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# GUIDELINES FOR USE OF LOW SULPHUR FUEL OILS IN SHIPS

2013

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# 0 Foreword

New $SO_x$ emission control criteria are developed or implemented in MARPOL Annex VI, EU directive and CARB regulations successively, requiring the use of low sulphur fuel oils with a sulphur content not exceeding 0.10% m/m when ships operating within specified areas (such as the emission control areas specified in MARPOL Annex VI, EU ports, waters of 24 n miles from California coast and its ports). For the requirements for the limit of the sulphur content of fuel oils used by ships, see Table 0.

Note: For users' easy reference, Table 0 only gives part of the requirements for the limit of sulphur content of fuel oils used by ships, the date of implementation and implementation areas as specified in MARPOL Annex VI, EU Low Sulphur Directive 2005/33/EC and Titles 13 and 17 of California Code of Regulations. For detailed requirements are to be referred to the above-mentioned convention, directive/regulations.

**List of Requirements for the Limit of Sulphur Content of Fuel Oils Table 0**

| Convention/Regulations | Sulphur content of fuel oils (% m/m) | Date of implementation | Implementation area |
|---|---|---|---|
| MARPOL Annex VI | 3.50 | 1 January 2012 | Outside $SO_x$ emission control area |
| | 0.50[1] | 1 January 2020 | |
| | 1.00 | 1 July 2010 | Inside $SO_x$ emission control area[2] |
| | 0.10 | 1 January 2015 | |
| EU Directive | 0.10 | 1 January 2010 | EU ports[3] |
| CARB Regulations | 1.50[4]<br>0.50[5] | 1 July 2009 | California waters[6] |
| | 1.00[4]<br>0.50[5] | 1 August 2012 | |
| | 0.10[4]<br>0.10[5] | 1 January 2014 | |

Notes:1. A group of experts has been established by IMO to analyze and evaluate the global fuel oil supply and demand and the trends in fuel oil markets so as to determine the availability of such fuel oils. If IMO determines that it is not possible for ships to comply with this limit, then the criterion for fuel oils having a sulphur content up to 0.50% m/m will be implemented on 1 January 2025.

2. The emission control areas as specified in regulation 14 of MARPOL Annex VI include at present: Baltic Sea area, North Sea area, North American area and Caribbean Sea area (to be implemented on 1 January 2014).

3. Ships berthing at EU ports (including anchoring, mooring on buoy, alongside dock) for more than 2 hours are not allowed to use fuel oils with a sulphur content exceeding 0.10%.

4. Marine gas oil, corresponding to DMA grade "Distillate Fuel" as specified in ISO 8217 standard.

5. Marine diesel oil, corresponding to DMB grade "Distillate Fuel" as specified in ISO 8217 standard.

6. 24 n miles from California coast and its ports.

In order to produce such low sulphur fuel oils, oil refineries often desulphurize fuel oils with special technologies and procedures, leading to significant changes to many characteristics of low sulphur fuel oils. Since the fuel oil system and machinery installations of ships are normally designed for heavy oil/marine diesel oil and there is less experience in the use of low sulphur fuel oil, the changeover to low sulphur fuel oil will possibly cause failure of the fuel oil system and equipment or even the risk of losing power for the ship.

During the design or conversion of a ship, changes to the characteristics of low sulphur fuel oil are to be considered comprehensively and possible risks to the ship due to the use of low sulphur fuel oil are to be identified systematically. Measures are to be taken from aspects of design, arrangement, monitoring and alarms, operating procedures on the basis of risk analysis results so as to keep the risks and associated hazards within an acceptable range.

The Guidelines have been developed on the basis of the study on effects of the use of low sulphur fuel oils, giving special requirements for the design, arrangement, control and monitoring, operation and test of the systems and equipment related to the use of low sulphur fuel oils as a supplement to CCS rules. The aim of the Guidelines is to provide guidance to the design/conversion, survey and test of ships and not to replace the provisions and operational requirements of any conventions, statutory regulations or directives.

