways for the fuelling of the world fleet.

Whilst shipowners focus might be on the fuels as delivered, this step change on sulphur content is so significant that every stakeholder from the crude supply through to the refiners and supply distribution network are being impacted. The trigger for the change will start to come when shipowners set their dates for ordering the first loads of 0.50% compliant fuels. The China 0.50% limit zones have already shown 0.50% being supplied in that region. Taiwan's 01 January 2019 coastal and port 0.50% limits may also see an increase in this demand.

The transition period has already started and decisions need to be made. The compliance options are clear. Ship operators need to evaluate their compliance strategies based on each ship's specific operation and risk criteria. This evaluation needs to be unbiased and separate from any vested interests. At Lloyd's Register (LR), we are ready to offer independent support in the journey from making a decision to implementing it.

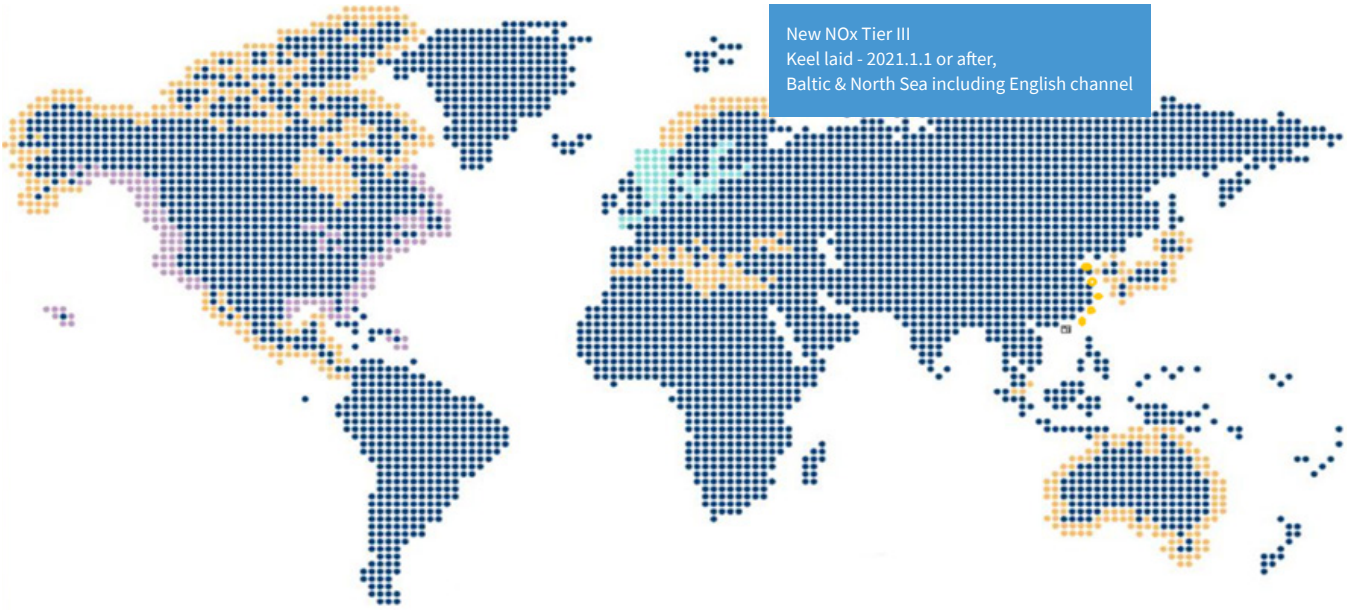
Part 1: Regulation

Your preparatory plan for the 1 January 2020 0.50% implementation

The outside SOx emission control area (ECA) step change from sulphur 3.50% to 0.50% from 1 January 2020 is resulting in a major shift change for the marine fuel product portfolio, impacting all the stakeholders in the industry as well as ships worldwide.

The end result will be a marked reduction in marine SOx emissions on the coastlines. It should be noted that there is no sulphur cap as such, only a limit outside the ECA.

It is permissible that fuel oils with sulphur content in excess of 0.50% as given in regulation 14 may be used, providing that the SOx has been removed to an equivalent limit, such as through an EGCS.



Max fuel oil sulphur content for ECAs-SOx:
Up to Dec 31, 2014: 1.00%
From Jan 1, 2015, 2015: 0.10%

NOx Tier III requirement for ECAs-NOx:
Newbuilding keel laid
from Jan 1, 2016

Exisiting ECAs:
- Baltic & North Sea ECAs-SOx
- North American & US Caribbean ECAs-SOx and ECAs-NOx

- Possible future ECAs

Chineses SOx ECAs
0.50% ALL THREE AREAS ON
01 01 2019 alongside at this time

Yangtze River Delta
Pearl River Delta
Boha Rim

Taiwan
Entering commercial ports from
01 01 2019 0.50% Sulphur control

Figure 1: Map of emission control areas

1. Background regulation

At the 70th session of the marine environment protection committee (MEPC), in October 2016, it was confirmed that 1 January 2020 would be retained as the start date for the 0.50% max sulphur fuel oil requirement under Regulation 14.1.3 of MARPOL Annex VI. This covers all fuel oils used by ships outside the existing ECA for SOx emissions (Baltic, North Sea, North America & US Caribbean) where the limit remains at the level at which it has been since 1 January 2015: 0.10% max sulphur.

While Regulation 4 of MARPOL Annex VI provides for the use of approved alternative means, such as exhaust gas cleaning systems (EGCS), in order to meet this requirement it is fully anticipated that the majority of ships, at the implementation date, intend to comply on the basis of using fuel oils as supplied that meet the 0.50% max sulphur limit.

MARPOL Annex VI was initially adopted in 1997 and, as it entered into force in 2005, a 4.50% sulphur limit on all fuel oils used outside those areas designated as ECAs was applied. As shown by the IMO sulphur monitoring data, even before the Annex entered into force, the 4.50% limit effectively represented the usual maximum at that time; the key point was that a system was put in place. When, in 2012, that limit was reduced to the current 3.50% sulphur, it only affected (as shown by the IMO data) some 10–15% of the delivered tonnage; in terms of the technical impact on users, it was undetectable. In contrast, this further reduction in the outside ECA limit to 0.50% will affect virtually all residual fuel deliveries. This will, therefore, for those ships operating solely outside ECAs, effectively be the first tangible and substantial impact of the Annex VI SOx reduction programme.

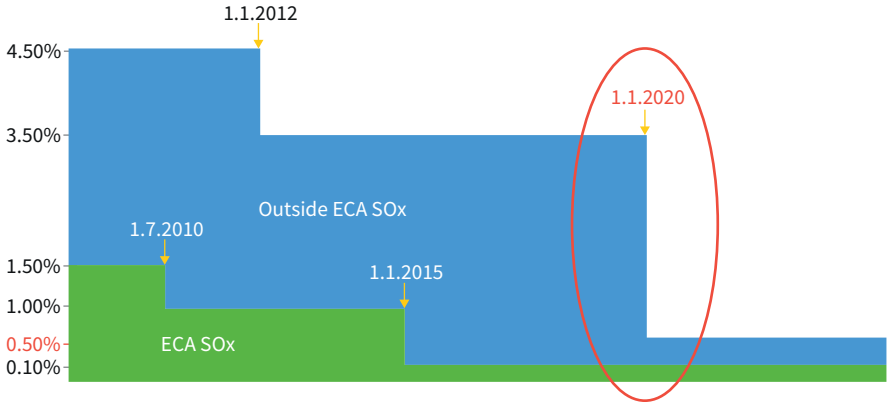


Figure 2: Sulphur content requirements

2. Implementation deadline 1 January 2020

Given that MEPC has now confirmed its decision and the MARPOL amendment timescales, it must be understood that 1 January 2020 is now unalterably fixed. While MEPC and the pollution, prevention, response (PPR) sub-committee are considering means to assist in the consistent implementation of this 0.50% max sulphur limit, this cannot in any way change or soften that date.

