

INTERSESSIONAL MEETING ON
CONSISTENT IMPLEMENTATION OF
REGULATION 14.1.3 OF MARPOL ANNEX VI
Agenda item 2

ISWG-AP 1/2/12
25 May 2018
ENGLISH ONLY

**DEVELOPMENT OF DRAFT GUIDELINES FOR CONSISTENT IMPLEMENTATION OF
REGULATION 14.1.3 OF MARPOL ANNEX VI**

Safety implications associated with 2020 fuels and their respective challenges

**Submitted by Liberia, Marshall Islands, ICS, BIMCO, INTERTANKO,
INTERCARGO and WSC**

SUMMARY

Executive summary: This document provides technical information to assist the Intersessional Meeting of the Sub-Committee to successfully complete the work that has been assigned to it by the two parent Committees. The information is intended to ensure that safety risks associated with the transition to 0.50% m/m sulphur fuel are properly considered and to assist the meeting to develop transition and implementation guidance and planning.

*Strategic direction, 1
if applicable:*

Output: 1.17

Action to be taken: Paragraph 32

Related documents: MEPC 70/INF.12; MEPC 71/9/5, MEPC 71/17; MSC 98/23; PPR 5/13, PPR 5/13/7, PPR 5/24, PPR 5/WP.6 and ISWG-AP 1/2

Background

1 The annex to this document provides technical information on safety implications relating to blended fuels which may be used in order to meet the 0.50% m/m sulphur limit as requested by MSC 98. It further provides information on several other topics related to the scope of the work of the Intersessional Meeting on Consistent Implementation of the regulation 14.1.3 of MARPOL Annex VI for its consideration.

- 2 At MEPC 71, the Committee had, inter alia:
- .1 approved the new output on "Consistent implementation of regulation 14.1.3 of MARPOL Annex VI", for inclusion in the Sub-Committee's Pollution Prevention and Response (PPR) biennial agenda for 2018-2019 and the provisional agenda for its fifth session, with a target completion year of 2019;
 - .2 approved the scope of the work as prepared by PPR 4 (PPR 4/21, annex 13, paragraph 13), including the additional item requested by MSC 98 on safety implications relating to the option of blending fuels in order to meet the 0.50% m/m sulphur limit;
 - .3 instructed the Sub-Committee to report to MSC any safety issues that might be identified with regard to low-sulphur oil fuel; and
 - .4 requested ISO to consider the framework of ISO 8217 with a view to ensuring consistency between the relevant ISO standards on marine fuel oils and the implementation of regulation 14.1.3 of MARPOL Annex VI.

3 Following consideration at PPR 5, the Sub-Committee agreed that this Intersessional Meeting on consistent implementation of regulation 14.1.3 of MARPOL Annex VI would be held. The Sub-Committee also agreed to the work plan to complete this output including development of the draft Guidelines for consistent implementation of regulation 14.1.3 of MARPOL Annex VI at this Intersessional Meeting, based on the outline prepared at PPR 5, as set out in annex 5 to document PPR 5/WP.6, for finalization at PPR 6, with a view to approval at MEPC 74 (spring 2019).

4 The co-sponsors have undertaken an in-depth examination of safety aspects of low sulphur fuels, presented in the annex, with the view to raising the industry's and government awareness to the potential problems associated with 2020 fuels and their respective challenges and to inform the work of the Intersessional Meeting.

Discussion

5 At MEPC 70, the Committee decided to implement the 0.50% m/m cap on sulphur content in marine fuel on 1 January 2020 for ships outside Sulphur Emissions Control Areas (SECAs). The co-sponsors would emphasize that they are committed to a successful transition and to implementing the new 0.50% m/m sulphur cap in accordance with the decision of the Committee. The decision was based on an IMO study prepared by CE Delft. This study forecasts marginal overall availability of compliant fuel on the assumption that there will be some 3,800 ships installed with scrubbers, as well as that 75% to 80% of the MARPOL compliant fuels would be fuel blends.

6 At MEPC 72, the Committee further approved draft amendments to MARPOL Annex VI regulation 14 and to the form of the Supplement to the IAPP certificate prohibiting the carriage of non-compliant fuel oil, with a sulphur content exceeding 0.50% m/m, for use onboard ships. These amendments will be forwarded to MEPC 73 for adoption. The earliest entry into force date of the measure, if adopted, will be 1 March 2020. The amendments do not alter existing regulations 3, 4 and 18 of MARPOL Annex VI. Regulations 3 and 4 make provision for exemptions for the testing of new technology and for equivalent means of compliance (for example, use of exhaust gas cleaning systems) respectively. MARPOL Annex VI regulation 18 makes provision for non-availability of compliant fuel.

7 It is expected that the majority of ships will comply with the amended regulations by using low sulphur fuel oil, switching from higher sulphur fuel oil currently used. This has resulted in widespread concerns over the worldwide availability of safe and compliant fuels in the period before and following implementation of the 2020 MARPOL Annex VI sulphur cap.

8 As 2020 is fast approaching it is evident that only a limited number of ships will have exhaust gas cleaning systems (SO_x scrubbers) installed by 2020 and that there will be very limited adoption of alternative fuels such as liquefied natural gas (LNG). This means that compliance will rely on the oil refining industry and its capability to provide the market with sufficient quantities of quality and safe compliant low sulphur fuel. Marine Gas Oil/ISO grade DMA (MGO/DMA) is the premium quality option to meet the 0.50% m/m sulphur requirement. According to a recent study by the International Energy Agency (IEA)¹ it is anticipated that the share of Marine Gas Oil (MGO) will initially increase from 19% to 43% in 2020, but will drop back to 19% at the end of the forecasting period, as MGO is replaced by Very Low Sulphur Fuel Oil (VLSFO) whose share rises from 34% to 49% in 2023. VLSFO is expected to primarily consist of blended products.