It is not possible for the Guidelines to cover all equipment and systems using low sulphur fuel oil. For each ship, the machinery installations are to be evaluated by qualified persons. The possible risks due to the changeover and use of different fuel oils are to be identified, and a suitable design or conversion plan and applicable procedures are to be developed. The detailed evaluation report will be provided.

# Chapter 1 General

## 1.1 Application

1.1.1 The Guidelines apply to ships using low sulphur fuel oils in order to comply with requirements of MARPOL ①, regional or national directive/regulations ②.

Note: The term low sulphur fuel oil in the Guidelines refers specifically to the distillate fuels having a sulphur content not exceeding 0.10% m/m, see the definition of 1.2.1(1).

1.1.2 Unless otherwise specified, the requirements this guideline are only supplementary to the relevant CCS rules, not replacing the relevant provisions of any conventions, statutory regulations or directives.

## 1.2 Definitions and abbreviations

1.2.1 For the purpose of the Guidelines, the following definitions apply:

(1) Low sulphur fuel oil (LSFO) means the distillate fuel complying with all criteria of ISO 8217: 2010 standard, except that its sulphur content is not over 0.10% m/m.

Note: For users' easy reference, the requirements for distillate marine fuels as specified in ISO 8217: 2010 are tabulated in Appendix 2 of these Guidelines. For detailed requirements, the original standard is to prevail.

(2) Fuel oil (FO) means the normal fuel oils other than LSFO, which are normally supplied to main and auxiliary engines as well as boilers when the ship operates outside the $SO_x$ emission control areas (such as HFO, MDO).

(3) Marine diesel oil (MDO) means the distillate fuels complying with all criteria of ISO 8217:2010 standard, excluding LSFO.

(4) Heavy fuel oil (HFO) means the residual fuels complying with all criteria of ISO 8217:2010 standard.

Note: For users' easy reference, the requirements for residual marine fuels as specified in ISO 8217:2010 are tabulated in Appendix 3 of the Guidelines. For detailed requirements, the original standard is to prevail.

(5) $SO_x$ emission control area (SECA) means an area ③ where, in pursuance of the convention, regional or national directive/regulations mentioned in 1.1.1 above, only LSFO may be used.

1.2.2 For the purpose of the Guidelines, the following abbreviations are used:

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① MARPOL Annex VI.

② EU Directive (EU Low Sulphur Directive 2005/33/EC), CARB regulations (Titles 13 and 17 of California Code of Regulations).

③ Emission control areas as specified in Regulation 14 of MARPOL Annex VI, ports as specified in EU directive, waters and ports as specified in CARB regulations.

(1) CARB: California Air Resources Board.

(2) EU: European Union.

### 1.3 Plans and documents

1.3.1 In addition to the plans and documents as required in CCS Rules for Classification of Sea-Going Steel Ships, the following plans and documents are to be submitted for approval:

(1) Details of viscosity/temperature control of LSFO (if applicable), including chiller system, operating principle, control system and instructions for operation (according to 2.5.4);

(2) On-board test procedure (according to 1.5);

(3) Control, monitoring and safety systems of boilers (according to 3.3);

(4) List of alarm and indication points (according to 2.6.1).

1.3.2 In addition to 1.3.1, the following plans and documents are to be submitted for information:

(1) LSFO tanks capacity calculations (according to 2.2.2);

(2) Declarations and relevant information from manufacturers (according to 3.1);

(3) Calculations for changes of LSFO viscosity/temperature (according to 2.5.3);

(4) Operation manual (according to Chapter 4);

(5) Risk analysis report (according to 1.4).

### 1.4 Risk analysis

1.4.1 A recognized method for risk analysis/assessment is to be used to analyze and evaluate the safety issues in relation to the use and changeover of LSFO.

1.4.2 Appendix 1 of the Guidelines may be taken as reference for factors to be considered, contents of report and analysis table during risk analysis.

