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Petroleum products — Fuels (class F) — Considerations for fuel suppliers and users regarding marine fuel quality in view of the implementation of maximum 0,50 % sulfur in 2020

Produits pétroliers — Combustibles (classe F) — Considérations à l'usage des fournisseurs de combustibles et des utilisateurs pour la qualité des combustibles pour la marine en vue de la mise en application de la teneur maximale en soufre de 0,50 % en 2020

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Foreword

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This document was prepared by Technical Committee ISO/TC 28, *Petroleum and related products, fuels and lubricants from natural or synthetic sources*, Subcommittee SC 4, *Classifications and specifications*.

Any feedback or questions on this document should be directed to the user’s national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

This document was developed in cooperation with ship owners, ship operators, classification societies, fuel testing services, engine designers, marine fuel suppliers, traders, fuel additive suppliers and the petroleum industry, in view of the implementation of maximum 0,50 mass % S in marine fuels in 2020 for operation outside Emission Control Areas (ECAs).

The increasing demands of environmental legislation are leading to a transition in the nature of marine fuels. This document takes into consideration the anticipated diverse range of characteristics of these marine fuels.

In view of the implementation date, it was considered that a revision of ISO 8217:2017 was not possible in the given timeframe. As such, the best option for the industry was the development of this document.

MARPOL Annex VI[1] aims among other things to reduce SO_x emissions from fuel oil combustion on board ships engines. This can be achieved by using fuels with a lower sulfur content or by operating an approved equivalent alternative mean (e.g. exhaust gas scrubber). It is the fuel purchaser's and the user's responsibility to establish applicable requirements and to specify on that basis the corresponding maximum fuel sulfur content required to the supplier.

Petroleum products — Fuels (class F) — Considerations for fuel suppliers and users regarding marine fuel quality in view of the implementation of maximum 0,50 % sulfur in 2020

1 Scope

This document addresses quality considerations that apply to marine fuels in view of the implementation of maximum 0,50 mass % S in 2020 and the range of marine fuels that will be placed on the market in response to the international statutory requirements to reduce exhaust gas emissions. It defines general requirements that apply to all 0,50 mass % sulfur (S) fuels and confirms the applicability of ISO 8217 for those fuels.

It gives technical considerations which might apply to particular fuels for the following characteristics:

— kinematic viscosity;

— cold flow properties;

— stability;

— ignition characteristics;

— catalyst fines.

Additionally, it provides considerations on the compatibility between fuels and additional information on ISO 8217:2017, Annex B (see Annexes B and D).

NOTE 1 For the purposes of this document, 0,50 mass % S fuels refers to distillate and residual fuels with a sulfur content up to 0,50 mass %.

NOTE 2 For the purposes of this document, “mass %” and “volume %” are used to represent the mass and volume fractions respectively.

NOTE 3 This document can also be used in conjunction with earlier editions of ISO 8217 in the event an earlier edition is referenced in the commercial agreement between parties.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 8217:2017, *Petroleum products — Fuels (class F) — Specifications of marine fuels*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
stability
stability of a residual fuel
resistance to the breakdown and precipitation of asphaltenic sludge despite being subjected to forces, such as thermal and ageing stresses, while handled and stored under normal operating conditions

3.2
compatibility
ability of two or more fuels to be commingled at a defined ratio without evidence of material separation, which could result in the formation of multiple phases, such as flocculation, where dispersed particles of asphaltenes form bigger clusters which might lead to sludge formation

3.3
stability reserve
ability of an oil to maintain asphaltenes in a peptized (colloidally dispersed) state and prevent flocculation of the asphaltenes

3.4
cloud point
CP
temperature at which a cloud of wax crystals first appears in a transparent liquid when it is cooled under specified conditions

[SOURCE: ISO 3015:2019, 3.1[2], modified — In the definition, liquid has been specified to be "transparent".]

3.5
cold filter plugging point
CFPP
highest temperature at which a given volume of distillate fuel fails to pass through a standardized filtration device in a specified time when cooled under standardized conditions

[SOURCE: IP 309[3]]

3.6
pour point
PP
lowest temperature at which a fuel will continue to flow when it is cooled under specified standard conditions

[SOURCE: ISO 3016:2019, 3.1[4], modified — In the definition, "sample of a petroleum product" has been replaced by "fuel".]

