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# Products from petroleum, synthetic and renewable sources — Fuels (class F) — Specifications of marine fuels

*Produits d'origine pétrolière, synthétique ou renouvelable — Combustibles (classe F) — Spécifications des combustibles pour la marine*



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# Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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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*.

This seventh edition cancels and replaces the sixth edition (ISO 8217:2017), which has been technically revised.

The main changes are as follows:



- terms and definitions (Clause 3) have been updated;
- the Scope and the general requirements in Clause 5 have been amended;
- Tables 2 and 3 have been added;
- former Table 2 has been modified and has become Table 4;
- changes to the distillate fuels, including the following:
  - the requirement to report the fatty acid methyl ester(s) content (FAME) of DF grades has been changed, allowing up to 100 %;
  - the distinction between winter and summer quality for cloud point and cold filter plugging point has been removed;
  - the requirement to report the net heat of combustion for DF grades has been added;
  - a minimum cetane number requirement for DF grades has been added;
  - the requirement for oxidation stability for DF grades has been added;
- Clauses 9 and 10 have been added;
- new Annexes F, H and K have been added (the former Annex F has become Annex G, the former Annex G has become Annex I, and the former Annex H has become Annex J);

— existing annexes have been reviewed and updated.

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 prepared in cooperation with ship owners, ship operators, shipping associations, national standards bodies, classification societies, fuel testing services, engine designers, fuel treatment equipment manufacturers, marine fuel suppliers, fuel additive suppliers and the petroleum industry to meet the requirements for marine fuels supplied on a world-wide basis for consumption on board ships.

The increased focus on environmental concerns and legislation to address them is leading to a transition in the nature of marine fuels. There is a shift away from marine fuels supplied from traditional oil products derived from the processing of petroleum crude, and a shift towards oil products derived from synthetic and renewable, recycled or alternative sources. This document takes into consideration the diverse nature of these fuels and incorporates a number of categories of distillate and residual fuels, even though it is possible that not all categories are available in every supply location. This document facilitates the transition, however sustainability aspects and accounting are not within the scope.

The categories of fuel in this document have been classified according to ISO 8216-1 and include the distillate fuel categories DMX, DMA, DMB, DMZ, DFA, DFB, DFZ and the residual fuel categories RMA, RME, RMG, RMK and RF.

In the instances where a fuel, which does not conform exactly to any of these distillate or residual fuel categories, is offered to a purchaser, the fuel characteristics or limits can be agreed between the buyer and the seller, and defined by both a category of fuel given by this document, together with any different or additional fuel characteristics or limits, as necessary to adequately define that fuel.

This document specifies the permitted minimum flash point limits following the provisions given in the SOLAS Convention.[3]

MARPOL Annex VI,[4] which controls air pollution from ships, includes a requirement that either the fuel does not exceed a specified maximum sulfur content, or an approved equivalent alternative means is used. During the lifetime of this document, regional and/or national authorities can introduce their own local emission requirements, which can impact the allowable sulfur content. It is the buyer's and the user's responsibility to establish which statutory requirements are necessary to meet and specify on that basis the corresponding maximum fuel sulfur content to the seller.

# Products from petroleum, synthetic and renewable sources — Fuels (class F) — Specifications of marine fuels

**WARNING — The handling and use of products specified in this document can be hazardous if precautions as mentioned in the Safety Data Sheet (SDS) are not taken into consideration when product is handled. This document does not purport to address all the safety and health considerations that can be associated with its use. It is the responsibility of the users of this document to establish appropriate safety and health practices and to determine the applicability of regulatory limitations prior to use.**

## 1 Scope

This document in its entirety defines the general requirements and specifications for fuels used in marine diesel engines and boilers, prior to onboard fuel handling (storage, settling, centrifuging, filtration, heating) before use.

For the purposes of this document, the term "fuels" comprises of the following:

— hydrocarbons from petroleum crude oil, oil sands and shale oil;

— synthetic hydrocarbons, renewable hydrocarbons or hydrocarbons from recycled sources, with molecular structures that are indistinguishable from petroleum hydrocarbons;

— fatty acid methyl ester (FAME), where permitted as specified in this document;

— blends of any of the above, where permitted as specified in this document.