### 1.5 On-board tests

1.5.1 On-board tests are to be carried out for ships using LSFO according to the relevant requirements of CCS Rules for Classification of Sea-Going Steel Ships to confirm that continuous operation of related systems and equipment on LSFO. The functions of control, alarm and safety protection systems relating to the use of LSFO are to be verified.

1.5.2 Fuel oil changeover is to be tested to verify that the changeover between FO and LSFO may be completed safely and reliably by the system and that relevant parameters are kept within the specified range. If the cylinder oil needs to be changed for engine operation in fuel oil changeover, the changeover of cylinder oil is also to be tested.

1.5.3 If the LSFO as specified in 1.1.1 is not available for the test, marine diesel oil may be substituted as an alternative. The marine diesel oil is to be heated during the test so as to decrease the viscosity close to that of LSFO. A report for the use of LSFO is to be submitted to CCS during the first periodical survey of the ship after using LSFO for the first time, and at least the following items are to be included:

– specifications of LSFO;

– duration of the changeover to LSFO and position of the ship;

– equipment operating with LSFO and operation loads;

– operating time of the equipment and key parameters (such as temperature/viscosity of fuel oil);

– control, monitoring and safety protection functions;

– assessment of the operation condition of equipment.

# Chapter 2 Fuel Oil Systems

## 2.1 General requirements

2.1.1 The flash point of LSFO is to comply with the requirements of paragraph 1.2.9, Chapter 1, PART THREE of CCS Rules for Classification of Sea-Going Steel Ships.

2.1.2 Where the mixing of fuel oils during the changeover between fuel oils is required according to the system design, the compatibility between various fuel oils mixed is to be ensured.

## 2.2 Storage of fuel oils

2.2.1 Dedicated LSFO storage tanks are to be provided on board, arranged not directly adjacent to heated tanks so as to prevent LSFO from being heated.

2.2.2 The LSFO storage capacity is to be sufficient for the consumption needed for ships operating in an intended emission control area or berthing and the consumption of LSFO is to be calculated taking into account various fuel oil consumption factors comprehensively.

## 2.3 Daily service tank and settling tank

2.3.1 Depending on different fuel oils used by main and auxiliary engines and boilers, the daily service tanks of LSFO may be provided as follows:

(1) For ships outside an emission control area with main and auxiliary engines and boilers operating with heavy fuel oil, where heavy fuel oil and marine diesel oil daily service tanks are provided in accordance with Section 2 of Chapter 4, PART THREE of CCS Rules for Classification of Sea-Going Steel Ships, the LSFO daily service tank may be provided as follows:

① an independent LSFO daily service tank with the capacity for at least 8 h operation of the ship; or

② a marine diesel oil daily service tank (or heavy fuel oil daily service tank) is substituted for a LSFO daily service tank with the capacity for at least 8 h operation of the ship, the arrangement and design of the system is to allow the heating means (if any) of the heavy fuel oil or marine diesel oil daily service tank to be reliably stopped, and there is to be sufficient time for such substitute daily service tank and the system being fully flushed to remove all the fuel oils with a sulphur content exceeding the limit for LSFO before the ship enters the emission control area.

(2) For ships outside an emission control area with main engines and boilers operating with heavy fuel oil and auxiliary engines operating with diesel oil, where heavy fuel oil and marine diesel daily service tanks being provided in accordance with Section 2 of Chapter 4, PART THREE of CCS Rules for Classification of Sea-Going Steel Ships, the LSFO daily service tank may be provided as follows:

① an independent LSFO daily service tank with the capacity for at least 8h operation of the ship; or

② a marine diesel oil daily service tank (or heavy fuel oil daily service tank) is substituted for a LSFO daily service tank with the capacity for at least 8 h operation of the ship, the arrangement and design of the system is to allow the heating means (if any) of the heavy fuel oil or marine diesel oil daily service tank to be reliably stopped, and there is to be sufficient time for such substitute daily service tank and the system being fully flushed to remove all the fuel oils with a sulphur content exceeding the limit for LSFO before the ship enters the emission control area.

