PRACTICAL CONSIDERATIONS FOR THE TRANSITION TO 2020 COMPLIANT FUEL

ABS

PRACTICAL CONSIDERATIONS FOR THE TRANSITION TO 2020 COMPLIANT FUEL

OVERVIEW

The IMO 2020 global sulfur limit requirements become effective on 01 January 2020. Common compliance options to address these requirements include the use of compliant fuels, the use of alternative fuels with a sulfur content less than 0.50% such as LNG, or the installation of an exhaust gas cleaning system, commonly known as a scrubber. This document introduces the regulatory requirements and outlines items to be considered when sulfur limit compliant fuel is selected as the compliance option.

Regulation 14 of IMO MARPOL Annex VI requires fuels with a sulfur content not more than 0.50% to be used globally from 1 January 2020. Fuel options to comply with this requirement include:

- Residual Marine Fuel (RMF) with a sulfur content above 0.10%, not exceeding 0.50%, that requires some form of heating to achieve required injection viscosity for combustion
- Distillate Marine Fuel (DMF) with a sulfur content above 0.10%, not exceeding 0.50%, that does not require heating to achieve injection viscosity

This global sulfur cap limit is in addition to the existing 0.10% sulfur content limit on the use of fuels in Emission Control Areas (ECAs), which has been in effect since 1 January 2015. Fuel options to comply with the 0.10% limit include:

- Low sulfur residual marine fuel (LSRMF) with a sulfur content not exceeding 0.10% that requires some form of heating to achieve required injection viscosity for combustion, or
- Low sulfur distillate marine fuel (LSDMF) with a sulfur content not exceeding 0.10% possessing a minimum viscosity of 1.4 cSt at 40°C

This document focuses on the items to be considered when transitioning from high sulfur heavy fuel oil (HFO) to the use of low sulfur limit compliant fuel including completing appropriate hazard analysis and the development of Ship Implementation Plans.

Compliance solutions which incorporate the use of a SOX scrubber or use of alternative fuels such as LNG for the sulfur limit compliance are outside the scope of this paper.

REGULATORY REQUIREMENTS

In IMO designated Emission Control Areas (ECAs), compliance with a sulfur limit of 0.10% has been in force since 01 January 2015. Beginning 01 January 2020, a global 0.50% sulfur limit will go into effect. In addition to IMO requirements, there are regional and local requirements that may be applicable as illustrated in Figure 1 below.