The general requirements and specifications for fuels in this document can also be applied to fuels used in stationary diesel engines of the same or similar type as those used for marine purposes.

This document specifies seven categories of distillate fuels, one of which is for diesel engines used for emergency purposes. It also specifies four categories of residual fuels for sulfur content at or below 0,50 % by mass, five categories of residual fuels containing FAME and five categories of residual fuels for sulfur content exceeding 0,50 % by mass.

## 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 2719, *Determination of flash point — Pensky-Martens closed cup method*

ISO 3015, *Petroleum and related products from natural or synthetic sources — Determination of cloud point*

ISO 3016, *Petroleum and related products from natural or synthetic sources — Determination of pour point*

ISO 3104, *Petroleum products — Transparent and opaque liquids — Determination of kinematic viscosity and calculation of dynamic viscosity*

ISO 3675, *Crude petroleum and liquid petroleum products — Laboratory determination of density — Hydrometer method*

ISO 3733, *Petroleum products and bituminous materials — Determination of water — Distillation method*

ISO 4259-2, *Petroleum and related products — Precision of measurement methods and results — Part 2: Interpretation and application of precision data in relation to methods of test*

ISO 4264, *Petroleum products — Calculation of cetane index of middle-distillate fuels by the four variable equation*

ISO 5165, *Petroleum products — Determination of the ignition quality of diesel fuels — Cetane engine method*

ISO 6245, *Petroleum products — Determination of ash*

ISO 8754, *Petroleum products — Determination of sulfur content — Energy-dispersive X-ray fluorescence spectrometry*

ISO 10307-1, *Petroleum products — Total sediment in residual fuel oils — Part 1: Determination by hot filtration*

ISO 10307-2, *Petroleum products — Total sediment in residual fuel oils — Part 2: Determination using standard procedures for ageing*

ISO 10370, *Petroleum products — Determination of carbon residue — Micro method*

ISO 10478, *Petroleum products — Determination of aluminium and silicon in fuel oils — Inductively coupled plasma emission and atomic absorption spectroscopy methods*

ISO 12156-1, *Diesel fuel — Assessment of lubricity using the high-frequency reciprocating rig (HFRR) — Part 1: Test method*

ISO 12185, *Crude petroleum, petroleum products and related products — Determination of density — Laboratory density meter with an oscillating U-tube sensor*

ISO 12205, *Petroleum products — Determination of the oxidation stability of middle-distillate fuels*

ISO 12937, *Petroleum products — Determination of water — Coulometric Karl Fischer titration method*

ISO 14596, *Petroleum products — Determination of sulfur content — Wavelength-dispersive X-ray fluorescence spectrometry*

ISO 14597, *Petroleum products — Determination of vanadium and nickel content — Wavelength-dispersive X-ray fluorescence spectrometry*

EN 116, *Diesel and domestic heating fuels — Determination of cold filter plugging point — Stepwise cooling bath method*

EN 14077, *Petroleum products — Determination of organic halogen content — Oxidative microcoulometric method*

EN 14078, *Liquid petroleum products — Determination of fatty methyl ester (FAME) content in middle distillates - Infrared spectrometry method*

EN 14214, *Liquid petroleum products — Fatty acid methyl esters (FAME) for use in diesel engines and heating applications — Requirements and test methods*

EN 15195, *Liquid petroleum products — Determination of ignition delay and derived cetane number (DCN) of middle distillate fuels by combustion in a constant volume chamber*

EN 15751, *Automotive fuels — Fatty acid methyl ester (FAME) fuel and blends with diesel fuel — Determination of oxidation stability by accelerated oxidation method*

EN 15940, *Automotive fuels — Paraffinic diesel fuel from synthesis or hydrotreatment — Requirements and test methods*

EN 16329, *Diesel and domestic heating fuels — Determination of cold filter plugging point — Linear cooling bath method*

EN 16715, *Liquid petroleum products — Determination of ignition delay and derived cetane number (DCN) of middle distillate fuels — Ignition delay and combustion delay determination using a constant volume combustion chamber with direct fuel injection*

EN 17155, *Liquid petroleum products — Determination of indicated cetane number (ICN) of middle distillate fuels — Primary reference fuels calibration method using a constant volume combustion chamber*