3.7 Total sediment-aged

3.7.1
potential total sediment
TSP
total sediment, determined by ISO 10307-1[15], after ageing a sample of residual fuel for 24 h at 100 °C under prescribed conditions

[SOURCE: ISO 10307-2:2009, 3.1[16]]

3.7.2
accelerated total sediment
TSA
total sediment, determined by ISO 10307-1, after dilution of a sample of residual fuel with hexadecane in the ratio of 1 ml per 10 g of sample under carefully controlled conditions, followed by storage for 1h at 100 °C

[SOURCE: ISO 10307-2:2009, 3.2]

4 General considerations for 0,50 mass % S marine fuels

4.1 Overview

This clause addresses aspects which apply to all fuels produced to meet a 0,50 mass % S limit.

4.2 Sulfur content

ISO 8217:2017, Table 1 and Table 2, do not set sulfur limits other than technical limits for the DM / DF grades in recognition that it is for the purchaser to specify the maximum sulfur content when ordering the fuel based on regulatory requirements applicable to where the fuel will be used. Consequently, sulfur is not a factor in selecting the grade category of an ordered fuel oil.

This means that the purchaser can continue to order the same grade of fuel as before and all corresponding specifications shall be met. In doing so, the required fuel characteristic specific limits for the treatment system and engines, such as CCAI, micro carbon residue, vanadium, aluminium and silicon, are met.

The measurement of the sulfur content shall be according to the test methods specified in ISO 8217.

4.3 Flash point

The flash point for all marine fuels under ISO 8217, except for DMX, is set at 60 °C minimum in accordance with the relevant requirements under the International Convention for Safety of Life at Sea (SOLAS)[5]. These values therefore continue to apply equally to marine fuels produced to meet a 0,50 mass % S limit.

It is therefore the responsibility of fuel suppliers to ensure that each fuel as delivered meets the flash point criterion.

4.4 Application of ISO 8217:2017 to 0,50 mass % S fuels

The fuels referenced in this document shall meet ISO 8217. All fuels within the scope of ISO 8217 produced to a 0,50 mass % S limit shall fall within either ISO 8217:2017, Table 1 and Table 2.

NOTE 1 Some fuels on the market meet ISO 8217:2017, Table 2 requirements while consisting of mainly high boiling asphaltenes-free material of petroleum refining. Their characteristics allow them to be considered within the context of ISO 8217:2017, Table 2, (See Annex A).

NOTE 2 It is expected that the kinematic viscosity of 0,50 mass % S fuels might vary widely, even within the same grade (see 5.2) and that 0,50 mass % S fuels can exhibit a directionally waxier nature (see 5.3).

5 Specific considerations for 0,50 mass % S marine fuels

5.1 Overview

This clause addresses aspects which may apply to particular marine fuels produced to meet a 0,50 mass % S limit.

5.2 Kinematic viscosity

Historically, fuels within the same grade were very similar in kinematic viscosity and typically close to the maximum limit of the ordered grade. The kinematic viscosity is expected to vary widely for 0,50 mass % S fuels, even within the same grade and is no longer the controlling characteristic that it once was. For example, some lower viscosity fuels may have other characteristics such as density, carbon residue and catalyst fines typical of higher viscosity grades. Therefore, particular attention should be given to the correct temperature and viscosity settings in the fuel system as different viscosity fuels should be adjusted to the correct temperature to comply with the machinery requirements. The kinematic viscosity of the fuel is therefore best communicated prior to delivery.

A low kinematic viscosity might have implications on the cold flow properties/wax formation of the fuel, see 5.3.

5.3 Cold flow properties/Wax formation

It is expected that the implementation of the 0,50 mass % S limit will result in a wider range of fuel formulations. There is a common understanding that some 0,50 mass % S fuels can exhibit tendencies towards being of a waxier nature.

Even when stored at a temperature at or above its pour point, the formation of wax crystals is possible in either a distillate or residual fuel, if the storage temperature is below the wax melting temperature. A fuel having a higher wax melting temperature might require heating significantly above its pour point temperature in order to dissolve the wax crystals, preventing them from precipitating in storage tanks and to avoid filter blocking in the fuel management system.