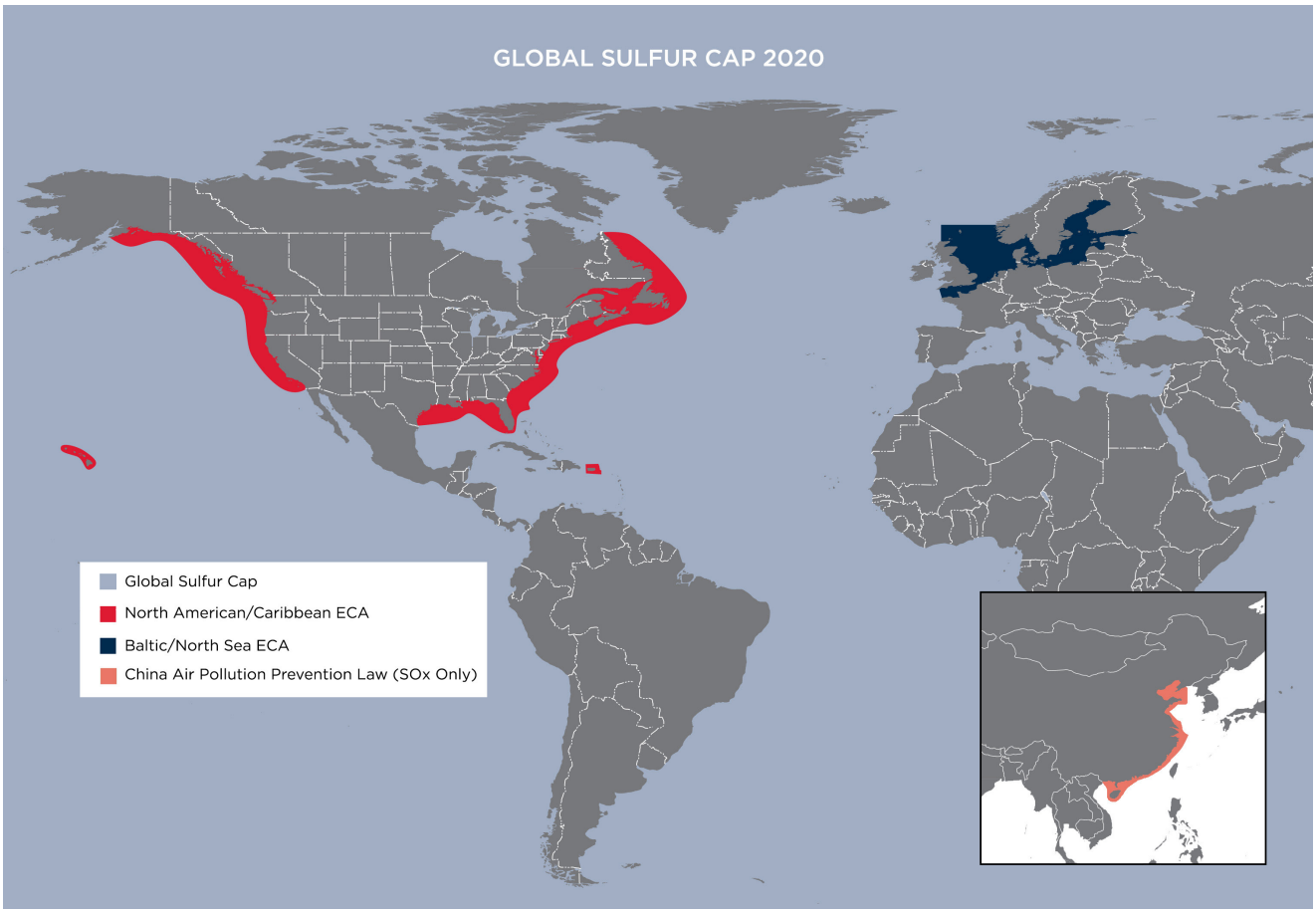

Figure 1: IMO and Local Emission Control Areas for Fuel Sulfur Limit

Examples of local and regional requirements addressing fuel sulfur content are:

- **European Union**. EU Sulphur Directive 1999/32/EC, as amended by Directives 2005/33/EC and 2009/30/EC (codified under Directive EU 2016/802/EU) mandates all ships use fuel with a maximum sulfur content of 0.10% when at berth, including at anchor, while in EU ports for stays more than two hours. A scrubber may be used as an equivalent subject to washwater discharge restrictions by some EU member states.
- **State of California**. The Ocean Going Vessel (OGV) Fuel Regulation (13 CCR § 2299.2/17 CCR § 93118.2) requires compliance via 0.10% maximum sulfur content distillate fuel within California-regulated waters. A scrubber is not an acceptable equivalent.
- **The People's Republic of China**. The People's Republic of China Air Pollution Prevention Law, as per the Ministry of Transport (MoT) Notice 2018-168 and supplemented by China Maritime Safety Administration (MSA) Notice 2018-555 dated 29 December 2018, requires ships to use fuel with a maximum:
  - 0.50% sulfur content while operating within ECAs defined by the Law beginning 01 January 2019
  - 0.10% sulfur content while operating in the inland water emission control areas from 01 January 2020 and around the island of Hainan beginning 01 January 2022.

Operation of a scrubber as an equivalent alternative may be subject to restrictions, as discharge of washwater from open loop systems is not permitted in the China Inland Water ECA, Bohai Rim Waters, and port areas within the Coastal ECA.

SELECTION AND APPLICATION OF COMPLIANT FUEL

When compliant fuel is selected to address the 0.50% sulfur limit, the following items need to be considered:

1. Fuel Quality
2. Vessel Design/Modification
   - Fuel oil storage, settling and service tanks, and segregation
   - Suitability of existing equipment and systems
3. Operational Considerations
   - Tank cleaning
   - Fuel switching
4. Fuel Oil Procurement
5. Documentation and Reporting
6. Crew training

To assist in the identification of hazards, and to appropriately document their mitigation, a risk assessment focusing on the impact of the change to compliant fuel should be performed.

FUEL QUALITY

For global sulfur limit compliance, it is expected that low sulfur marine fuel of 0.50% maximum sulfur content will be commonly used. As stated in the ISO Statement issued in July 2018, such fuel will be fully capable of being categorized within the existing ISO 8217 standard, and to meet the general requirements found in ISO 8217:2017 and all characteristics noted in Tables 1 and 2 of the standard. ISO is currently developing guidance regarding the application of the existing ISO 8217 standard to low sulfur fuels.