ASTM D240, *Standard Test Method for Heat of combustion of Liquid Hydrocarbon Fuels by Bomb Calorimeter*

ASTM D664, *Standard Test Method for Acid Number of Petroleum Products by Potentiometric Titration*

ASTM D2622, *Standard Test Method for Sulfur in Petroleum Products by Wavelength Dispersive X-ray Fluorescence Spectrometry*

ASTM D4294, *Standard Test Method for Sulfur in Petroleum and Petroleum Products by Energy Dispersive X-ray Fluorescence Spectrometry*

ASTM D6751, *Standard Specification for Biodiesel Fuel Blend Stock (B100) for Middle Distillate Fuels*

ASTM D6890, *Determination of Ignition Delay and Derived Cetane Number (DCN) of Diesel Fuel Oils by Combustion in a Constant Volume Chamber*

ASTM D7371, *Standard Test Method for Determination of Biodiesel (Fatty Acid Methyl Esters) Content in Diesel Fuel Oil Using Mid Infrared Spectroscopy (FTIR-ATR-PLS Method)*

ASTM D7668, *Standard Test Method for Determination of Derived Cetane Number (DCN) of Diesel Fuel Oils—Ignition Delay and Combustion Delay Using a Constant Volume Combustion Chamber Method*

ASTM D7963, *Standard Test Method for Determination of Contamination Level of Fatty Acid Methyl Esters in Middle Distillate and Residual Fuels Using Flow Analysis by Fourier-Transform Infrared Spectroscopy-Rapid Screening Method*

ASTM D8183, *Standard Test Method for Determination of Indicated Cetane Number (ICN) of Diesel Fuel Oils using a Constant Volume Combustion Chamber—Reference Fuels Calibration Method*

IP 470, *Determination of aluminium, silicon, vanadium, nickel, iron, calcium, zinc and sodium in residual fuel oil by ashing, fusion and atomic absorption spectrometry*

IP 500, *Determination of the phosphorus content of residual fuels by ultra-violet spectrometry*

IP 501, *Determination of aluminium, silicon, vanadium, nickel, iron, sodium, calcium, zinc and phosphorus in residual fuel oil by ashing, fusion and inductively coupled plasma emission spectrometry*

IP 570, *Determination of hydrogen sulfide in fuel oils — Rapid liquid phase extraction method*

IP 631, *Determination of the contamination level of fatty acid methyl esters in middle distillate and residual fuels using Flow Analysis by Fourier Transform Infrared Spectroscopy — Rapid Screening Method*



## 3 Terms and definitions

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

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

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

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

**3.1**
**ultra low sulfur fuel oil**
**ULSFO**
marine fuel with a maximum sulfur content of 0,10 % by mass

**3.2**
**very low sulfur fuel oil**
**VLSFO**
marine fuel with a maximum sulfur content of 0,50 % by mass

**3.3**
**high sulfur fuel oil**
**HSFO**
marine fuel with a sulfur content exceeding 0,50 % by mass

**3.4**
**fatty acid methyl ester**
**FAME**
ester derived by transesterification or esterification of fats and oils of vegetal or animal origin

Note 1 to entry: See Annex A for information on bio-based liquid fuels including fatty acid methyl ester(s).

**3.5**
**bio-based**
wholly or partly derived from *biomass* (3.7)

[SOURCE: ISO 16559:2022, 3.23, modified — "wholly or partly" added.]

**3.6**
**biofuel**
fuel produced directly or indirectly from *biomass* (3.7)

[SOURCE: ISO 16559:2022, 3.27, modified — "solid, liquid or gaseous" deleted.]

**3.7**
**biomass**
material of biological origin excluding material embedded in geological formations and/or fossilized

[SOURCE: ISO 16559:2022, 3.32, modified — Example and Note 1 to entry deleted.]

**3.8**
**biodiesel**
generic name for *bio-based* (3.5) fuel with properties similar to diesel or diesel containing bio-based blends

Note 1 to entry: The term is often used to describe *fatty acid methyl ester (FAME)* (3.4), but it is not exclusive to describe FAME or fuel containing FAME.