2020 fuel oils considerations

9 Although the newer blended fuels which are under development in preparation for 2020 are not yet available in the market, concerns have been raised about these fuels, which will be compliant with the 0.50% m/m sulphur limit but which may differ in their composition from supplier to supplier and port to port. This could potentially lead to compatibility and mechanical problems. There is no guarantee that a ship bunkering 0.50% m/m sulphur at a European port will then be able to pick up a compatible fuel as it goes east, even if ordering from the same fuel supplier. It is expected that there will be regional variation between how compliant fuels are blended. Some regions are expected to provide a 0.50% m/m solution based primarily on fuel oil, whilst others are expected to provide distillate-based solutions.

Safety implications and impact on fuel and machinery systems relating to the option of blending fuels in order to meet the 0.50% m/m sulphur limit

10 By far the most important aspect of the challenges the 2020 sulphur cap entails are the safety concerns, which are tightly connected with the sudden surge of demand for compliant fuels. How will ship machinery react to continuously operating (not just occasionally whilst transiting a SECA) on much lower viscosity fuels? For example, it is understood that changing to lower viscosity fuels may expose fractures in pipes which are not apparent when using much thicker HFOs. The resulting leakage could result in a machinery breakdown or fire. A particular risk is hidden degradation of pipe flange joints and couplings which are able to form an effective seal where HFO is used, but which may leak if used with lower viscosity fuels. This risk may be more pronounced with blended fuels as if the blend is unstable it may result in variations in viscosity, with systems receiving fuel below the intended viscosity. Experience following implementation of the 0.10% m/m sulphur limit within SECAs on 1 January 2015 indicates a marked increase in incidents of loss of propulsion and machinery problems, when switching to operation on marine distillate fuels. At that time the US Coast Guard (USCG) and California ARB (CARB)² recorded a significant number of incidents involving fuel leakages caused by fuel switchovers from HFO to low viscosity distillates. In some cases, such leaks resulted in fuel pumps seizure and breakdown of onboard machinery. There were also concerns with possible fires when fuel oil leaks were close to hot surfaces. Use of distillates and non-distillates with sulphur content of 0.10% m/m in cold environments could also lead to machinery breakdowns. It is essential that ships are

¹ IEA, *Oil Market Report 2018, Analysis and forecasts to 2023*.

² U.S. Coast Guard District Eleven Department of Homeland Security, Marine Safety Information Bulletin, 14-01, 9.9.2014; *Loss of Propulsion Incidents (LoPI), 2004-2011*, California Air Resources Board (CARB).

provided with specific information on the Cloud Point as well as the Pour Point temperatures so ship crews know how to treat the fuel to avoid precipitations and possible filter clogging. These are few examples, and industry have learned many valuable lessons from experiences during the implementation of the 0.10% m/m sulphur limit within SECAs in 2015. Industry guidelines have been developed and are available to assist with addressing these matters.

11 It should be noted, however, there are two new challenges with enforcement of the 1 January 2020 date for use of low sulphur fuels:

- .1 many ships have not been in SECAs and so their crews do not have the benefit of those learning experiences. The industry will do its best to be prepared and train the crews accordingly; and
- .2 although in 2015 ships used distillate fuels (MGO), which are known and understood fuels and which conform to ISO standard 8217 - Petroleum products -- Fuels (class F) -- Specifications of marine fuels, it is expected that in 2020 ships might need to use new and unproven blended fuel oils which differ greatly from existing fuels and which will not be distillates and which will not conform to ISO 8217 (see paragraph 14). Therefore, it cannot be assumed that those companies operating within SECAs will have sufficient experience to fully understand risks associated with switching to 0.50% m/m sulphur fuels prior to 1 January 2020.

12 Compliant fuels should be understood to encompass compliance with both MARPOL Annex VI and SOLAS requirements (i.e., chapter II-2, regulation 4). The recently observed surge of incidents with low flashpoint distillate fuel deliveries in US ports³ with measured flashpoints well below the minimum required by SOLAS raises further concerns for ships, crews and ports. Very recent deliveries of unstable fuels in European ports⁴ bring additional worries as in 2020 a sharp increase in the share of Marine Gas Oil (MGO) is expected as already explained in paragraph 8. Using solely the sulphur content as a blending target will not guarantee safe fuel blends. The co-sponsors suggest that experience gained from these incidents should be reflected in the draft Guidelines with a view to assisting the industry to develop precautionary measures accordingly.

13 The switch to 0.50% m/m sulphur fuels, especially to blended fuels which are not in conformance with ISO 8217, raises several important safety issues. These issues include, but are not limited to, stability, compatibility, combustionability, lower flashpoints, inadequate safety margin for cat fines and extended ignition delays because of poor combustion characteristics. All of these issues may negatively impact fuel and machinery systems. Those safety concerns are further elaborated and identified in the annex to this document.

Fuel quality issues, particularly regarding new types of fuels and blends

14 The relevant fuel specification ISO 8217 is under review. However, ISO has already informed the Organization (PPR 5/24, paragraph 13.6.20) that it will not be able to finalize this prior to implementation of the 2020 sulphur cap. As an interim measure ISO intends to make a publicly available specification (PAS) in mid-2019, approximately six months before ships will have to be compliant with the new sulphur limit of 0.50% m/m. Hence blended fuels are unlikely to have been fully tested by engine manufacturers before this date.