3. IMO Guidelines

At PPR5 (Feb 2018), the terms of reference (ToR) for the intersessional meeting on consistent implementation of Regulation 14.1.3 of MARPOL Annex VI were formulated. The deliverable will be a guideline document along with amendments to relevant sections of Annex VI addressing the concerns being raised that need greater clarity to ensure uniform and consistent implementation. These include, to name a few elements: enforcement, sulphur content verification, addressing non-availability of compliant fuel oil, and recommendations to address any concerns around the possible impact on machinery and operations. These will be addressed at the intersessional workgroup (ISWG) from 9–13 July 2018, for final submission and adoption by MEPC 74 in April 2019.

The IMO has also requested the international standards organisation (ISO) to address the quality concerns being expressed and to ensure that the ISO 8217 fuel standard suitably covers the new fuel blends. In response ISO is developing a publically available specification (PAS) to support the current addition of the ISO 8217:2017

A ban on the carriage of non-compliant fuel as a fuel oil (not as a cargo) is expected to enter into force on 1 March 2020, this is intended to facilitate enforcement.

Part 2: Overview of compliance options

1. Compliance options

The primary option is to use the compliant fuel oil route to meet the Regulation 14 requirements by controlling the sulphur content in the fuel against the given limits for inside and outside an ECA-SOx. The 2020 implementation date is expected to precipitate a wider range of fuel formulations being made to meet the 0.50% sulphur content target. These will consist of ultra low sulphur fuel oil (ULSFO) of <0.10% and very low sulphur fuel oil (VLSFO) of <0.50%, consisting of blends of residual marine (RM) fuels, distillates marine (DM) fuels and with the inclusion of low sulphur cutter stocks and various other refinery streams. The default option will be marine in gas oil characterised under ISO 8217:2017 as a DMA grade (distillate marine grade A). Other alternative fuels also now making their way into the market marine fuel oil pool include: LNG, liquefied petroleum gas (LPG), biofuels (covering a range of feedstocks) and methanol.

The secondary option is governed by the MARPOL Annex VI Regulation 4 equivalent means. At this time, the only approved equivalent means being increasingly adopted is to retain the continuity of using HSFO but in conjunction with an EGCS to achieve an equivalent reduction in SOx emissions. Other options have been considered, including the blending of high to low sulphur fuels on board; again, this process would need to be approved through the ship's flag Administration.

To sum up, there are three routes to compliance, which are:

a. Primary

i. To use conventional compliant fuel – namely, sulphur controlled distillates or residual fuel oil.
ii. To use alternative fuel oil types meeting the sulphur content controlled limits, such as LNG, methanol or hydrogen, or various biofuels and synthetically manufactured fossil or non-fossil fuel oils.

b. Secondary

To use the option given in Regulation 4 for equivalent means to remove sulphur oxides from the exhaust emission after combustion – the use of an EGCS.

A high proportion of shipping is known to be choosing the compliant fuel oil route; this document focuses on the steps for ships to consider towards achieving a smooth implementation of this new regulatory requirement, from shore procurement to onboard storage, handling and use.

Part 3: 0.50% conventional fuel pathway

1. Implications for shipowners

a. Global operations outside an ECA-SOx

Ships normally operating outside an ECA will be presented with a major change in the composition and formulations of the diesel fuel oil being supplied and its potential operational impact on the machinery plant if not understood and managed.

The previous reduction in the outside ECA fuel oil sulphur limit from 4.50% to 3.50% from 1 January 2012 affected only some 10–15% of deliveries and the underlying nature of those fuel oils was unchanged. In contrast, based on the IMO's 2016 data, over 80% (by tonnage) of residual fuel oils supplied that year was in the range of 2.00–3.50% sulphur with an overall average of 2.58%. Furthermore, it is fully expected that virtually all 0.50% max sulphur fuel oils will be produced and delivered very close to or at that limit value – i.e. in the range of 0.48% to 0.50%.

Consequently, all affected shipowners would be strongly advised to have in place a ship-specific transition plan to ensure ship readiness for 0.50% 2020 implementation. Note that a generic transition process timeline has been drafted to cover key considerations for timely preparedness for compliance (see figure 3).

b. Operating both inside and outside an ECA-SOx

For ships operating both inside and outside an ECA-SOx, it could be seen that the introduction of the 0.50% limit will not have quite the same impact as those currently only operating outside an ECA. The former will already be familiar with the need to maintain the two grades (ECA-SOx and non ECA-SOx) separately and to duly manage the changeover between the two on entering/exiting those areas. The technical challenges of change over and machinery set up already having been established.

In fact, the much reduced differential in the sulphur content between the two fuels will tend to ease the changeover problems and reduce the extent by which the ECA-SOx fuel is degraded by admixture with any remaining non ECA-SOx fuel and associated pipe-wall residues.

Additionally, since much of the maximum 0.50% sulphur stock will not be the full IFO 380 type residual fuels but instead somewhat lower viscosity products, the time taken for engine changeover will be reduced – albeit with the potential for the increased risk of an unstable interface between the two. But providing this is kept within the fuel conditioning unit booster circuit after the service tank then this should be effectively managed by the crew who have been made aware of this possibility.

2. Implications for refineries

The petroleum industry, while in general expressing availability of the 0.50% product from 2020, has advised that there will be a major shift in refinery configurations and operations to accommodate and deliver to the ships this new marine fuel demand for 0.50% sulphur content fuel oils. As it has done repeatedly in the past, the refining industry is expected to adapt to the new demand spectrum, however it has been stated that this will result in an unprecedented change in the range of characteristics of the fuels which will be supplied. This will require some difficult commercial decisions in the different approaches that can be taken, any one of which will require significant investment, time and resources to put into place. Every refinery has a different level of complexity, which will dictate the degree of options open to them; these include but are not limited to:

- Upgrading fuel oil residues to a distillate grade, the demand for which will be dictated by the uptake of the EGCS by the marine industry from 2020 and finding other shore based options – Where these refineries have been already upgraded then this option will be certainly applied. There will be insufficient capacity of these high complexity refineries available for this and any upgrade requires some 5-8 years to build not lest significant investment.
- Desulphurisation, which is not a favoured option due to the high cost and energy requirements.
- Further blending with low sulphur fuels, but this also requires significant investment. For many providers this will likely become the norm.
- Using sweeter crude options and blending.

At the start of 2020, it is anticipated that there will be a glut of high sulphur residual fuel oils with no market to go to, and, at this point, the refining industry will be able to gauge the true impact of EGCS and take a measured approach as to the best investment paths to take. Taking into account that a coking plant can take some seven years and about USD 0.5 billion in investment to put in place. This change will require refiners to each work out for themselves how this new world will appear, since these are generally high-cost, long-term investment decisions.

It should be expected that, as encountered when the North American ECA-SOx came into effect, at least initially, much of the 0.50% max sulphur product will be the result of exceptionally heavy blending – the

high ratios thereby resulting in some higher uncharacteristic fuel oils, but still falling within the ISO 8217 specifications, with some having limited remaining stability reserve and, in some instances, dumbbell combustion characteristics, where the carbon distribution results potentially in an uneven heat release during the combustion process. This phenomena is affected by the actual nature of blend feedstocks used.