**3.9**
**bio-distillate marine fuel**
blend of a petroleum distillate marine fuel with *bio-based* (3.5) liquid fuel

Note 1 to entry: DF grade is used to describe bio-distillate marine fuel grade.

**3.10**
**bio-residual marine fuel**
blend of a petroleum residual marine fuel with *bio-based* (3.5) liquid fuel

Note 1 to entry: RF grade is used to describe bio-residual marine fuel grade.

**3.11**
**synthetic hydrocarbon**
liquid hydrocarbon obtained from synthesis

**3.12**
**renewable hydrocarbon**
liquid hydrocarbon produced from renewable resources

Note 1 to entry: *Biomass* (3.7) is an example of a renewable resource.

**3.13**
**paraffinic diesel fuel**
liquid hydrocarbons obtained by synthesis or hydrotreatment

EXAMPLE Synthetic diesel, renewable diesel, *hydrotreated vegetable oil (HVO)* (3.14).

**3.14**
**hydrotreated vegetable oil**
**HVO**
liquid hydrocarbon produced from renewable feedstock by hydrotreatment

Note 1 to entry: Also called renewable diesel or *paraffinic diesel fuel* (3.13).

**3.15**
**gas to liquid**
**GTL**
liquid hydrocarbons obtained by the conversion of natural gas or other fossil gaseous hydrocarbons

**3.16**
**biomass to liquid**
**BTL**
liquid hydrocarbons obtained by the conversion of *biomass* (3.7) via thermochemical processes (gasification)

**3.17**
**power to liquid**
**PtL**
liquid hydrocarbons obtained by conversion of electricity



**3.18**
**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 stored, handled and treated under normal operating conditions

[SOURCE: ISO/PAS 23263:2019, 3.1, modified — “handled and stored” replaced by “stored, handled and treated”.]



**3.19**
**compatibility**
ability of two or more fuels to be commingled at a defined ratio without evidence of material separation, which can result in the formation of multiple phases, such as flocculation, where dispersed particles of asphaltenes form bigger clusters which can lead to sludge formation

[SOURCE: ISO/PAS 23263:2019, 3.2, modified — “could” and “might” replaced by “can”.]

**3.20**
**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/PAS 23263:2019, 3.4]

**3.21**
**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: ISO/PAS 23263:2019, 3.5]

**3.22**
**pour point**
**PP**
lowest temperature at which a fuel will continue to flow when it is cooled under specified standard conditions

[SOURCE: ISO/PAS 23263:2019, 3.6]

**3.23**
**existent total sediment**
**TSE**
sum of insoluble organic and inorganic material, separated from the bulk of the sample by filtration through a specified filter, and also insoluble in a predominantly paraffinic solvent

Note 1 to entry: TSE is obtained by hot filtration.

[SOURCE: ISO 10307-1:2009, 3.1, modified — "existent" added to the term; "TSE" added as a preferred term; Note 1 to entry added.]

**3.24**
**potential total sediment**
**TSP**
total sediment after ageing a sample of residual fuel for 24 h at 100 °C under prescribed conditions

[SOURCE: ISO 10307-2:2009, 3.1, modified — "TSP" added as a preferred term; "determined by ISO 10307-1," deleted from the definition.]

**3.25**
**accelerated total sediment**
**TSA**
total sediment 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 1 h at 100 °C

[SOURCE: ISO 10307-2:2009, 3.2, modified — "TSA" added as a preferred term; "determined by ISO 10307-1," deleted from the definition.]

**3.26**
**unrefined used lubricating oil**
**unrefined ULO**
oil that has not been processed and filtered to remove lube oil additives and contaminants

Note 1 to entry: Refined used lubricating oil can be suitable as blend stock for marine fuel.

## 4 Application and sampling

This document specifies the required properties for a fuel at the time and place of custody transfer, prior to onboard handling and treatment.

NOTE Appropriate guidance about fuel treatment systems for diesel engines can be found in Reference [5].

Sampling of a fuel is an important part of the fuel's quality verification and should be carried out in accordance with ISO 13739 or an equivalent national standard. The sample shall be representative for the entire quantity of fuel loaded onto the receiving ship and may be taken in any location agreed between the parties.

Testing of the fuel shall be carried out in accordance with the test methods given in Table 1, Table 2, Table 3 or Table 4, as appropriate.