³ Bunker Alert 02,03,06,11/2018 Veritas Petroleum Services (VPS), January-April 2018.

⁴ Lloyd's Register, FOBAS Alert, 8 May 2018.

15 The co-sponsors would draw attention to the fact that MARPOL Annex VI regulation 18 requires Parties to take all reasonable steps to promote the availability of fuel oils which comply with the Annex and to inform IMO of the availability of compliant fuel oils in its ports and terminals. MARPOL Annex VI regulation 18 provides general requirements for quality, including that fuel is not to jeopardize the safety of ships or adversely affect the performance of the machinery or be harmful to personnel. Therefore, MARPOL Annex VI already places obligations on Parties to the Annex regarding the availability of safe, compliant fuel oil. The co-sponsors note that many of these concerns and supporting information were also brought to the attention of the Committee in document MEPC 70/INF.12 (INTERTANKO) following implementation of the 0.10% m/m sulphur limit applicable within SECAs in 2015. The 2020 change to fuel sulphur content will impact far more ships than the change of 2015. Unlike 2015 where ships primarily changed to ISO 8217 distillate fuel oils, in 2020 ships will adopt blended fuel oils and new products which are outside of the ISO 8217 standard.

Proposals

16 The submission provides technical information on the problems and respective challenges associated with 2020 compliant fuels to assist the Intersessional Meeting in preparing draft Guidelines for consistent implementation of regulation 14.1.3 of MARPOL Annex VI, especially addressing the parts of the draft Guidelines where text is missing or needs further elaboration. In this context reference is made to document PPR 5/WP.6, annex 5 and parts 1, 2, 4, 5 and 6 of document ISWG-AP 1/2. In particular, the technical information should be considered by the Intersessional Meeting when considering possible implementation planning and guidance material and documents.

17 The co-sponsors consider that as a matter of urgency the Intersessional Meeting identify any consequential regulatory amendments and/or guidelines necessary to address the issues referred to in the above paragraph 16 (MEPC 71/17, paragraph 14.27.2; PPR 4/21, annex 13; and ISWG-AP 1/2, paragraph 3.7), and bring them to the attention of MEPC 73.

18 Any potential safety implications resulting from new blends or fuel types should be reported to MSC 100, taking into account that MEPC 71 when approving the scope of work, included an additional item on the safety implications relating to the option of blending fuels in order to meet the 0.50% m/m sulphur limit as requested by MSC 98 (MEPC 71/17, paragraph 14.27.4).

Action requested of the Intersessional Meeting

19 The Intersessional Meeting is invited to consider the proposals made in paragraphs 16 to 18 and take action as appropriate.

ANNEX

TECHNICAL ANNEX

1 According to MARPOL Annex VI, the sulphur content limits for marine fuel oils will be reduced to 0.50% m/m for ships operating outside of Sulphur Emission Control Areas (SECAs) from 1 January 2020. The change is drastic as it is expected to impact about 75% of the marine fuels supplied today.⁵

2 The bunker industry is facing challenges as it impacts production, supply chain, storage facilities, availability, price and fuel quality as well as vessel and crew safety.

3 This document addresses some of the concerns associated with the 2020 fuels and their respective challenges, focusing on the **worldwide availability of safe compliant fuel oil**. The information is intended to assist the intersessional meeting on consistent implementation of regulation 14.1.3 of MARPOL ANNEX VI and to facilitate informed decision-making.

4 The following definitions will be used throughout this document:

- .1 ULSFO, Ultra low sulphur fuel oil, max 0.10% m/m sulphur
- .2 VLSFO, Very low sulphur fuel oil, max 0.50% m/m sulphur
- .3 LSFO, Low sulphur fuel oil, max 1.00% m/m sulphur
- .4 HSFO, High sulphur fuel oil, above 1.00% m/m sulphur

Discussion

Marine Fuels

5 Heavy fuel oils (HFO) have traditionally been a by-product of oil refineries. They consist of what is left when the more valuable fractions have been extracted through distillation and cracking processes and are sold at prices below the crude cost. Historically, product targets for HFO were density and viscosity but with the emerging legislative environment, the blend target has moved to sulphur. There is no such thing as a perfectly suitable fuel, even if it meets every parameter of the ISO 8217⁶ specification for residual marine fuels. On-specification fuel does not necessarily mean that it is fit for its intended use.

6 As HFO is a low value product, suppliers avoid using blend components that could be sold at a higher price on their own. Also, HFO is not a clean product and it is unlikely that tanks/barges in the supply chain are cleaned prior to loading the HFO. It is therefore not unusual for HFOs to contain components that either do not originate from traditional refinery processes or even waste chemicals. Components such as tyre oil, tall oil, used lube oil, gasoline and even chemicals of unknown origin occasionally show up in HFOs.

⁵ International Energy Agency (IEA), *Oil 2018, Analysis and Forecasts to 2023*; Table 1.4: Bunker Deliveries, in OECD and main Non-OECD Countries (kb/d).

⁶ ISO 8217:2012, Table 2-Residual marine fuels.

7 Since residual fuels can contain virtually any components found in a refinery in different concentrations, it is an almost impossible task to standardize marine fuel oil composition. No one can say for sure which combination and concentration of chemical components will be encountered in a given fuel, at a given port, at a given time.

8 Marine engines are able to operate with almost any fuel – provided that it can be pumped and injected into the engine. Most unusual components likely go unnoticed as the engines burn them successfully. Looking at the statistics, marine fuels rarely cause significant problems. However, when something does go wrong it is a severe situation for the ship operator.