3. What type of fuel can we expect for a 0.50% max sulphur limit?

With the current max sulphur limit of 3.50%, all ship systems that could use residual grade products up to the viscosity norm of 380 cSt (V50) and, in some cases, up to 700 cSt, will have been generally doing so. However, it is fully expected that fuel oils as supplied, meeting the 0.50% limit, will range anywhere from light distillate (MGO) through to heavy residual with a range of widely differing fuel oil compositions in between referred to as VLSFO.

Commingling and segregation

The process of hydrocracking produces more highly paraffinic fuels, which sends two signals: the first being that the management of cold flow properties of both distillates and residual fuels will have to be more carefully considered; and the second being that it could present additional operational issues in regards to the likely incompatibility of the two or more fuels intended to be commingled in the ship's bunker tanks. This will require more consideration by the shipowner in the way it applies 'fill to capacity' policies with the charterer and applying a strict bunker segregation policy where so required.

Consequently, while different stems of residual fuels could be mixed (commingled) – i.e. when loading to maximum on top of previous bunkers – best practice would warrant the ship avoiding any attempt to mix. The risk of incompatibility between two different fuels is likely to be more pronounced than that faced today. In view of this, particular attention will need to be given to setting up a commingling plan, which primarily should aim to keep bunkers of different sources segregated or make efforts to ensure the compatibility between the fuels to be mixed prior to possible commingling is first confirmed and a safe ratio blend mix is determined. Should the fuels not be compatible, then mixing should not be carried out, any attempt to do so could result in two perfectly stable fuels becoming unstable and totally unusable.

Given the distribution of refining capacity and the other product demands in an area, it may well be that some areas/ports are more likely to only provide a particular type of 0.50% max sulphur fuel oil – be that a distillate or some form of intermediate blended product, or a higher viscosity residual fuel oil.

In view of this applying best management and fuel care practices, combined with flexible fuel system design, will ensure risks are mitigated.

Fuel terminologies have been updated for the 2020 changing fuel scene as shown in table 1.

Table 1: Fuel categories

1 January 2020 fuel categories	Sulphur Content	Residual Marine (RM)	Distillate Marine (DM) (MGO)	Blends of RM + DM and other streams
HSFO Demand will drop right off proportional to EGCS usage RMG grades	>0.50% no maximum	Yes	No	Unlikely except for lower viscosity requirements
VLSFO Price differential to MGO will encourage the use of blended fuels	<0.50%	Yes	Yes	Expected
ULSFO	<0.10%	No	Yes	Yes in 2015 over 20 different specification where brought to market). We expect a wide range in 2020 – but all will still need to meet ISO 8217 as did the 2015 specifications

4. Shipowners' key considerations for fuel supplied to the ship

a. Fuel availability

Although the IMO fuel availability study identified that overall there was the required refining capacity to meet the marine requirement, it is to be expected that, at least initially, there may be quantity shortfalls in some areas, whilst the available stocks are evenly distributed. While the preference may be for a ship to procure a residual fuel of higher viscosity for a maximum 0.50% fuel oil, it may just be that only a light distillate will be available. This poses the question of additional cost and also the technical and operational readiness of the engines and boilers to operate on a distillate fuel oil for a prolonged operational period in a safe manner.

Suppliers position

As well as the IMO fuel availability study, a number of major fuel oil suppliers have publicly stated that compliant fuels will be available before the 2020 deadline, although a consistent distribution of these 0.50% VLSFOs may take a little time. We have been advised that some 30 Mt of 0.50% stock will need to be in the storage tanks globally to service the fleet at the start of 2020. There is, therefore, always a possibility that smaller ports may not have these fuels available due to limited storage facilities over time, prompting ships to have to bunker 0.10% ULSFO grade with the additional cost implication on the charter party.

Product quality

Whilst the major fuel oil suppliers have further assured the industry of the availability of 0.50% fuel oil, the products offered to the market will however vary considerably in their formulations and characteristics (while all fuels supplied are expected to meet ISO 8217 international marine fuel specification for ships). This assures the industry that the requirement for the SOLAS flash point minimum limit of 60 °C and inherent fuel stability for storage, handling and use should be met.

The refineries, storage depots and physical suppliers will have to contend with over 200 million tonnes of HSFO becoming surplus to demand from 1 January 2020 onwards, being replaced by the demand for maximum 0.50% VLSFO. While the oil industry has confirmed that the refineries have the capability to supply globally, there may be initial shortages in meeting the high demand. This should be quickly addressed by the relocation of the products to meet a particular local demand. Where non-availability does become an issue, however, under the provisions of Regulation 18, a fuel oil non-availability report may be submitted for approval to the local competent authority for their clearance to load non-compliant fuel oil. The need for more details surrounding the different scenarios will be addressed at the IMO PPR ISWG for the consistent implementation of the Reg. 14.1.3. in July 2019.

EGCS status

The anticipated demand for HSFO is based on the number of EGCS that will ultimately be in service. This is, however, anticipated to be not much more than 1,000 ships at the start of 2020, equating to 7-10 Mt of HSFO.

While the availability of VLSFO and ULSFO is at the forefront of shipowners' minds, those intending to operate on a Regulation 4-approved EGCS plus HSFO option should also consider that HSFO may not be that available in many ports, in particular the less frequented bunker ports. This needs to be seen in the context of marine fuel oil suppliers also needing to change over their own storage, handling and supply facilities. Note that, apart from fuel oil suppliers with known EGCS-using clients, there will effectively be no market for marine fuel oils exceeding 0.50% max sulphur after 1 January 2020 – and even before that date there will be an ever-decreasing demand.

HSFO fuel buyers

Hence, from the fuel buyer's perspective, it is imperative for ship operators who intend to use HSFO with EGCS to swiftly initiate a dialogue with fuel suppliers and charterers on their ship's requirements and the availability of the HSFO fuel post 2020. It is envisaged that suppliers from relatively small ports in particular will have no incentive to store HSFO over longer periods of time as they will have limited opportunities to supply ships installed with scrubber technology, unless they have been advised on intended ongoing orders.

b. When will the 0.50% fuels become available?

This question is unlikely to begin to be answered until mid-2019 and will very much depend on when demand starts and the rate that it will build. It will need to be taken into account that the supply chain has to prepare by cleaning out HSFO from the storage tanks and barges, as well as their transfer pipelines, which will be a logistical challenge for the supply chain as a whole. The onus, therefore, is on the shipping industry to discuss with their supply network what notice is required when ordering the 0.50% fuel, and then the supply chain will be ready to supply for meeting the clients specific loading timeline, with the knowledge that by December there will likely only be a few ships still ordering HSFO. In order to meet the 1 January 2020 deadlines shipowners will need to calculate the time needed to ensure they have used up all their HSFO and prepared the tanks for 0.50% VLSFO (these may well need early inspection for the degree of cleaning required to avoid contamination). In particular ships setting off on a long trans ocean voyage will need to ensure that the only remaining on board fuel will be

compliant from 01 January 2020, thus ships may be loading at least one tank of 0.50% a number of months before the required usage date.

c. Fuel quality control

i. ISO 8217:2017 marine fuel oil specification quality control

Concerns have been expressed to the IMO MEPC regarding the anticipated changes in the fuel characteristics, which will be the outcome of the refiners and suppliers reformulating the marine fuels to meet this lower sulphur limit. In response, the IMO has asked the ISO marine fuels committee to address these quality concerns which impact technical and safety aspects of operations and submit a report/guidance to MEPC 74 by April 2019, as well as guidance for the marine industry on the application of the current specification and any amendments to the ISO 8217 marine fuel specification to follow.