A consequence of this is that a fuel having a relatively low kinematic viscosity might not require much, or even any, heating to achieve the required engine injection viscosity but might nevertheless still require heating to melt the wax crystals present (see Annex A).

For distillate fuels in particular, the fuel purchaser should verify that the cold flow properties (CP, CFPP, PP) of the ordered fuel are suitable for the ship's fuel storage and management system design and the climate conditions expected to be encountered during the intended voyage. ISO 8217 includes the requirement to report CP and CFPP for winter grades of DMA, DMZ, DFA and DFZ.

NOTE More information can be found in the CIMAC guideline for managing cold flow properties of marine fuels[6].

5.4 Stability

The stability of a residual fuel is essential for the safe handling and use on board ships and for residual fuels the measure of the fuels resistance to precipitate asphaltenes is covered in ISO 8217:2017, Table 2, by total sediment-aged. In view of the diversity of the fuels being brought onto the market[17] to meet the 0,50 mass % S requirement, other test methods that might provide information on the stability and potential instability of fuels have also been evaluated (see Annex C).

NOTE More information can be found in the CIMAC guideline on General guidance in marine fuel handling in connection to stability and compatibility[7].

5.5 Ignition characteristics

The ignition characteristic of a residual fuel is addressed by the Calculated Carbon Aromaticity Index (CCAI) limits set down in ISO 8217:2017, Table 2 and will be applicable to 0,50 mass % S residual fuels. However, as with the best practices applied today on pre-2020 fuels, attention should be given to each newly sourced fuel put into use, ensuring machinery plant settings are correctly setup and manufacturers operating limits are not exceeded.

NOTE More information can be found in the CIMAC guideline on the Fuel Quality Guide Ignition and Combustion[8].

5.6 Catalyst fines

Catalyst fines (cat fines) might also be found in 0,50 mass % S fuels and the maximum limits on the content of Aluminium plus Silicon in ISO 8217:2017, Table 2, restrict the catalyst fines content in 0,50 mass % S fuels.

Because of the expected wider variation in kinematic viscosity for 0,50 mass % S fuels, even within the same grade, fuels with a lower viscosity might however still have catalyst fines typical of higher viscosity fuels.

6 Compatibility

Fuel blend formulations are expected to vary widely across the regions. Suppliers cannot guarantee the compatibility between different fuels of which one or both contain a residual component. Managing such fuels on board the ship relies on the competence of the fuel purchaser and the ship's crew. Ship operators should aim to minimize commingling of fuel to prevent fuel incompatibility issues. Applying full segregation between fuels is the preferred option but it is recognized that some degree of commingling on board the ship might not be possible to avoid, e.g. when switching between fuels.

Ship operators, as they do today, should consider the risk of incompatibility when using consecutive fuels from different ports and regions and are encouraged to continue to evaluate their segregation policy and the means to determine the compatibility between fuels on board and from on shore (see Annex C).

Annex A
(informative)

Fuel classification

Majority of today's high sulfur fuels are predominantly aromatic in nature and contain asphaltenes.

Some of the 0,50 mass % S fuels might have a different formulation than what is more generally seen before 2020; while they meet ISO 8217:2017, Table 2 requirements, these fuels might noticeably be consisting of mainly high boiling asphaltene-free material of petroleum refining.

These fuel formulations however typically exhibit good ignition quality, a high flash point and good lubricity characteristics; they are cleaner, deposit less ash than RM grades and normally have a higher kinematic viscosity and pour point than distillate marine fuel grades.

The behaviour of these fuel formulations is defined by their paraffinic/waxy nature. Due to the physical characteristics of these fuels, the cold flow properties (CP, CFPP) that have been introduced in ISO 8217:2017 cannot be determined. Cold flow behaviour of these fuels however, can best be characterized by the pour point. While the pour point of these fuels might be in the typical range of residual marine fuels, it should be recognized that these fuels might contain paraffinic/waxy components that melt only well above the fuels' pour point. In storage and transfer, these fuels should be heated/kept at a temperature at least 10 °C above the pour point. When purchasing the fuel, the vessel's fuel storage tanks heating capabilities should be considered and any constraints included in the ordering specification of the fuel. Where there are any constraints, the pour point and storage requirements should be obtained from the supplier prior to delivery.