9 Endemic cases, where a series of vessel suffer similar problems related to batch(es) of fuels being supplied during a short period in the same area, surface every two to three years.

- .1 2010-2011, Polymethacrylate cases, Houston
Several vessels experienced sticking fuel pumps and some blacked out due to fuel starvation. The cause of the problem was presence of polymethacrylates in the fuel. The source of the contamination was the barge which carried various cargoes in between HFO.
- .2 2015, Corrosive fuels, East Russia
Several vessels experienced corrosion of filters, separators and fuel pumps. Significant amounts of investigative testing indicated that the fuels likely suffered from oxidation, resulting in corrosive organic acids being formed during operation. Although not confirmed, it is speculated that a new type of blend component had been added to these fuels.
- .3 2018, Sticking fuel pumps/separator sludging/filter clogging, Houston
Several vessels experience fuel pump sticking, sludging of separators and filter clogging after bunkering in Houston, March 2018. Some vessels reported corroded fuel pumps. Investigative analysis is still ongoing.

10 In all of the above situations, the routine fuel analysis showed that the ISO 8217⁷ limits for residual marine fuels were met, which indicates the complexities involved in identifying unusual components in fuel oils and the ability to link them to reported machinery problems.

Regulatory impact

11 Between 19 May 2005 with the entry into force of MARPOL Annex VI and 1 July 2010 with the entry into force of the revised MARPOL Annex VI, the sulphur requirements for fuels consumed in SECAs were established at 1.50% m/m. Whereas producing fuels with max 4.50% m/m sulphur fuel (which was global sulphur cap at the time) was not an issue, producing fuels with max sulphur content of 1.50% m/m, and later 1.00% m/m on and after 1 July 2010, required more blending.

12 As a result of the increased blending, the industry witnessed trends of higher average cat fines (Al+Si) content, higher density and generally less stable fuels. As the industry adapted to the low sulphur HFOs, the blends improved in the sense that fewer unstable fuels were supplied. The average high cat fines content, however, did not change during the years irrespective of the SECA sulphur requirement 1.50 % m/m or 1.00 % m/m respectively.

⁷ ISO 8217:2012, Table 2-Residual marine fuels.

13 On 1 January 2015, MARPOL Annex VI reduced the marine fuel sulphur requirements to 0.10 % m/m for vessels operating in SECAs. As a cheaper alternative to the traditional distillates, new types of fuels were introduced to the market – the Ultra-Low Sulphur Fuel Oils (ULSFOs).

14 The ULSFOs vary widely in composition. Some are blended products containing residuals; some ULSFOs are similar to distillate fuels except for their pour point.

15 In general, compared to the distillate fuels, the ULSFOs have higher viscosity, can contain some cat fines (Al+Si) and typically have a higher Pour Point to mention just a few of the differences. Although being an alternative to distillate fuels and not a residual product as such, the ULSFOs are sold as ISO 8217 residual grades, primarily RMD80 or RMG180 (ISO 8217, table 2) as these grades better cover the properties of the products as supplied.

16 A consequence of removing the max 1.00% m/m sulphur fuels from the market was an overall, average reduction in cat fines level (Al+Si). A blend component used in many 1.00% m/m sulphur fuels was slurry oil from the Fluidized Catalytic Cracker. Slurry oil is one of the lowest value refinery components and it is typically low in sulphur. The low sulphur marine fuels therefore became a good outlet for slurry oil.

17 The 2015 SECA compliant fuel oils introduced new challenges to the industry. The cleaner gas oils (MGO/DMA) have lower viscosity and although the ULSFOs have higher viscosities than MGO, they also have significantly higher pour point, and sometime a small gap between the clod point and pour point temperatures. They pose different challenges that also have to be managed on board, taking into consideration that material that was once used in road diesel is now being used in MGO against a less stringent specification/market.

Blend components

18 The main components of fuel blends can be separated in two categories:

- .1 paraffinic, or wax, are straight chained hydrocarbons. They exhibit excellent ignition and combustion properties but have inferior cold flow properties; and
- .2 aromatic are cyclic molecules which improve the stability of the fuel.

19 Residual streams contain asphaltenes. Asphaltenes are sticky molecules which agglomerate and eventually precipitate if not kept in suspension. Aromatics have a stabilizing effect on asphaltenes as they keep them suspended in the fuel.

20 Paraffins on the other hand, do not have the ability to keep the asphaltenes suspended. For the fuel blender, the target is to get the right balance between asphaltenes, aromatics and paraffins.

Trends in marine fuel supply

21 Oil refineries are becoming less involved in the production and supply of finished marine fuels.

22 Oil traders are becoming increasingly dominant in the supply and distribution of marine fuels. Oil traders tend to have their own tank farms/terminals where they:

- .1 import finished fuels;

- .2 import fuel components (from a wide variety of sources);
- .3 blend finished fuels in the most cost-efficient way, i.e. right up to as many spec limits as possible; and
- .4 supply fuels to ships.

What will oil traders import?

23 Essentially anything that will enable them to produce a fuel that meets the numbers in tables 1 or 2 of ISO 8217.

24 A fuel or some fuel components may be purchased:

- .1 from a known refinery;
- .2 from another trader who has blended their own imports;
- .3 as a distressed cargo on the sea – this can be a cargo that has been rejected by the original purchaser because it may be off spec in some way;
- .4 from ships debunkering off spec fuel; and
- .5 as a generic material such as "Cutter Stock" of unknown or partially unknown composition.