(3) For ships outside an emission control area and using LSFO as marine diesel oil, the provision of daily service tanks is to comply with the requirements of Section 2 of Chapter 4, PART THREE of CCS Rules for Classification of Sea-Going Steel Ships. However, all marine diesel oil daily service tanks are to be substituted by LSFO daily service tanks with the total capacity for at least 8 h operation of the ship.

2.3.2 For ships calling at EU ports only or operating less than 8 h within an $SO_x$ emission control area (including the time for fuel oil changeover while entering or leaving the emission control area), the capacity of LSFO daily service tanks may be provided based on the actual consumption needed. However, the provision of other fuel oil daily service tanks is to comply with the requirements of Section 2 of Chapter 4, PART THREE of CCS Rules for Classification of Sea-Going Steel Ships.

2.3.3 For ships constructed before 1 July 1998, the capacity of LSFO daily service tanks may be provided based on the actual consumption needed.

2.3.4 Dedicated LSFO settling tanks are normally to be provided on board ships. If the quality of LSFO complies with the fuel specifications of the equipment manufacturer without settling, purifying or other treatment, or the LSFO in the storage tank may be transferred directly to the daily service tank after being purified by a separator, the dedicated LSFO settling tank is not required.

2.3.5 The LSFO daily service tank and settling tank are not to be directly adjacent to heated tanks so as to avoid LSFO from being heated.

**2.4 Fuel oil transfer and treatment piping systems**

2.4.1 Fuel oil pumps and purifiers are to be suitable for the LSFO used.

2.4.2 The LSFO transfer and treatment piping systems are to be separated from other fuel oil piping systems, or there is to be sufficient time for the piping systems being fully flushed so as to avoid contamination of fuel oils.

**2.5 Fuel oil supply piping system**

2.5.1 For ships intending to use heavy fuel oil or marine diesel oil outside emission control areas and LSFO in such areas, the arrangement of fuel oil pumps is to comply with the following requirements.

(1) Outside emission control areas:

Two fuel oil pumps are to be provided, as specified in 4.2.2.2 and 4.2.3.1 of Chapter 4, PART THREE of CCS Rules for Classification of Sea-going Steel Ships.

(2) Within emission control areas one of the following configurations:

① two fuel oil pumps as in (1) instead of separate LSFO pumps, provided these are both suitable for LSFO and each is capable of delivering fuel oil at the required capacity for normal operation of the ship;

② when both of the two fuel oil pumps in (1) are suitable for LSFO but one pump alone is not capable of delivering fuel oils at the required capacity, then both pumps may operate in parallel to achieve the required capacity for normal operation of the ship. In this case, one separate fuel oil pump is to be provided in addition to the two fuel oil pumps as specified in (1). The additional pump is, when operating in parallel with one of the pumps in (1), to be suitable for and capable of delivering LSFO at the required capacity for normal operation of the ship;

③ when the two fuel oil pumps as in (1) are not suitable for LSFO, two separate LSFO pumps are to be provided additionally, each capable of supplying fuel oil at the required capacity for normal operation of the ship.

Note 1: The requirement for alarm at automatic start of standby pumps applies to separate LSFO pumps for ships holding the class notation for unattended machinery space.

Note 2: Where electrical power is required for the operation of propulsion machinery, the requirements are also applicable for machinery for power generation when such machinery is supplied by common fuel supply pumps.

Note 3: The required capacity for normal operation of the ship means the capacity required for the operation of equipment at rated load.

2.5.2 During the changeover to LSFO, a mixing tank is normally to be provided for mixing of fuel oils having different temperatures so as to avoid thermal shock to machinery installations and fuel oil systems due to drastic fuel oil temperature changes.