As the industry transitions through the 2020 period, it is expected that most of the low sulfur fuel available to the marine industry will be blended products, commonly known as 0.50% max sulfur fuel oil. These fuels are based on vacuum gas oil (VGO), or blends incorporating various heavy and light refinery product streams, including residual fuel oils and middle distillates. These vary from the traditional distillates due to the variation of their compositions. Key quality concerns associated with these fuels include:

- Compatibility
- Stability
- Catalytic (“cat”) fines
- Density
- Flash point
- Ignition and combustion characteristics
- Unusual components
- Pour point
- Viscosity
- Lubricant compatibility

COMPATIBILITY

Mixing different blends of fuel may lead to the formation of asphaltenes and heavy sludge in the fuel oil system, resulting in a potential blockage and loss of fuel supply to the engine. While each individual fuel oil should be delivered as a stable product, compatibility of one fuel oil with another cannot be readily predicted without testing. Generally, fuels of the same viscosity grade with similar densities are likely to be compatible; however, it is advisable to avoid mixing fuel from different sources or to mix residual marine fuel with distillate marine fuel. Also, instability can be introduced

during the blending process, and occur as a result of commingling incompatible bunker fuels. Vessel owners should prepare for increased bunker segregation in line with standard procedures to minimize the associated risks and work closely with their bunker suppliers to purchase compatible fuels.

Mitigation measures to address fuel incompatibility include optimization of design and implementation of operational procedures. These may include:

- Segregation of fuel tanks and piping
- Procedures for testing for fuel compatibility, including laboratory and onboard testing
- Procedures for tank cleaning prior to loading different fuels
- Procedures to prevent comingling of different fuel blends in the same tank
- Crew training to increase awareness of the properties of the fuels being carried
- Development of a fuel management plan

STABILITY

Bulk fuel stored for long periods can become unstable due to the asphaltenes precipitating out of the solution, causing the formation of sludge. This has the potential to block filters and pipes and leave tanks with an un-pumpable residue. To mitigate the precipitation issue:

- Piping arrangements for the storage tank should be considered to allow recirculation of the stored fuel to prevent asphaltene buildup
- Regular sampling should be performed when the fuels are being stored for an extended period of time

CATALYTIC FINES (CAT FINES)

Cat fines are created as a result of catalytic cracking in the crude oil refining process, during which tiny fragments of the catalyst material become entrained in the refined products and residues. These cat fines are typically a combination of aluminum and silicon and are very hard, abrasive particles. In limited quantities they can cause gradual engine wear. If present in larger amounts, they can cause significant damage to engine components such as fuel pumps, fuel injection valves, cylinder liners and piston rings. In extreme cases, they can result in the total failure of the engine. A maximum cat fine content of 10ppm at the engine inlet is typically recommended by engine manufacturers. Compliant fuel is expected to follow the same industry specification for cat fines limits but it's important to perform pre-treatment of the fuel.

Mitigation measures to reduce the cat fines are:

- Optimize onboard treatment, e.g., maintaining the optimum operation conditions for the purifiers, centrifugal and filters
- Install fine filter before engine
- Develop operating procedures to address cat fines in the fuel. This can include monitoring and optimizing the temperature of settling tanks, providing additional time for settling, adjusting the flow rate and increasing the sampling frequency
- Install settling and service tanks with slop bottoms as a means to remove cat fines
- Clean/drain service and settling tanks on a regular basis
- Implement policies to ensure fuel is always tested before use
- Perform a purification system test whenever new fuel is introduced to verify the purification system setting

DENSITY

The density of the 0.50% sulfur limit compliant fuel is expected to be in the range specified by ISO 8217. However, the density may vary due to the different production processes. The density may also differ from the currently used HFO. While density variation may not have an immediate safety impact on machinery, it could affect the operation of the purifier and the reading of tank gauging system, leading to the potential malfunction of these components. As a result, the:

- Purifier setting may need to be adjusted for a different fuel density for its optimized operation
- Mass-based tank gauging systems may require calibration according to fuel density for accurate reading

FLASH POINT

Fuel flash point is an important characteristic which requires careful consideration as it can have significant safety impacts. Fuels with a flashpoint below 60°C can increase the risk of fire and explosion. This is an issue that is relevant both now and post 01 January 2020. SOLAS Regulation II-1/4.2.1.1 requires that the flashpoint of any fuel oil used in machinery spaces must not be less than 60°C. The same is specified in ISO 8217 (except for distillate grade DMX). It is therefore crucial that the bunkered fuel will not present such a risk. However, even if the fuels bunkered with flashpoints not less than the minimum required value are stored at temperatures below the determined flash point, flammable vapors may still develop in the tank headspace, especially if fuel heating is provided.