As it stands today, ISO 8217:2017 provides coverage for all marine distillate, residual and new blends of fuel oils, as set at the end of 2014 for the implementation of the 0.10% ECA step change of 2015. It is anticipated that some of the formulations that will be offered to the market will have characteristics that are unfamiliar to some ship operators, as was the experience of the ULSFO blends brought to the market in 2015 but yet still fall under the control of ISO 8217. During the latter part of 2019, we can expect further guidance from the ISO and the international council on combustion engines (CIMAC) fuels working group on how best to order and manage these less familiar formulations.

Publicly available standard

After the release of the ISO 8217:2017 edition in March 2017, ISO TC28/SC4/WG6 started working on the next edition to encompass 0.50% VLSFO, which is being anticipated may raise additional stability, compatibility and cold flow considerations in terms of handling and using these fuels. There is insufficient time between now and 2020 to develop a full revision of the specification – hence one of the options that is now going ahead is to release a PAS in support of ISO 8217 to see through the early part of the 2020 implementation, providing any specific guidance that might be considered important to communicate on additional known aspects that require particular attention. This will also allow ISO TC28/SC4/WG6 time to better understand the new fuel formulations coming onto the market in 2020 and thereafter apply any further revisions to the specification between about 2023 and 2025. It is expected that, for the next 18 months, the group's focus will be to address three underlying given concerns, but being alert to others that may arise leading up to 2020, these being: the stability of the fuel blends; a means to better determine the compatibility between one fuel and another and the wax content in lighter RM fuel blends. All other parameters, including flash point, are also being addressed.

i. Fuel safety

Covered under ISO 8217, marine fuels are required to be supplied against the SOLAS requirements; in particular, the flash point must not drop below 60 °C. Buyers are recommended to ensure that fuels are purchased against the latest edition of the ISO 8217:2017 specification taking into consideration the requirements of the specification in its entirety – not just against the Table 1 and Table 2 requirements. It is recommended that reputable quality fuel suppliers should be chosen to mitigate the risk that off specification fuel is supplied.

5. Key onboard fuel management considerations

The application of best practice in onboard management and fuel care will ensure that uncertainty in terms of fuel characteristics and any perceived safety concerns as loaded can be overcome to mitigate any operational risk. This can be best achieved by first carrying out an independent analysis of representative bunker samples to obtain full transparency of the fuel composition as loaded and then adjust the machinery plant settings accordingly to be optimised for storage, treatment and combustion.

a. Compliance

As the world heads for global ECA coverage, every bunker will come under scrutiny and ships will run the risk of being found non-compliant if due diligence in the ordering, handling and use of these compliant fuels are not properly carried out. This should include ensuring that the crew have witnessed the drawing of the MARPOL sample and signing of the accompanying documentation along with the accompanying bunker delivery notes, any respective 'letter of notices' and sample tracking records; and maintaining records of the entry into and exit from an ECA-SOx changeover.

Ships should therefore reassess their procedures for maintaining compliance to Annex VI Regulation 14: 18. The IMO is currently drafting a further guideline (to be available in the second quarter of 2019), which is on aspects affecting the consistent implementation of Regulation 14.1.3.

This will include current uncertainties, such as those surrounding:

- Fuel oil non-availability
- Enforcement and guidance for port state control
- Onboard verification of the sulphur content
- Ban on the carriage of non-compliant fuel oil
- Amendments to Annex VI, which will be carried out where applicable

It is outside the scope of this document to cover the full spectrum of quality concerns around marine fuels; the aim of this document is to focus on the specific characteristics that are likely to require additional

attention over and above that being given today for the anticipated incoming 0.50% S fuels.

Much has been stated about concerns over the compatibility of two different fuels and the importance of verifying before attempting to mix them. The following provides some more insight into this issue, in view of its consequential impact on operations should attention not be given to this issue of mixing fuels on board.

b. Fuel stability defined

The stability of a residual fuel is defined by its resistance to breakdown and precipitate asphaltenic sludge despite being subjected to forces, such as thermal and ageing stresses. An unstable fuel would have the tendency to precipitate asphaltenic sludge to the bottom of a tank clogging pipelines and filters and overloading separator plants – the degree of which will be a function of time and/or temperature.

The increased use of blended products to achieve 0.50% fuel heightens the risk of instability during storage handling and use. It is the responsibility of the supplier to ensure that there is sufficient stability reserve to sustain the storage and handing requirements of the ship under normal operation and handling conditions. Oil majors are only too aware of the consequences of supplying an unstable product, as it will immediately fail the ISO 8217 control on such a parameter and render the operational status of the ship as unsafe. Ships are best advised to confirm that the fuel delivered is stable for their operational purposes on delivery in accordance with ISO 8217 ordering specification.

c. Compatibility defined

Compatibility is the ability of two stable fuels when commingled to form a homogenous and stable compound. While every fuel should be manufactured with sufficient stability reserve to withstand the expected forces through normal onboard use, it does not necessarily follow that two stable fuels are compatible when blended or mixed together.

Incompatibility is the inability of two or more blended components to exist together without breaking down and precipitating sludge. Two perfectly stable fuels deemed incompatible when mixed can form an unstable product.

Asphaltene sediment from tank bottom

In 2015 some suppliers specifically advise that their ULSFO (0.10%) should not be mixed with other fuels – at least only less than 2% of ULSFO with the new fuel. Where ships have ignored these precautions, they have seen the fuels become unstable, which can result in a debunking operation.

The consequences of mixing incompatible fuels, leading to an unstable product, are severe and very often the only resolution is to manually remove the fuel from the tanks and unblock pipework. It is for this reason that the industry body advises, where possible, that fuels from different sources are kept segregated; measured commingling is, however, possible when due processes are followed to determine that the fuels concerned are compatible with one another.

d. Storage and segregation of bunker planning

Every ship should re-evaluate their bunkering strategy – the flexibility in terms of whether filling to capacity can be avoided, which will depend very much on the number of storage tanks, their holding capacity and ship operating profiles to enable bunkers to be kept segregated.

e. Ordering bunkers and diversity of supply

In view of the likely diversity of the nature of VLSFO/ULSFO that could be supplied, the following is a summary of the four main scenarios a ship may be faced with at each bunker – the approach to which should be considered when setting up the bunker order clause.

- **Scenario 1** – 3.5% replaced with VLSFO 0.50% with RM specs (no shortages)
- **Scenario 2** – No or low VLSFO (RM) availability, requiring use of DM spec fuel (DMA)
- **Scenario 3** – ULSFO (0.10%) only available for 0.50% compliance (DM or RM)
- **Scenario 4** – No ULSFO or VLSFO available, so must load HSFO with an approved fuel oil non availability report (FONAR)

When setting up the bunker order clause, consideration should therefore be given to these different scenarios that may be offered from the bunker suppliers in a port – particularly in the months at the start of 2020, while compliant fuel stocks are being evenly distributed to meet demand.