2.5.3 In order to ensure that the viscosity of LSFO under various conditions complies with the requirements for machinery installations, the temperature/viscosity of LSFO at the inlet of machinery installations is to be calculated. Factors such as working loads, fuel oil changeover, ambient temperature and possible thermal transfer and thermal accumulation during normal operation of the ship are to be considered for the calculation.

2.5.4 A dedicated fuel oil cooling system (such as seawater cooling or cooling through a refrigerating system) is to be provided if the viscosity of LSFO does not comply with the requirements for machinery installations upon calculation according to 2.5.3. The cooling system is to comply with the following requirements in addition to the relevant requirements of PART THREE of CCS Rules for Classification of Sea-Going Steel Ships.

(1) The fuel oil cooling system is to be designed taking into account the refrigerating capacity needed for the operation of machinery installations using fuel oil, e.g. main and auxiliary engines, boilers at various loads, ensuring that the temperature and temperature changes of fuel oil are maintained within the specified range.

(2) The fuel oil cooling system is to have automatic temperature control. Means for manual operation are to be provided.

(3) The surface temperature of coolers is to be maintained above the pour point of fuel oil.

(4) Where the fuel oil pressure exceeds the cooling medium pressure, means for detection of leakage are to be provided.

2.5.5 An independent piping system is to be provided for LSFO. However, a piping system common to LSFO and to other fuel oils may be provided if:

(1) all heaters may be reliably stopped or bypassed and indication of the status of the heating system is provided;

(2) the system is capable of being fully flushed before the ship enters an emission control area so as to ensure that the sulphur content of fuel oils used by equipment complies with the requirements of relevant conventions, regional or national directives/regulations.

2.5.6 Return oil pipes/re-circulating pipes are to be so designed and arranged as to prevent the contamination of LSFO tanks from high sulphur fuel oils.

2.5.7 Means are to be provided to prevent excessive heating of LSFO when a machinery installation is in standby mode.

2.5.8 Fuel oil pump relief valves are not to discharge to the suction side of the pumps.

**2.6 Controls, alarms and indications**

2.6.1 In addition to the relevant requirements of CCS Rules for Classification of Sea-Going Steel Ships, the following alarms or indications are to be considered for the controls, alarms and indications of LSFO:

– alarm for high temperature or low viscosity;

– alarm for low temperature (if a refrigerating system is provided);

– alarm for low water level in fuel oil cooling system expansion tank (if provided);

– indication of status of the heating system (in operation or not), if common to fuel oil systems.

2.6.2 Where any difference exists in the setting of alarms of different fuel oils, means are to be provided to prevent any false alarm or improper action being activated in fuel oil changeover.

# Chapter 3 Machinery Installations

## 3.1 General requirements

3.1.1 The manufacturers of machinery installations (diesel engines, boilers, separators, fuel oil pumps, etc.) are to declare that their products are capable of continuous operation on LSFO. Such declarations are to include details on the use of LSFO such as operational capability, possible conditions and limitations, control and safety systems.

3.1.2 Conditions or limitations for the use of or the changeover to LSFO are not to impair the normal operation of machinery installations.

## 3.2 Diesel engines

3.2.1 The quality of the cylinder oil (alkalinity) and the arrangement of its system are to be suitable for the engine operation with fuel oils having different sulphur contents.

3.2.2 Where different cylinder oils are required to be used for the engine operation with fuel oils having different sulphur contents, the cylinder oil tank and system are to be so designed and arranged as to be suitable for the storage and use of various cylinder oils.

3.2.3 Where a diesel engine operates with fuel oils having different sulphur contents, the engine is to be operated and checked according to the requirements of the manufacturer, giving particular attention to the adjustment of cylinder oil feed rate and the cylinder oil changeover .

3.2.4 If the modifications of engines for operation with LSFO affect their $NO_x$ emissions, the engines are to be re-inspected and re-certified according to the Guidelines for Testing and Survey of Emission of Nitrogen Oxides from Marine Diesel Engines.