25 Very few traders can tell you with confidence what a fuel actually contains in terms of components.

Fuel properties

26 Although 2020 fuels are not yet widely available in the market, some parameters are expected to be more relevant than others. This section will explore the parameters of primary interest for 2020 fuel blends.

Stability and Compatibility

27 Stability is a measure of the fuel's ability to keep asphaltenes in suspension. If the asphaltenes come out of suspension (precipitates), the fuel is said to be unstable. When this happens, separators experience increased sludging and filters may block. In the worst cases, the separators overload and cannot operate properly.



28 It is not possible, on a vessel, to homogenize the fuel if it has gone unstable and the separators cannot remove all asphaltenes. It is a serious situation which typically results in the vessel having to offload the unstable fuel.

29 Whereas stability is a fuel property, compatibility is used to describe how two fuels will interact, if mixed.

30 Two perfectly stable fuels may result in an unstable mix where asphaltenes precipitate and cause sludging. Changing over between fuels is a known challenge that causes separator sludging and filter clogging. However, when the change-over has been completed, the excessive sludging is no longer an issue.

31 It is unavoidable that fuels are mixed in the piping during change-over. However, tanks should be run down as much as possible before changing between fuels in order to limit the period where sludging is a possibility and to avoid the development of a large amount of unstable fuel mix in tanks.

32 As such, it is important to be able to segregate bunkered fuels on board. If a new bunker is to be loaded on top of a previous fuel, it is strongly recommended to check the compatibility, at the given mix ratio, prior to bunkering. If the fuels are incompatible, mixing should be avoided.

33 There is no guarantee that a vessel bunkering 0.50% m/m sulphur at Rotterdam will then be able to pick up a compatible fuel in Singapore as it goes east. Some regions are expected to provide a 0.50% m/m solution based primarily on fuel oil, whilst others are expected to provide distillate-based solutions.

Test methods for stability checks

34 The main test methods used to evaluate stability are:

- .1 TSE (Total Sediment Existent), ISO 10307-1
The fuel sample is filtered as is.
- .2 TSP (Total Sediment Potential), ISO 10307-2
The fuel sample is stressed through heating before filtering.
- .3 TSA (Total Sediment Accelerated), ISO 10307-2
The fuel sample is stressed by chemicals before filtering.

35 Common for all three methods is that the amount of deposit collected on the filter is measured as an indication of how much sediment deposition comes out of the fuel.

36 If $TSE = TSP = TSA$, the fuel is dirty rather than unstable. Dirty fuels may also be challenging to filters and separators, but whereas unstable fuels cannot be managed on board, dirty fuels can be consumed, e.g. by diluting with a different, cleaner fuel (important note: Mixing of fuels should be limited to an absolute minimum until compatibility (see item on compatibility) between fuels have been confirmed).

37 If $TSE < TSP < TSA$, the fuel is unstable. The higher the TSA and TSP, the higher the risk of encountering sludging in the fuel system. Depending on the level of TSA and TSP, the fuel may be usable. However, storing and mixing fuels with an inferior stability should be avoided as time, heat and mixing are likely to worsen the situation.

Cold flow properties

38 Three properties are used when evaluating the flow properties of marine fuels:

- .1 Cloud Point (CP) (ISO 3015)
The temperature at which wax particles form in the fuel. At this point, the fuel goes "cloudy", thereof the name "Cloud Point". CP only applies to clear and bright fuels (usually distillates).
- .2 Cold Filter Plugging Point (CFPP) (ASTM D6371)
The temperature at which the sample can be drawn through a 45 micron filter within a specified time.
- .3 Pour Point (PP) (ISO 3016)
The temperature at which the fuel ceases to flow, i.e. where it is perceived as solid.

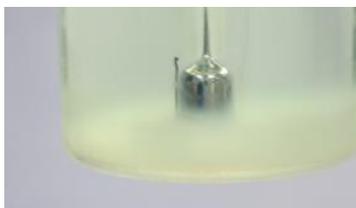


Figure 1: Cloud Point



Figure 2: CFPP



Figure 3: Pour Point

39 The CFPP and the PP can be suppressed by cold flow improving (CFI) additives, whereas the CP cannot be impacted by additives. The difference between CP, CFPP and PP is 3°C to 5°C for untreated fuels, with CP having the highest temperature and PP the lowest. Treated fuels may have a difference as large as 40°C to 50°C.

40 Although a few "fits all" products are available in the market, the most suitable CFI additives need to be chosen based on the actual fuel composition. This is why it is recommended that CFIs are applied at the terminal rather than on board the ship. Another reason is that it is complicated to ensure a homogeneous mixing on board.

41 Issues related to wax are:

- .1 Filter blocking (risk can be evaluated through the CP and CFPP).
Recommendation: Keep temperature above CFPP through separator(s) and filter(s).
- .2 Tank storage (risk can be evaluated through the PP).
Recommendation: Keep temperature at least 10°C above the PP.

42 The excellent ignition and combustion properties of wax are of no use if the fuel cannot be successfully injected into the engine. It is not uncommon to hear about fuels solidifying in tanks, or wax clogging filters and overloading separators during cold seasons.

43 In June 2015, the Marine Accident Incident Branch (MAIB)⁸ issued a safety bulletin about an "Auxiliary boiler explosion onboard the containership *Manhattan Bridge* at Felixstowe container terminal, England resulting in one fatality and one serious injury". The explosion may have been caused by wax deposition clogging the supply filter, restricting the amount of fuel reaching the boiler.