It is recommended that orders are made against the latest edition of the ISO 8217:2017 marine fuel standard, which incorporates the latest fuel quality considerations.

f. Distillate operational considerations

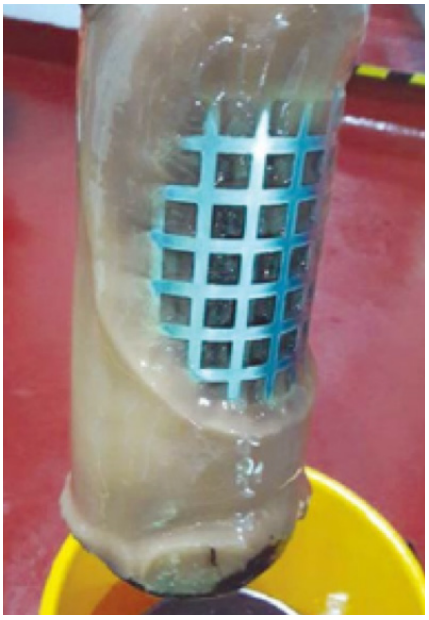
Where there are local shortfalls of RM 0.50% max, it may be expected that the ships affected will be expected instead to load ECA-SOx fuels, which may mean taking a full load bunker of a distillate (DM) grade fuel oil. In view of the potential technical and operational implications upon such ships that have not become familiar with inside ECA-SOx operations, where distillates are widely used, then the same preparations carried out for 2015 need to be considered for this 2020 implementation date. (See figure 3).

g. Cold flow properties and wax content

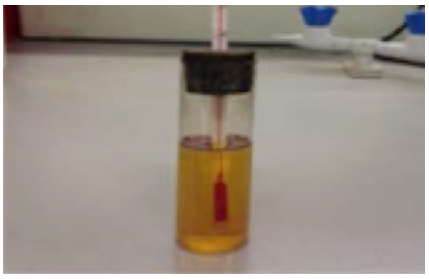
ISO 8217 limits the cold flow properties of a fuel through the control of the pour point (PP) for both the RM and DM fuel oils. However, given that wax crystals will form at temperatures above the PP, fuels that meet the specification in terms of PP can still, therefore, be challenging to operations in colder operating regions.

High paraffinic content of certain distillate fuels may lead to wax formation at ambient system temperatures, resulting in tanks, filters and purifiers being fouled with wax deposits, causing flow restriction to the machinery plant if temperatures are not maintained above the point wax crystals form.

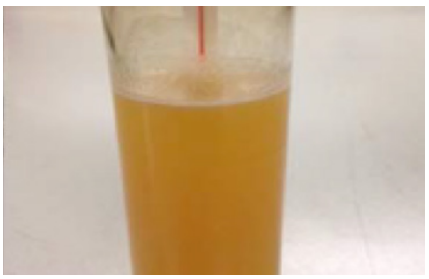
The cold flow properties of cloud point (CP), cold filter plugging point (CFPP) and PP of the fuel can provide information on the required storage and handling temperatures a ship needs to maintain to avoid fuel flow restrictions. These paraffinic fuels however, can be easily managed provided the temperature of the fuel is maintained above the wax appearance temperatures identified. Temperatures typically need to be kept 10°C above the PP, 1°C above the CFPP and CP which ever is higher.



Filter becoming blocked due to build - up of wax. DMA grade bunkered in ARA region - CFPP 5°C



Clear sample at 28°C



Wax crystals formed at 24°C

Pour point
The lowest temperature at which the fuel will continue to flow when cooled under set conditions (ISO 3016).

Cold filter plugging point
The highest temperature at which a given volume of fuel will no longer pass through a set filter size in the test defined time when cooled under set conditions (IP 309 or IP612).

Cloud point
The temperature at which a cloud of wax crystals first appears in the fuel (this test is only applicable to clear and bright fuels, as per ISO 8217 a DMA grade should be clear and bright) (ISO 3015).

PP, CFPP and CP have no correlation other than TPP < TCFPP < TCP. It can be shown that PPs well below 0°C can have CFPPs as high as 18°C.

Ships need to assess their operating profile and onboard tank and purifier/filter warming arrangements; if there are identified limitations, these need to be expressed in the bunker order clause for when the ship is going to be operating in a low-temperature region.

h. Viscosity and density

It is anticipated that the 0.50% sulphur fuel delivered will have broad ranging viscosity and density characteristics. table 2 below illustrates the data for 2017 on 0.10% sulphur fuels (ULSFOs), which ranges between 2.2 – 116.6 cSt against a maximum of 877 cSt for a high sulphur fuel oil.

Operationally, this will require ships to be attentive to the setup of the purification plant and pre-heat and viscosity control settings. In the case of 0.50% fuels today, the South American regions and China already have suitable products, as can be seen in table 3 below, which illustrates again the diversity of the viscosity, density and cold flow property of pour point.

Table 2

2017 data LR FOBAS		Distillate	ULSFO S ≤ 0.10%	Residual grades, S ≥ 0.11%
Density (kg/m³)	**Average**	**860**	**899**	**985**
	Median	857	902	989
	Max.	949	945	1035
	Min.	811	837	844
Viscosity (cSt) at 40°C dist. at 50°C residuals	**Average**	**3.8**	**32.8**	**345**
	Median	3.6	30.9	357
	Max.	32	116.7	877
	Min.	1.6	2.2	30
Net specific energy (MJ/kg)	**Average**	**46.2**	**42.4**	**40.4**
	Median	42.7	42.3	40.3
	Max.	43.2	43.1	43.0
	Min.	37.6	37.8	-

Table 3

2017 data LR FOBAS				Residual grades, 0.24-0.50% S
Bunkering country		China	Brazil	Argentina
Density (kg/m³)	**Average**	**977**	**954**	**953**
	Max.	991	968	968
	Min.	963	934	929
Viscosity (cSt) at 50°C	**Average**	**145 (154)**	**343 (353)**	**342 (343)**
	Max.	179	406	411
	Min.	92	260	96
Net specific energy (MJ/kg)	**Average**	41,2	41,6	41,6
	Max.	41,4	41,8	41,9
	Min.	40,9	41,3	41,4
Pour point (°C)	**Median**	**19,5**	Less than 6	Less than 6
	Max.	32	30	18
	Min.	Less than 6	Less than 6	Less than 6
	Comments	RME180	RMG380	RMG380

Figure 3: S2020 - Operational considerations inside ECA-SOx and outside ECA-SOx

Sulphur 2020 ≤ 0.50% Sulphur – Operational considerations within ECA-SOx and outside ECA-SOx

Fuel System Stage	Major concerns	Suggested solutions
Bunker requisition/bunkering operation	• Availability of ordered 0.50% VLSFO or 0.10 ULSFO? • Compatibility of new bunkers with old • Fuel quality stability/flash point/cold flow • Broad spectrum of fuel scenarios to handle against 0.50 order • Non availability FONAR process to ensure the capt/ceng is aware • Charterer understands ship scenario strategy and implications 0.10, 0.50 and >0.50 bunkers segregation strategy • Unstable fuel will result in heavy sludge deposits adversely impacting operations	• Define all supply scenarios and assess ship adaptability to respond • Review robustness of bunker clause • Agree comingling strategy and plan with charterer and supplier • Perform a fuel system/management assessment review for individual or group of vessels to identify and address operational and technical challenges at each component point in the fuel system from DM and RM operations. Order to latest edition of ISO 8217:2017
Fuel storage/transfer	• Fill to capacity requirements from charterer • Tank cleaning challenges of existing HSFO tanks to switch to 0.50% • Crew competence/awareness in managing the fuel change over and • Incompatibility between each bunkers • Overheating of MGO (0.10 or 0.5) from leaking steam heating valves and high temperatures adjacent RM tanks • MGO Fuel quality issues during long storage such as with FAME (fatty acid methyl ester), oxidation stability, microbial contamination. • HI cold flow temperatures CP and CFPP	• Apply comingling/segregation/ compatibility strategy/plan • Order compliant fuel well in advance of enforcement date of 1st of January 2020 to allow fuel tanks and systems to flush through • For extended ECA operation, dedicate segregated storage tanks for ULSFO sulphur fuel with separate service/settling tanks for VLSFO – • Use segregated transfer lines and pumps for 0.1SFO distillate operation. • After each bunkering check compatibility across all fuels • Plan tank cleaning well in advance of 01/01/20 = '2020 Ready' • Isolate steam lines to additional MGO tanks check steam v/vs sealing • Assess Cold flow management flexibility • Verify fuel change over plan and assess crew competence3/awareness • Avoid long storage periods of distillate fuels, regularly drain water from tanks to reduce microbial activity • Consult CIMAC Guidelines on managing fuels with FAME – (request for FAME scan on MGO bunker) • YACHTS fuel tank coating prevent corrosion and regular microbe tests
Settling/service tanks	• Segregate VLSFO and ULSFO vs MGO • Leaking steam heating valves will elevate MGO tanks temperature • High fuel temperature in settling/service tanks because of close proximity with RFO settling/service tank • Note that some adjacent tank heating with regards to storage tanks where maximum temperatures are not exceeding 45 deg C may be advantageous for high cold flow property fuels – seek guidance on this from Lloyd's Register FOBAS on a case by case basis	• If an existing LSFO settling tank is being used for 0.1SFO then ensure steam heating where applicable is isolated (if an MGO) Conduct inspection of trace heating valves and lagging condition.
Purifiers/filters	• Low viscosity temperature control • Filter blockage may occur especially at the time of fuel change-over or during circulation for tank cleaning due to solvency nature of the MGO • Excessive sludge generation at filters/ purifiers could result in fuel supply restriction • High melting point wax fuels may cause sludge at purifiers on low temperatures	• Crew awareness and training – attentive to fuel characteristics for purifier set up/ heating control during change over set up • Keep the backup filters clean and ready for quick change over (have sufficient spare replaceable filters where applicable) • Attention to purifier settings based on tested density and viscosity – recommended de-sludge cycles • Seek lab testing service support to asses wax melting points