Ship owners/crew should ensure therefore, that the vessel's fuel storage tanks heating capacity is sufficient to heat/keep the fuel at the recommended temperature.

It is further recommended to consider the viscosity of the fuel in relation to the cold flow properties of the fuel. Paraffinic/waxy components might require a higher temperature and therefore lower the viscosity of the fuel which might result in different viscosity settings of the fuel treatment system being required.

More information can be found in the CIMAC guideline for managing cold flow properties of marine fuels[6].

If commingling with residual fuels cannot be avoided, it should be minimized, or compatibility verified beforehand as asphaltenes present in residual fuels might not be kept in colloidal suspension (see Annex C).

NOTE Colloidal suspension, in which one substance of microscopically dispersed insoluble particles, is suspended throughout another substance.

Annex B
(informative)

Composition of marine fuels — ISO 8217:2017, Clause 5 and Annex B

ISO 8217:2017, Clauses 1 and 5, which is a general requirement directed to suppliers, are applicable to all marine fuels delivered in accordance with ISO 8217. Thereafter ISO 8217:2017, Table 1 or Table 2, as relevant, set down a number of category specific limits.

Marine fuels consist of a wide range of hydrocarbons from sources such as petroleum crude oil, synthetic or renewable sources, shale and tar sands, and potentially Fatty Acid Methyl Ester (FAME). The marine fuels standard is largely based on parameters related to operational performance/experience rather than a compositional standard.

In some cases, marine fuels that have met the ISO 8217:2017, Table 1 or Table 2 requirements have later gone on to cause operational problems despite the efforts of the ship to appropriately manage the fuel by applying best industry practices. At this point, after all appropriate operational procedures carried out have been confirmed, it could come into question as to whether the fuel contains deleterious materials and whether it has failed to meet the requirements of ISO 8217:2017, Clause 5. While these instances are infrequent, damage and loss of power and propulsion may occur.

In view of the above, advanced analytical investigative test methods are very often carried out on the fuel to determine if there is any anomaly in the composition of the fuel such as the presence of deleterious material, that could point to the cause of the problem, thus pointing to the failure of the fuel meeting Clause 5 general requirements.

It remains however difficult to break down the exact composition of a marine fuel and for most fuels supplied, this is neither needed nor feasible. It is however acknowledged that the ongoing advances in analytical techniques have made it possible to detect chemical species which could not be identified in the past. While there have been improvements in the capability to detect an increasing range of chemical species, it remains unknown if these species have been present previously in marine fuels and were consumed by vessels without operational issues or that they do warrant further consideration in the context of the investigation.

ASTM D 7845[10] is the often referred to standardised test method to identify individual components within a marine fuel. This test method offers a limited number of components where some are found within fuels on a regular basis without causing any operational difficulties. The test methods applied to detect components falling outside the scope of ASTM D 7845 are very often proprietary non-standardised and in-house test methods, generally used for investigative purposes. As such, results from one independent laboratory may not always be possible to reliably be compared to results obtained by another independent laboratory.

Best efforts are made to establish links between identified species and reported operational performance issues. However, even when incidents have occurred, sufficient data was generally not available to evaluate the effects of any one specific chemical species and/or combinations thereof.

This is further complicated when coming to consider the specific concentrations of the species detected and to be able to predict their possible impact on the variety of marine machinery systems in service, on personnel and/or on the environment. As such, it is currently very difficult to predict the potential behaviour of a fuel and whether it meets ISO 8217:2017, Clauses 1 and 5, solely based on the presence of what may be perceived as deleterious materials. If the presence of a chemical species at a concentration is recognized to have caused such operational problems, the fuel oil is deemed to have not met ISO 8217:2017, Clauses 1 and 5.

In cases where a ship suspects the specific fuel in use on board is the possible cause of the operational problems, applicable evidence should be gathered to support further investigation. Such evidence includes but is not limited to logging the case in detail, collecting further in-use fuel system samples, documenting the evidence leading up to, during and after the operational problems were experienced as well as any mitigating actions taken.