## 3.3 Boilers

3.3.1 Necessary means are to be provided to prevent excessive heating of LSFO when the boiler and burner are in standby mode.

3.3.2 The burner and its nozzles are to be so designed, arranged and installed as to be suitable for the properties of fuel oils used, giving particular attention to the difference in the calorific value, viscosity and density of LSFO.

3.3.3 Means are to be provided to prevent LSFO from the risks of vaporization, coke deposit or self-ignition due to heating before being sprayed.

3.3.4 After the operation of a boiler with LSFO, its furnace is to be fully scavenged so as to reduce the risk of explosion as far as possible.

3.3.5 The flame detection device of boilers is to be suitable for the different combustion characteristics of various fuel oils.

3.3.6 The boiler control system is to be designed to ensure safe and reliable operation of the boiler, taking into account different properties of various fuel oils.

3.3.7 The need for scavenging under various conditions is to be considered for the boiler control system, such as fully scavenging the furnace before ignition, after the extinction of flame or normal stop of the boiler.

# Chapter 4 Operation Manual

## 4.1 General requirements

4.1.1 Operation manuals are to be provided on board the ship.

4.1.2 The operation manual is to include at least the following:

(1) Procedures for the use and changeover of LSFO (see 4.2);

(2) Conditions and limitations relating to the use and changeover of LSFO;

(3) Operation and check;

(4) Maintenance;

(5) Emergency procedures (see 4.3).

## 4.2 Fuel oil changeover

4.2.1 Operational details, parameters to be monitored, time needed for changeover, control of changeover conditions (e.g. fuel oil temperatures, temperature gradient, loads), emergency measures relating to fuel oil changeover are to be specified in the changeover procedures.

4.2.2 The time needed for fuel oil changeover is to be calculated through the method specified by the equipment manufacturer, taking into account such factors as the amount of residual oil in daily service tanks, loads of equipment, temperature differences of fuel oils and temperature change gradient.

4.2.3 Where a different lubricating oil is required for operation of the engine after fuel oil changeover, an appropriate procedure for lubricating oil changeover is to be developed.

4.2.4 In order to avoid any failure due to human error during fuel oil changeover as far as possible, an automatic changeover system is recommended for fuel oil changeover. The automatic changeover system (if provided) is to be approved by CCS and is to be capable of manually operated to complete fuel oil changeover according to the specified procedures.

## 4.3 Emergency procedures

4.3.1 Appropriate emergency procedures are to be developed for possible failures during the LSFO changeover or operation with LSFO, such as incompatibility of fuel oils during mixing, excessive vaporization due to improper fuel oil changeover, failure of the automatic fuel oil changeover system, starting failure of diesel engines operating with LSFO, ignition or flame failure of boilers operating with LSFO, so as to reduce the harms caused by failures during the use of LSFO as far as possible.

The emergency procedures are to be completely included in the operation manual described in 4.1.

## Appendix 1 Risk Analysis

1 Dangers caused by the change of properties of LSFO are to be considered comprehensively, in particular the possible effects on fuel oil system and machinery installations due to the different sulphur content, calorific value, viscosity, density, flash point and lubricity.

2 Systems and equipment related to the use and changeover of LSFO are to be considered as far as possible.

3 In general, the following are to be included in a risk analysis report:

(1) Standards and methods used for the analysis;

(2) Assumptions and preconditions made for the analysis;

(3) Analysis objects, such as systems, equipment, operations, etc.;

(4) Possible risks;

(5) Causes of the risks;

(6) Possible effects of the risks;

(7) Measures taken to prevent or reduce the harms of risks and implementation.