44 Investigations revealed inferior cold flow properties of the gas oil in use at the time, supporting that wax depositions could have built up in the fuel system.

Viscosity

45 Marine engines are designed for operation on HFO as that has been the economical fuel of choice for the majority of ship operators. Since HFO is a high viscosity product (up to 700 cSt at 50°C), the clearance between plunger and barrel in the fuel pump is designed for high viscosity fuels. Distillate fuels have lower viscosity and using such fuel in a fuel pump designed for high viscosity may result in internal leakages, especially if the fuel pump is worn. The consequence is that the pump is unable to inject a sufficient amount of fuel into the combustion chamber which makes it difficult to start and/or manoeuvre the engine.

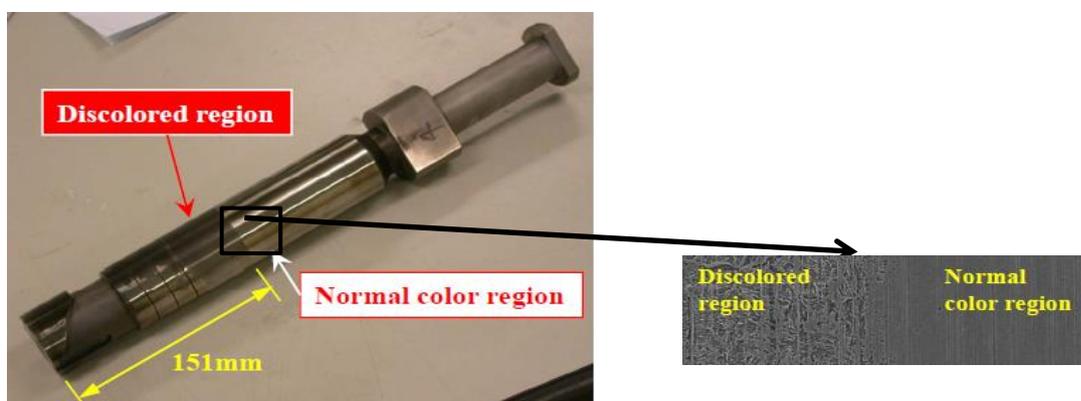
46 Viscosity is highly temperature dependent (the higher the temperature, the lower the viscosity). ISO 8217 specifies the viscosity at a reference temperature of 40°C for distillates and a minimum limit of 2 cSt at 40°C for distillate fuels (ISO 8217:2012 and ISO 8217:2017). In a hot engine room, even with the heating turned off, the temperatures at engine inlet can easily approach 50°C. Operators must therefore not forget this viscosity requirement to ensure safe operation at all times. It is important to note that viscosity related problems do not result in damages to the fuel pumps. Changing over to a higher viscosity fuel will facilitate proper injection again.

Acidity

47 Fuels with high acid numbers arising from acidic compounds occasionally cause accelerated damage to marine diesel engines.

48 Some sweet crude sources come with high AN - Acid Number (e.g. Doba crude).

49 Fuels with high acid number arising from acidic (not naphthenic) compounds occasionally cause accelerated damage to the injection equipment.



⁸ Marine Accident Incident Branch (MAIB) safety bulletin, June 2015.

Flashpoint

50 Flashpoint is one of the valid indicators of the fire and explosion hazard posed by the fuel. As required by SOLAS chapter II-2, regulation 4, the minimum flashpoint of any fuel used by the vessel or carried in its tanks should be not less than 60°C. A fuel with flashpoint less than 60°C falls therefore outside the SOLAS requirement and also the ISO 8217 specifications. There is no permissible negative tolerance. This applies to any fuel on board the vessel to which SOLAS applies, with an exception of fuel for lifeboats which can be grade DMX with a flashpoint min of 43°C.

51 In common understanding, a lower flashpoint is seen as an indicative factor for an increased risk of fire and explosion, but more importantly it constitutes a serious SOLAS violation and may also violate classification rules. In such a case the vessel's safety certificates may cease to be valid and the vessel will be no longer covered by insurance.

52 As indicated by several bunker alerts issued by well-respected fuel testing services (VPS, FOBAS, VeriFuel etc.) for ports of USA and Europe, mainly within SECAs, there have been several cases of samples representing distillate fuel deliveries with measured flashpoint down to 55°C. With increasing worldwide demand for low sulphur marine distillates as of 1 January 2020, some ports may offer automotive fuel instead that is not subject to SOLAS, as its flashpoint varies down to 50°C. Document CCC 4/INF.11 provides a table with the range of indicative flashpoints for worldwide land transport fuels.

53 It is of paramount importance for the safety of the vessel and the crew for the flashpoint of the fuel to be properly declared, ideally at the same time the Bunker Delivery Note (BDN) is provided to the ship.

2020 fuel considerations

54 The impact of IMO's maximum 0.50% m/m sulphur fuel legislation on the bunker industry is massive as it relates to about 75% of all supplied marine fuels. Not only will the fuels change in composition, but also the supply chain will have to adapt to the new environment as shoreside storage tanks, tank farms, barges etc. must be cleaned to avoid cross contamination by higher sulphur fuel products.

55 The marine industry has been a place to sell the residual refinery by-products, such as the high sulphur bottom of the barrel products; however, this will no longer be an option. Marine gas oil (MGO/DMA) is the premium quality option to meet the 0.50% m/m sulphur requirement, but this is also an expensive product. If/when demand increases, prices will also increase.