Fuel producers, suppliers, traders, fuel terminals and supply facilities should have in place adequate quality control procedures to ensure that the blend stocks used for formulating the 0,50 mass % S fuels are suitable for the use on board ship and that the fuel meets the requirements of ISO 8217:2017, 5.2, at the point of custody transfer.

Annex C
(informative)

Stability

Stability of a residual fuel is essential for the safe handling and use of the fuel on-board ships and is covered by the ISO 8217 requirement of the total sediment aged with the limit of 0,10 mass %.

The composition of residual fuels is complex to define (depends on crude source and refining processes) but generally residual fuels include asphaltenes, resins and liquid hydrocarbons. Asphaltenic sludge can precipitate when the asphaltenes, which are high molecular weight polar molecules having a predominantly aromatic structure, are not kept in colloidal suspension. This can occur when the fuel is subjected to forces, such as thermal and ageing stresses, the degree of which will be a function of time and temperature.

To enable long term stability, every fuel should be manufactured to withstand the expected forces through normal on board use and normal on board storage. It does however not necessarily follow that two stable fuels when mixed together form a stable mixture. When storing fuel, this should be kept in mind. Every attempt should therefore be made to segregate different fuels.

The study[9] undertaken to evaluate the stability and the compatibility between marine fuels, in view of the implementation of maximum 0,50 mass % S in 2020 and the range of marine fuels that will be available on the market, showed that some fuels might exhibit a TSA well within the 0,10 mass % but when using the referee method, may exhibit a TSP exceeding 0,10 mass %. To ensure that the total sediment aged limit as specified in ISO 8217:2017, Table 2 has been met, it is recommended to use the referee test method.

Annex D
(informative)

Commingling of fuels

D.1 General

The risk of incompatibility between fuels has always existed and the commingling of residual fuels onboard is not recommended. However, commingling of fuels to some degree may be unavoidable if total segregation is not possible. In these cases, the compatibility between two fuels should be first determined to provide an informed decision as to whether to proceed with the commingling or not. Despite the risk, prior to 2020, limited operational issues were experienced because majority of the fuels were proven to be compatible in the proportions they were commingled.

Due to the expected higher variety in fuels composition post 2020, the risks for incompatibility between fuels might increase. The best practice of either complete segregation or controlled commingling in combination with compatibility checks prior to commingling, should be maintained.

A fuel supplier cannot possibly guarantee that the delivered fuel is compatible with the fuel on board a ship without testing. Therefore, the ship's crew should manage the risks, as some degree of mixing of different fuels on board a ship cannot be avoided, and many ships today already have procedures in place to minimize the mixing. The design and layout of the ship's fuels' storage and treatment system vary from vessel to vessel making it impracticable to make a standard recommendation for switching between fuels.

Instead, each ship should define its own loading and handling procedures to mitigate the risk of commingling incompatible fuels on board.

D.2 Pre-delivery compatibility testing and fuel formulation

Compatibility can, at present, only be determined between two identified components. Hence, if samples of both the fuel to be delivered and the fuel with which it is intended to be mixed are available then compatibility testing, prior to delivery, can be undertaken.

Suppliers are encouraged to provide information on the nature/type of the fuel in way of its typical variable characteristics such as viscosity, density and cold flow properties. This can help the ship's crew to better prepare and manage the fuel on board the ship.

D.3 Additional test methods and indicators to evaluate stability and compatibility of fuels

D.3.1 ASTM D 4740

ASTM D 4740[11], commonly known as "spot test" is a quick and first pass approach and already today often applied, either on board or in a laboratory, to evaluate the cleanliness of fuels and the compatibility between fuels. A frequently used ratio is a 50:50 mix of the two fuels. However, the true ratio in which two fuels will be commingled, if known, can be used for preparing a more representative sample for the compatibility check.

Mixtures of paraffinic/waxy fuels and e.g. marine gasoils or other paraffinic fuels sometimes have been rated high by this spot test, although none of the fuels contained any significant level of asphaltenes. This is because for such combination of fuels, any apparent inner ring in the spot to be evaluated might be caused by substances other than flocculated asphaltenes (e.g. waxes, coke) and can mistakenly be