4 A generic work sheet for risk analysis is given in Table 1 for guidance.

**Risk Analysis Sheet (Example)** **Table 1**

| Analysis item | Risk | Cause | Potential effects | Safety protection | Improvement measures |
|---|---|---|---|---|---|
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

## Appendix 2 Distillate Marine Fuels (from ISO 8217: 2010)

| Characteristics | | Unit | Limit | Category ISO-F | | | | Test method reference |
|---|---|---|---|---|---|---|---|---|
| | | | | DMX | DMA | DMB | DMZ | |
| Kinematic viscosity at (40℃)[a] | | $mm^2/s$ | max. | 5.500 | 6.000 | 6.000 | 11.00 | ISO 3104 |
| | | | min. | 1.400 | 2.000 | 3.000 | 2.000 | |
| Density at (15℃) | | $kg/m^3$ | max. | — | 890.0 | 890.0 | 900.0 | see 7.1, ISO 3675 or ISO 12185 |
| Cetane index | | — | min. | 45 | 40 | 40 | 35 | ISO 4264 |
| Sulfur[b] | | % (m/m) | max. | 1.00 | 1.50 | 1.50 | 2.00 | see 7.2, ISO 8754, ISO 14596 |
| Flash point | | ℃ | min. | 43.0 | 60.0 | 60.0 | 60.0 | see 7.3, ISO 2719 |
| Hydrogen sulfide[c] | | mg/kg | max. | 2.00 | 2.00 | 2.00 | 2.00 | IP 570 |
| Acid number | | mg KOH/g | max. | 0.5 | 0.5 | 0.5 | 0.5 | ASTM D664 |
| Total sediment by hot filtration | | % (m/m) | max. | — | — | — | 0.10[e] | see 7.4, ISO 10307-1 |
| Oxidation stability | | $g/m^3$ | max. | 25 | 25 | 25 | 25[f] | ISO 12205 |
| Carbon residue: micro method on the 10 % volume distillation residue | | % (m/m) | max. | 0.30 | 0.0 | 0.30 | — | ISO 10370 |
| Carbon residue: micro method | | % (m/m) | max. | — | — | — | 0.30 | ISO 10370 |
| Cloud point | | ℃ | max. | −16 | — | — | — | ISO 3015 |
| Pour point (upper)[d] | winter quality | ℃ | max. | −6 | −6 | −6 | 0 | ISO 3016 |
| | summer quality | ℃ | max | 0 | 0 | 0 | 6 | ISO 3016 |
| Appearance | | — | — | Clear and bright[j] | | | [e, f, g] | see 7.6 |
| Water | | % (V/V) | max. | — | — | — | 0.30[e] | ISO 3733 |
| Ash | | % (m/m) | max. | 0.010 | 0.010 | 0.010 | 0.010 | ISO 6245 |
| Lubricity, corrected wear scar diameter (wsd 1, 4) at (60℃)[h] | | μm | max. | 520 | 520 | 520 | 520[g] | ISO 12156-1 |

a 1 $mm^2/s$ = 1 cSt.

b Notwithstanding the limits given, the purchaser shall define the maximum sulfur content in accordance with relevant statutory limitations. See Annex C.

c Due to reasons stated in Annex D, the implementation date for compliance with the limit shall be 1 July 2012. Until such time, the specified value is given for guidance. For distillate fuels the precision data are currently being developed.

d Purchasers should ensure that this pour point is suitable for the equipment on board, especially if the ship operates in cold climates.

e If the sample is not clear and bright, the total sediment by hot filtration and water tests shall be required, see 7.4 and 7.6.

f If the sample is not clear and bright, the test cannot be undertaken and hence the oxidation stability limit shall not apply.

g If the sample is not clear and bright, the test cannot be undertaken and hence the lubricity limit shall not apply.

h This requirement is applicable to fuels with a sulfur content below 500 mg/kg (0.050 mass %).

j If the sample is dyed and not transparent, then the water limit and test method as given in 7.6 shall apply.