56 With 17 months to go before the 1 January 2020 deadline, suppliers and refiners are looking at their options, i.e. which fuels to place in the market to fulfill the sulphur legislation. Alternative blend components are likely to enter the market, e.g. vacuum gas oil (VGO). The details of these fuels are still proprietary and not shared with the industry, but there seems to be a common agreement that the 2020 fuels will re-introduce a larger degree of fuel blending (as was the case for the max 1.50% m/m and max 1.00% m/m sulphur fuels) to the market. In the IMO/Delft availability study, it was estimated at 75% to 80% of the total low sulphur supply.

57 Vacuum gas oil (VGO) is a potential blend component for the max 0.50% m/m sulphur fuels. Some VGOs have sulphur content in the 0.15% to 0.30% range which make them a candidate to blend up to 0.50% m/m sulphur, thereby getting rid of some higher sulphur bi-products. The challenge related to this option is that VGOs are paraffinic. High sulphur components are typically aromatic in composition and contain asphaltenes. The blender needs to be careful as mixing paraffinic and aromatic components can result in instability.

58 Some potential blend components are low viscosity products. A worst-case scenario would be a highly paraffinic fuel with low viscosity. This poses a challenge during handling, if the fuel has to be heated to avoid wax depositions in the separator and filters, and then subsequently cooled down before injection in order to meet the min 2 cSt viscosity at engine inlet.

59 An item which has not been touched upon yet is the risk of non-compliance. In the days of 1.50% m/m and 1.00% m/m sulphur fuels, a significant amount of fuels were supplied with sulphur exceeding the limits.

60 It must also be noted that on every analysis, there is an uncertainty level – the so-called reproducibility (which is applied by ISO 8217 through ISO 4259). If the true value of the sulphur analysis is for example 0.50%, there is 50% risk of getting a test result slightly above 0.50% and 50% risk of getting a result slightly below the 0.50%. The proposal by China (MEPC 72/5/7) to make the test methods provided in ISO 8754:2003 and ISO 14596:2007 for measuring the sulphur content of fuel oil mandatory in order to avoid any disputes has been forwarded by MEPC 72 to this Intersessional Meeting for further consideration.

61 A wise fuel blender includes a safety margin and sets the sulphur target below 0.50% m/m in order to limit the risk of exceeding the limit; however, the blender will go as close to target as possible to avoid giving too much valuable products away. Sometimes the supplier oversteps the target, and the closer he blends to 0.50% m/m, the higher the risk is that an analysis result comes out above the limit. According to the provisions of ISO 4259, the bunker supplier must not obtain a test result over the required specification limit value. This means that their target value should be lower than the specified sulphur content limit, i.e., the limit minus 95% target margin. Similar recommendations are also found in the CIMAC 2014 Guidelines – the interpretation of marine fuel oil analysis test results with particular reference to sulphur content.

Operational considerations

62 Refineries are not identical. Several American and some European refineries are currently installing delayed coker units which can convert all residuals into distillate components. It is, however, uncertain if these delayed cokers will be operational before 2020. Their realistic starting dates are mostly beyond 2020 (IEA, Oil Market Report 2018), and they are more likely to come on stream by 2023.

63 European and American refineries are old and, until the delayed cokers go into service, have a larger amount of residual products for which to find a source. Asian refineries are new and modern and provide a higher amount of distillate products, typically paraffinic. Regional differences therefore must be considered when bunkering max 0.50% m/m sulphur fuels. Fuels bunkered in Europe/America may be aromatic based with some asphaltenes whereas fuels bunkered in Asia may be more paraffinic. This will impact the risk of incompatibility between fuels, and the fuel management on board must be considered in this respect.

Risk of loss of propulsion during fuel switching

64 With the exception of vessels equipped with an approved exhaust gas cleaning system, ships will have to transition to using fuel oils with a maximum sulphur content of 0.50% m/m to comply with the 2020 sulphur cap. In addition, different batches of the same fuel blends (product) will have to undergo a fuel change-over. Experience following the establishment of the 1 January 2015 introduction of the 0.10% m/m sulphur limit indicates a marked increase in incidents of loss of propulsion and machinery problems when switching to operation on marine distillate fuels. The US Coast Guard (USCG) reported several incidents involving fuel leakages caused by fuel change-overs. Limited experience with compliant fuel does not place the proper safeguards to avoid leakages and pollution, engine room fire and loss of propulsion.

65 However, problems may occur even if following robust change-over procedures. The main differences lie in viscosity and flashpoint. Compliant fuels if heated run the risk of "flashing", vaporization and eventual loss of power. The lower viscosity compliant fuel cannot be sucked by the existing pumps without prior cooling. The compliant fuel is also a kind of a solvent/cleaner removing built-up asphaltenes and other waxy formations which then collect and clog the fuel filters and strainers. The load on the purifiers will be increased, requiring more frequent cleaning. Fuel is injected with positive displacement ram type pumps. Viscosity constitutes a barrier sealing the fit between fuel pump plunger and barrel. If the fit is tight, the pump seizes, or if it is worn with increased clearances, the required injection pressure will not be reached. This will result in engine black-out with potential detrimental effects for the ship and/or its surroundings.

66 It is well known from physics that a vessel without power automatically positions itself at 90 degrees with respect to the waves, experiencing maximum roll motions. It is thus imperative to manage the temperature of the fuel and the injection system components with the required viscosity so the thermal expansion is uniform. The rate of temperature change must be less than 2 degrees per minute to ensure uniform expansion and avoid loss of propulsion. The problem is more acute on boilers which were not designed to burn lighter fuel. In addition, deteriorated cold flow properties may cause loss of flame failure and explosion. As reported by the USCG, the experience from California is that fuel switch doubled the incidents of loss of propulsion, occurring once every three to five days off the coast of California.