Fuel system stage	Major concerns	Suggested solutions
Viscosity controller/service system change over point	• Overheating and or thermal shock • Leaky 3-way C/O valve with the risk of HSFO/VSFO contamination • Unsatisfactory or poorly executed fuel change over procedure • Fuel starvation due to filter blockage at the time of change over • Flushing time required	• Calculate the change over flushing time, which can be verified through analysis of spot samples before the date of implementation • Sea trial the change over, start/stop/ahead/astern and fuel system sampling before the date of enforcement in open waters • Consider engine fuel return arrangement – additional valve by -pass straight back to settling tank to minimise flush through time • Ensure viscosity controller, changeover valves and other fuel system components are in good state of repair and maintenance • Rate of change in temperature should be approximately 2 oC/minute • Ensure Viscotherm PID controller is responding uniformly to the change in viscosity demand. • Option: MGO/HFO segregated parallel service system - link at a change over after duplex hot filters3 (refer to LR DIST Notation) • Identify/install designated sampling points in the fuel service system after service tank to facilitate sampling for compliance verification
Fuel pumps/injectors/exhaust valve	• Low viscosity at engine inlet may result in loss of hydrodynamic sampling for compliance verification lubrication between fuel pumps/injectors causing excessive wear • Poor lubricity characteristics of the fuel (viscosity is a bigger concern) • Excessive fuel temperature can also cause gassing up or vapour lock • Fuel leakage and insufficient pressure from worn fuel pump/injectorsand old seals • Excessive wear at exhaust valves	• Check viscosity at point through all fuel system – best above 3.0 cSt min 2cSt on fuel system components (check with OEM advice) • Install4 chillers/coolers as required • Check fuel system seals/O ring condition • Ensure fuel pumps leakage drains are clear – monitor drain tank more regularly for excessive fuel leakage/losses • Review maintenance schedule of fuel system components • Check bunker order requirements – apply ship specific limits • Check OEM for extended distillate operations engine set up requirements – such as: exhaust valve seats to stellite from nimonic – cylinder head replacement, fuel valve and valve cooling – timing etc. • Check fuel drainage arrangements around fuel pumps are clear to the collection tank and alarm system is working
Combustion/engine performance	• Diversity of fuel formulations combustion performance • Delayed ignition - Engine knock • Cylinder lubrication • Low energy content/low density of the fuel • Loss of power	• For each new bunker • Take electronic power card/draw card to evaluate the engine performance and make necessary timing adjustments • Contact engine manufacturer for further guidance regarding extended distillate and low sulphur operations • OEM and lubricant recommendations on CLO should be referred to • 2nd CLO grade storage tank may be required on board for 0.1SFO/LSFO such as CLO BN of 30 or 40

1 MARPOL Annex VI regulation 14.4.3 dictates that while ships are operating within emission control area, the sulphur content of the fuel oil used on board ship shall not exceed 0.10% m/m on. Regulation 14.1.3 requires that the sulphur content of fuels in use shall be a maximum of 0.50% m/m from 01.01.2020. Regulation 4 allows for equivalents such as an exhaust gas cleaning system approved by the ship's flag.
2 MARPOL Annex VI emission control area for sulphur oxides (SOx).
3 Carryout crew assessment and training/awareness programmes as required.
4 Advise ship's class of any planned fuel system/machinery modification which may require plan approval.

Note: Above information is for guidance only and we recommend ship operators to perform a risk assessment to evaluate and make decisions based on the operational and technical profile of individual vessel or group of vessels. Lloyds Register will be pleased to assist in any aspect of your fleet assessment of '2020 ready'.

6. Key steps to consider in the ship implementation switchover plan from HSFO to VLSFO

It is recognised that the one-off switch from HSFO, to the VLSFO 0.50% maximum sulphur content will require significant planning to ensure a smooth transition to 0.50% compliance, with a number of operational aspects being affected. The suggested generic implementation timeline (shown in figure 4 below) outlines the key areas for ship operators to consider for their fleet and for each ship specifically, acknowledging the wide variation between ship types and sizes, operating profiles, and tank storage and fuel system arrangements.

	Mar - Dec (Planning)	**Nov - Aug** (Preparations)
	Sulphur 2020 implementation plan	**Ship made ready plan**
Key considerations	Commercial/charterer/supplier dialogue Machinery scope of fuel requirements/settings Fuel handling ULSFO VLSFO of RM/DM any constraints Designated sampling point identification Awareness/training shore and ship best practices for 2020 >0.50 ship audit run down plan fuel grade scenarios Fuel oil tank switchover timeline Cylinder oil requirements	Sea trials on distillates and VLSFO 0.10/0.50 Cleaning and preparing tanks for 0.50 Apply commingling strategy loading plan Act on technical observations boiler A/E and M/E Modification of tanks/fuel system arrg. System modifications
Specific actions	**Fuel management sulphur 2020 update (PDCA)** • Identify company sulphur 2020 leader • >0.50 audit run down plan • Guide on mitigating risk/ safety concerns • Bunker clause addressing fuel scenarios • Commingling plan, segregation strategy • Enforcement/inspection facilitation • VLSFO to ULSFO c/o calculations • Switch over loading plan • Tank and pipeline preparation schedule • Non-availability FONAR • Lubricating oil requirements re fuel Scenarios • Cold flow limitations management • Compliance documentation • Structure modification timeline	**Ship specific actions** • Crew awareness/training • Engage crew in applying best practices • Operational/technical observations • Finalise system readiness for switch over • Continue open dialogue with charter on change requests and bunker scenarios

Key: S≤0.10% ULSFO (Ultra Low Sulphur Fuel Oil) | S≤0.50% VLSFO (Very Low Sulphur Fuel Oil) | RM – Residual Marine Fuel; DM – Distillate Marine Fuel

Figure 4: Preparatory considerations for compliant fuel options

a. Preparing HSFO storage tanks

The changeover procedure would ideally be a gradual process whereby tanks are emptied one by one, checked, and thereafter refilled with 0.50% fuel oil. However, while this could work for ships that are to drydock at some point approaching 1 January 2020, it will, in reality, rarely be possible for such a controlled process to take place – noting that some ships need to remain in service with the usual reserve quantities. The following are a few points to consider in preparing tanks:

- Assign a 'potential' HSFO tank if 0.50% maximum sulphur content fuel oil is not available then the HSFO fuel oil supplied could be loaded to this assigned tank. When assigning a tank, its size and internal structural members should be considered, fewer the better to facilitate future cleaning.
- Cleanliness of tank bottoms and walls should be determined. Some additives are available on the markets that claim to avoid the need for physical tank cleaning. However, these need to be applied to a number of bunker loadings before the deadline to enable effective cleanliness to be achieved. Full details should be sought after by the additive suppliers as to their suitability for your intended purposes.
- Pipeline and system clean-up – dead ends/closed systems (i.e. stand-by heaters). Sufficient flush through of compliant fuel will require at least one 0.50% bunker loading, if not two passing through the system before the implementation date. The applications of cleaning additives in the storage tanks may also facilitate this process.
- Selection of engine system lubricating oil and cylinder lubricating oils, where applicable, should be evaluated in light of the possible options of fuel oils being offered for use.
- Isolated systems – including potentially those that are currently distillate fuelled, noting that distillate fuel supplied to date outside ECA-SOx could have been above 0.50%.

b. How much fuel can remain in the bottom of tanks before filling with 0.50% fuel?