## Appendix 3 Residual Marine Fuels (from ISO 8217: 2010)

| Characteristic | | Unit | Limit | Category ISO-F- | | | | | | | | | | | Test method reference |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | RMA | RMB | RMD | RME | RMG | | | | RMK | | | |
| | | | | 10.00[a] | 30.00 | 80.00 | 180.0 | 180.0 | 380.0 | 500.0 | 700.0 | 380.0 | 500.0 | 700.0 | |
| Kinematic viscosity at (50℃)[b] | | $mm^2/s$ | max. | 10.00 | 30.00 | 80.00 | 180.0 | 180.0 | 380.0 | 500.0 | 700.0 | 380.0 | 500.0 | 700.0 | ISO 3104 |
| Density at (15℃) | | $kg/m^3$ | max. | 920.0 | 960.0 | 975.0 | 991.0 | 991.0 | | | | 1010.0 | | | see 7.1, ISO 3675 or ISO 12185 |
| CCAI | | — | max. | 850 | 860 | 860 | 860 | 870 | | | | 870 | | | see 6.3 a) |
| Sulfur[c] | | % (m/m) | max. | Statutory requirements | | | | | | | | | | | see 7.2, ISO 8754, ISO 14596 |
| Flash point | | ℃ | min. | 60.0 | 60.0 | 60.0 | 60.0 | 60.0 | | | | 60.0 | | | see 7.3, ISO 2719 |
| Hydrogen sulfide[d] | | mg/kg | max. | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | | | | 2.00 | | | IP 570 |
| Acid number[e] | | mg KOH/g | max. | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 | | | | 2.5 | | | ASTM D664 |
| Total sediment aged | | % (m/m) | max. | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | | | | 0.10 | | | see 7.5, ISO 10307-2 |
| Carbon residue: micro method | | % (m/m) | max. | 2.50 | 10.00 | 14.00 | 15.00 | 18.00 | | | | 20.00 | | | ISO 10370 |
| Pour point(upper)[f] | winter quality | ℃ | max. | 0 | 0 | 30 | 30 | 30 | | | | 30 | | | ISO 3016 |
| | summer quality | ℃ | max. | 6 | 6 | 30 | 30 | 30 | | | | 30 | | | ISO 3016 |
| Water | | % (V/V) | max. | 0.30 | 0.50 | 0.50 | 0.50 | 0.50 | | | | 0.50 | | | ISO 3733 |
| Ash | | % (m/m) | max. | 0.040 | 0.070 | 0.070 | 0.070 | 0.100 | | | | 0.150 | | | ISO 6245 |
| Vanadium | | mg/kg | max. | 50 | 150 | 150 | 150 | 350 | | | | 450 | | | see 7.71, IP 501, IP 470 or ISO 14597 |
| Sodium | | mg/kg | max. | 50 | 100 | 100 | 50 | 100 | | | | 100 | | | see 7.8, IP 501, IP 470 |
| Aluminium plus silicon | | mg/kg | max. | 25 | 40 | 40 | 50 | 60 | | | | 60 | | | see 7.9, IP 501, IP 470 or ISO 10478 |
| Used lubricating oils (ULO): calcium and zinc; or calcium and phosphorus | | mg/kg | — | The fuel shall be free from ULO. A fuel shall be considered to contain ULO when either one of the following conditions is met: calcium > 30 and zinc > 15; or calcium > 30 and phosphorus > 15 | | | | | | | | | | | see 7.10, IP 501 or IP 470, IP 500 |

a This category is based on a previously defined distillate DMC category that was described in ISO 8217:2005, Table 1. ISO 8217:2005 has been withdrawn.
b 1 $mm^2/s$ = 1cSt.
c The purchaser shall define the maximum sulfur content in accordance with relevant statutory limitations. See 0.3 and Annex C.
d Due to reasons stated in Annex D, the implementation date for compliance with the limit shall be 1 July 2012. Until such time, the specified value is given for guidance.
e See Annex H.
f Purchasers shall ensure that this pour point is suitable for the equipment on board, especially if the ship operates in cold climates.