67 These risks can be mitigated and managed by a number of operational and technical measures, including a management review, provision of appropriate onboard safety procedures and crew training. The co-sponsors consider that it is essential that such operational matters are considered by the organization when it deliberates implementation planning and safety risks associated with the 2020 transition to 0.50% m/m sulphur fuel.

Tank cleaning

68 Fuel storage tanks having carried HFOs for many years will contain high sulphur unpumpables in the bottom, and HFO sediments will have deposited on the tank walls. Settling and service HFO tanks have hopefully been regularly drained, but even so, sediments may have formed on tank walls/bottoms over the years. It is also likely to find deposits and sediments in the fuel piping.

69 As discussed earlier, 2020 fuels are expected to contain more distillate components than HFO. Distillates are known to have good solvency properties and to dissolve sediments. If a distillate based 2020 fuel is bunkered in a former, uncleaned HFO tank, the operators will face two challenges:

- .1 the high sulphur unpumpables will mix with the 2020 fuel, significantly increasing the risk of exceeding the 0.50% m/m sulphur limit at engine inlet; and
- .2 the 2020 fuel will dissolve the sediments/deposit in the tanks/piping and carry them with the fuel. As a result, filters may block and the separators have to work harder.

70 Experience has shown that it takes a long time (months) to completely remove years of HFO usage, even if the tanks have been cleaned. It is difficult to thoroughly clean all crevices and "pockets" in the tanks and piping.

71 Operators must therefore carefully plan the tank cleaning process prior to 1 January 2020, primarily to avoid being non-compliant due to high sulphur unpumpables having contaminated the fuel. Secondly, to avoid operational difficulties such as filter blocking.

72 The operators need to evaluate the fuel system of each vessel and the work required to clean the tanks. It should also be considered to flush the piping to eliminate the HFO remnants.

73 For the operator to get an idea of how long it will take to clean the system to an acceptable level, he/she should consider performing a trial on a vessel in his/her fleet.

- .1 How should the tank be cleaned? Manually or by adding distillate? If by adding distillate, is it possible to safely consume the distillate afterwards, or will it have to be discarded?;
- .2 After cleaning the tanks, pump distillate to that bunker tank and start changing over to that tank; and
- .3 Filters, separators and fuel pumps must be closely monitored:
 - .1 initial running of the purifier at the shorter sludge cycle time to prevent excess build up and carry-over of contaminants from the settling tank; and
 - .2 additional back-flushing of the fuel auto-filter can be expected because of the cleaning effect.

Heating capacities

74 2020 fuels are likely to be more paraffinic as experienced with the ULSFOs entering the market since 2015. Paraffinic fuels require operational temperatures above the pour point (for storage) and sufficient temperatures at filters to avoid wax deposition and filter clogging. The same fuel can be excellent for use in tropical conditions but cause problems in colder climates.

75 As such, it is important that the operator either purchases fuels with the cold flow properties required for the area of operation; or ensures that the fuel can be heated in tanks and filters. Not all vessels have sufficient heating capacity in the distillate tanks to ensure continuous heating throughout the voyage and only turn the heating on near port. However, if a fuel becomes "solid", it is not possible to melt it on board, as the heat required exceeds the heating capacity available on ships. Instead, the fuels must be kept liquid at all times by keeping the correct tank temperature based on the pour point of the bunkered fuel.

76 It is strongly recommended to heat trace the filters to avoid wax depositing on the filter elements. The heat can be turned on based on a combination of the cold flow properties of the bunkered fuel and the climate in which the vessel operates.

Tank segregation

77 Incompatibility between fuels is not a new challenge. It is a known issue that bunkering two HFOs on top of each other may result in incompatibility; however, it is expected that this risk becomes larger after 2020 due to the increase in paraffinic based products.

78 2020 fuels will lead to greater onboard tank segregation thereby reducing the vessel's total effective bunker tank capacity. It is recommended that operators evaluate their options to keep the fuels apart as much as possible to avoid incompatibility.

Post 2020

Ignition Quality

79 The ignition characteristic of a residual fuel is determined by the Calculated Carbon Aromaticity Index (CCAI) specified in ISO 8217. The CCAI is an indication of ignition performance in order to avoid fuels with an uncharacteristic density-viscosity relationship. The ignition and combustion characteristics of a residual fuel in a diesel engine is dependent on the particular type, design, operating and engine condition, load profile and the chemical properties of the fuel oil. In engine applications where the ignition quality is particularly critical, a basis for suppliers and purchasers of residual fuels to agree on tighter ignition quality characteristics. While residual fuels blending at or close to the maximum density, the CCAI limit can restrict the combination of density and viscosity.

80 The CCAI is determined from the density and viscosity of a residual fuel, and while it does not provide information related to the combustion characteristics of residual fuel, it does provide an indication of the ignition delay. CCAI has been included in order to avoid residual fuel oils with uncharacteristic density viscosity relationships, which can lead to an extended ignition delay. New fuels should have their CCAI verified in line with the ISO 8217 specifications.

Cat Fines

81 Catalytic fines (cat fines) in fuels are expected to increase with blended low sulphur fuels. Dealing with the larger quantities, which can cause damage to engine fuel injection equipment and pistons/liners, has resulted in focus on fuel systems having the necessary fuel purification and treatment equipment on board and a recognition that correct maintenance and regular cleaning of fuel tanks are essential to avoiding engine damage.

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