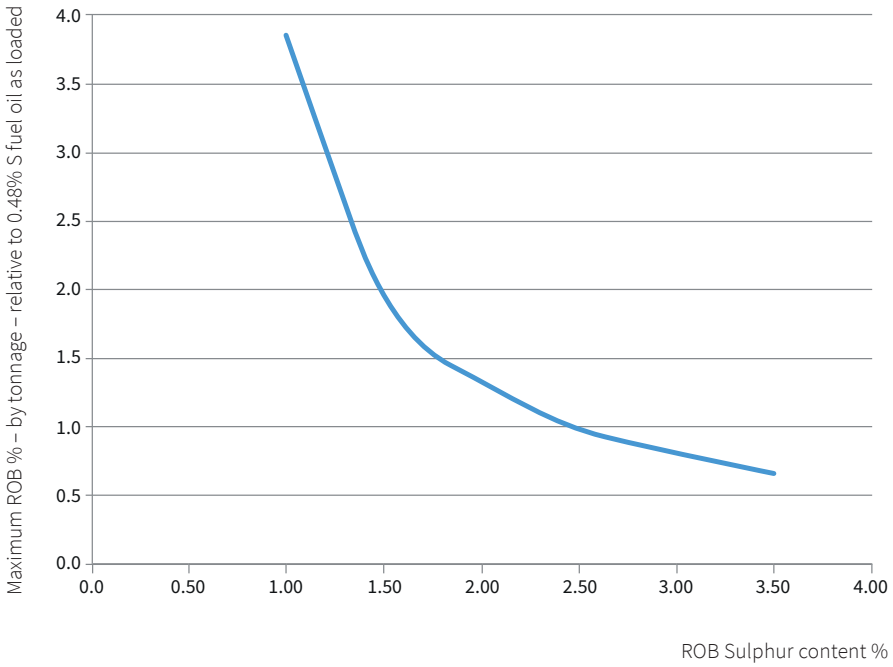


Figure 5 Blending ROB to 0.50%

figure 5 below illustrates the maximum remaining-on-board (ROB) in a particular tank that could be allowed if loading a fuel oil with a sulphur content of 0.48% – for example at the low end of the expected range for the 0.50% max controlled fuel oils.

Hence, where the ROB has a sulphur content of 2.50%, the max quantity (by tonnage) relative to that loaded at 0.48% sulphur would be a max of 1%, in order not to exceed the 0.50% limit. However, that assumes uniform and complete mixing of the two, which will rarely be the case in such instances; note that onboard fuel oil inspections only need to draw a snap sample, and residual high sulphur elements could adversely impact the spot sample result.

Of course, where the ROB sulphur content is higher, the allowable ROB ratio is that much lower – in this instance, under 0.7% by tonnage where the ROB is 3.50% sulphur.

Also note that the above is based on 0.48% as loaded and that, as that loaded value increases towards 0.50%, the acceptable ROB is duly reduced – half that shown in figure 5 when the loaded value is 0.49% and, of course, zero where that is 0.50%.

Hence, while tanks are unlikely to need to be wiped clean, they will need to be substantially emptied of all previous content – noting the risk of blocked drainage holes through ship structural members, allowing the retention in a tank of a significant quantity of 'old' fuel oil not detected from tank soundings.

7. Summary: What ship operators need to do now

- Ships will need to review their fuel management strategy/plan to include the management of the expected diversity of fuel compositions, such as there being sufficient tank storage options to build in flexibility to avoid commingling two or more different bunker fuels.
- Considering the expected variability and unconventional blends coming into the marine fuel market, the key challenge will be for the ship's crew to understand the possibility that each bunker loaded will have different characteristics from the previous bunkers, despite a similar ordering specification. This will require particular attention to:
  - Storage requirements (cold flow properties, compatibility and the possible need for segregation between new and old bunkers)
  - Handling and conditioning (correct purification setup)
- Use correct auto-viscosity control settings to ensure injection viscosity is maintained within the engine manufacturers and the fuel is not overheated.
- Shipowners will need to consider the cold flow properties in accordance with ISO 8217:2017 (for example sufficient heating capabilities in both residual and distillate fuel tanks).
- Shipowners should start a dialogue with charterers and suppliers/traders with regards to the transition period for starting the switch to using 0.50% VLSFO, which could be around October/November 2019.
- Ensure ships are already familiar with and experienced in using such fuels before the deadline, with regards to both technical and operational implications.
- Consideration will need to be given to preparing the tanks for the switch to 0.50% VLSFO and this may require tanks to be cleaned of the remaining HSFO and any sludge on tank bottoms.
- Installation of a designated fuel system sampling point in strategic positions is recommended, as this would facilitate an inspector's request to take samples in a safe manner.

The experience of using 0.10% ULSFO for both residual-based and pure distillate operations will stand you in good stead for tackling the new 0.50% VLSFOs. It is recognised, however, that there are many thousands of ships that have not yet truly experienced operations on much other than HSFOs and the occasional switch to distillates; this would suggest that the lessons learnt by some from the switch in 2015 will have to be learnt by many more for 2020.

Figure 6 below outlines the key elements of the fuel management process and apply the PDCA management process:

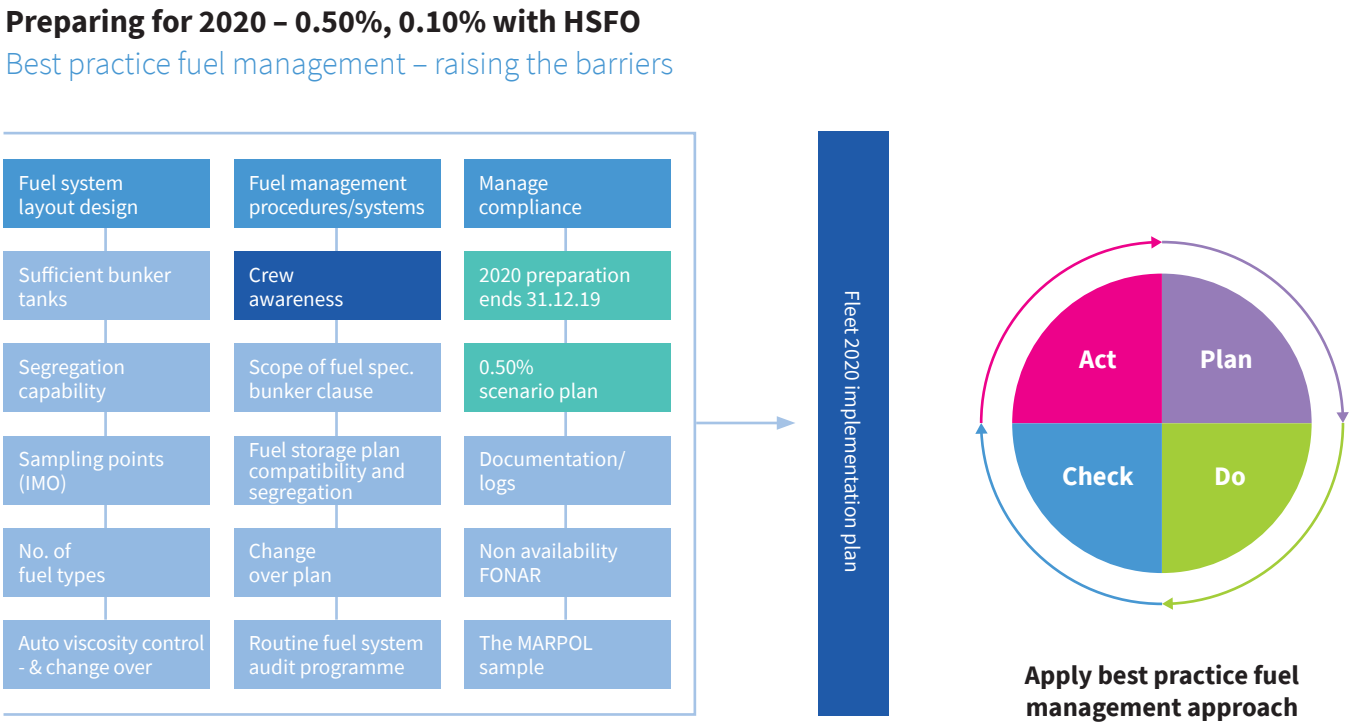


Figure 6 Key Management considerations

8. Other low sulphur fuel oils currently in use

a. LNG

LNG is low in sulphur and easily combusted in engines and boilers using mature and reliable technology. Gas engines are widely used in land-based industry and have been used in LNG carriers for many years. The IMO has developed the IGF Code –which provides the legal framework for operators and designers to work within. LR has published class rules for gas-fuelled ships.

Wholesale LNG prices are generally lower than RFO prices, but a lack of marine supply facilities means that LNG may be more expensive than RFO once delivery costs are taken into account. In some markets, LNG prices are indexed to oil prices and can match them even before supply costs are added.

Known gas reserves have steadily increased. The international energy agency data shows that they increased more than threefold between 1975 and 2010, and gas prices have become very attractive in some markets as a result of this abundance, particularly in North America. Where LNG supply infrastructure is in place, LNG is expected to become very financially attractive as a marine fuel in the short – medium term.

Converting existing ships to alternative fuels such as LNG is possible, and there is a lot of interest in this area in the North American market. However, conversions are expensive and technically challenging. Challenges include installing the fuel tank and containment systems, gas zoning and engine conversion.

b. Other alternative fuels with zero sulphur content

Other alternative fuels include LPG and methanol. While LR currently expects the use of LPG as a marine fuel to be limited to niche markets, such as LPG carriers using cargo to provide fuel, it is expected that methanol will establish a place in the market and we are already working on several methanol projects.
We have published provisional rules for methanol-fuelled ships and the IMO is working on incorporating methanol into the draft IGF Code.

c. Further advice on alternative fuels

Given the particular technical challenges and complexity of operating on fuels such as LNG and methanol, this guide does not cover them in detail. If you are interested in alternative fuels, contact your local LR group office for advice. We have extensive experience in supporting clients in adopting alternative fuels, and can provide a wide range of services including both classification and consulting.

9. How is LR supporting the efforts of the industry to work towards a consistent implementation of this Regulation 14.1.3?

LR is involved in a number of technical working groups which address marine fuel quality and the implementation of this regulation, these include:

1. ISO TC28 SC4 WG6 for the ISO 8217 petroleum products – Fuels (class F) – Specifications of marine fuels
2. CIMAC WG7 Marine Fuels – Engine builders forum (Cross industry global representation of engine/ boiler and ancillary marine fuel system equipment)
3. Active involvement within IMO's MEPC and PPR committees and working groups to advise member states on the development of the 2020 implementation plan details of which will be address at the ISWG in July 2018 for a final submission of a guidelines to MEPC 74 in April 2019
4. ESSF (European shipping sustainability forum) SG for air emissions from ships
5. ISO ISO/TC 28/SC 4/WG 17, specifications of liquefied natural gas for marine applications
6. CIMAC WG 8 marine lubricants
7. ESSF SG for exhaust gas cleaning systems (EGCS)
8. IACS our technical input to the machinery panel to review the recommendations of fuel system design in the context 2020

Part 4: Summary of our Sulphur 2020 support services.

Sulphur 2020 raised awareness on	Who should control?	LR marine consultancy and fuel assessment support	Outcome
Stability (ISO 8217:2017) Flash point (SOLAS)	The supplier is contractually and legally responsible to meet ISO 8217 and SOLAS requirements	Independent testing quality assurance as loaded, with additional analysis as required	Long-term storage and safety
Cold flow properties Distillates	Ship to understand fuel heating in tank, separator and pipe/line filter limitations For DM winter grades, ISO 8217:2017 supplier to report CFPP, CP and PP For RM – PP wax content and appearance temp may be requested	S2020 Change Plan system review/recommendations Supported by our fuel oil bunker analysis and advisory services (FOBAS) Wax content and melting temperature	Prevent wax crystal formation and deposits in tanks, purifiers and filters restricting fuel flow
Compatibility	Recipient ship to manage and take precautionary steps on loading new bunkers and the distribution of bunkers on board check compatibility with remaining bunkers	Bunker compatibility S2020 specialist support programme	Better informed to enable satisfactory outcome of the distribution and handling of new and old bunkers on board
Fuel system adaptability to varying quality	Ship-specific awareness of system capabilities to cover viscosity and cold flow temperatures	S2020 implementation change management plan Review	Better informed to enable satisfactory outcome of the distribution and handling of new and old bunkers on board
Crew awareness	Shipowner to evaluate crew readiness to manage the change and ensure compliance on 1 Jan 2020	Standard or bespoke workshops/E-/video programmes/general guidance	Awareness will mitigate the risks against the uncertainties of S2020
Fuel quality	Ship recommended to order to latest ISO 8217 specification (2017) Supplier to provide transparency of key bunker characteristics	As above, a full LR fuel testing programme can provide the full characteristics of the fuel correct system setup	Optimises the machinery performance, mitigating risks

Sulphur 2020 Ship Ready implementation plan for Regulation 14.1.3 compliance
1 January 2020 – (Example only for reference)

Ship details	Description	Additional details	Date actioned
Name			
IMO number			
Flag/class			
Compliance method	Compliant fuel/EGCS+ HSFO/?		
Date for Reg. 14.1.3 compliance – 0.50%			
	Maximum 0.50 % Outside ECA-SOx compliance option		
Bunker order ship specific requirements	Fuel specification redefined All scenarios		
	Bunker charter clause Charterer arrangements		
Structural modifications	Fuel Sulphur 2020 change management procedures – including modification of fuel change over plan ECA IN/OUT		
	Documentation review and update		
	Fuel handling treatment and conditioning system – designated sampling points.		
	Fuel tank arrangements – re-allocation – no of tanks?		
Switch HSFO to VLSFO	Plan completed		
	Calculations		
	Limitations		
	Non availability plan		
	Commingling plan		
	Flush through tank / pipes		
1st Purchase of VLSFO bunkers	Date to be supply first loading agreed with supplier		
Crew awareness programme	Provide high level activity training/ instructions/ISM etc.		

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