As a result, the following provisions should be considered:

- Ability to bypass heater or heat tracing
- Automatic shutdown of heating upon detection of high temperature limit (typically 10oC below flashpoint)
- Automatic shutdown of heating if the heating element is not submerged (no fuel flow or low oil level)
- Identification of additional hazardous areas due to the use of the fuel with potential low flash point
- Avoidance of uncertified electrical equipment in the vicinity of fuel tank vent outlet

IGNITION AND COMBUSTION CHARACTERISTICS

Fuels with poor ignition and combustion properties can, in extreme cases, cause serious operational problems, engine damage and even total breakdown. Poor combustion performance is normally characterized by an extended combustion period and/or poor rates of pressure increase and low peak combustion pressure ("p max"). These result in incomplete combustion of the fuel. The effects are increased levels of unburned fuel and soot that may be deposited in the combustion chamber, on the exhaust valves, in the turbocharger system, exhaust aftertreatment devices, waste heat recovery units, and other exhaust system components. Extended combustion periods may also result in exposure of the cylinder liner to high temperatures which may disrupt the lubricating oil film, leading to increased wear rates and scuffing. Unburnt fuel droplets may also carry over, impinging on the liner surfaces and causing further damage to the liner.

High and medium-speed engines are more prone to operational difficulties due to poor ignition and combustion properties than are low speed two stroke types. With four stroke engines, poor ignition can result in excessive exhaust gas system deposits, black smoke, engine knocking, and difficulties operating at low load. If the ignition process is delayed for too long by virtue of some chemical quality of the fuel, too large a quantity of fuel will be injected into the engine cylinders and will ignite at once, producing a rapid pressure and heat rise and causing associated damage to the piston rings and cylinder liners of the engine.

The following should be considered in consultation with engine manufacturer:

- The Calculated Carbon Aromaticity Index (CCAI) of the sulfur limit compliant fuel should be verified in line with the ISO 8217 specification. The CCAI is the ignition characteristic of residual fuel, determined in accordance with ISO 8217. In engine applications where the ignition quality is particularly critical, a detailed basis for suppliers and purchasers of residual fuels is to be agreed upon for precise ignition quality characteristics.

UNUSUAL COMPONENTS

Although the fuel may comply with ISO 8217, there may be components not specified in the standard that contaminate the fuel and cause filter plugging, fuel pump corrosion, excessive separator sludging, and fuel pump sticking, leading to the loss of propulsion. Some of the unusual components identified include styrene, ethylene, methylstyrene, indene and phenol. These components may not be identified using the standard test methods within ISO 8217.

To identify the unusual components, the following measures should be considered:

- Conduct testing, such as Gas Chromatography–Mass Spectrometry (GCMS) testing, in addition to the standard test in ISO 8217
- Perform a test run on one generator engine to identify any issues in running the engine with the fuel before providing the fuel to all engines

POUR POINT

The pour point indicates the minimum temperature at which the fuel should be stored and pumped. Temperatures below the pour point result in wax formation. 0.50% max sulfur fuel oils with low viscosity typically do not require heating. However, such fuel oils on ships operating in cold environments may experience potential wax formation, causing the failure of fuel system.

Mitigation may be considered to:

- Confirm the cold flow characteristics are suitable for the ship's design and intended voyage
- Provide heating arrangements for the fuel, if necessary

VISCOSITY

Equipment and systems that are designed for existing high sulfur heavy fuel may not be suitable for handling distillate low sulfur fuel (DMF or LSDMF). This is due to the latter's reduced lubricating capability and incompatibility with equipment specification, which could lead to poor performance or damage to the equipment or leakage from pipe joints, causing a potential fire hazard. Typically, engine and fuel pumps need viscosities above 2 cSt to function properly.

Mitigation measures are:

- Maintain required distillate fuel oil temperatures for the appropriate fuel oil viscosity (e.g. coolers)
- Provide an automatic control system for viscosity and temperature monitoring to maintain required viscosity
- Install equipment able to handle distillate low sulfur fuel
- Perform a complete tightness test on the fuel system

LUBRICANT COMPATIBILITY

Lubricants currently used for engines burning HFO may not be compatible with the sulfur limit compliant fuel. When low sulfur fuel is used, a reduced amount of sulfuric acid forms in the combustion chamber, and less additives in the lubricant will be used. If an incompatible lubricant is used for an extended period, the unused additive in the lubricant will build up as deposits on the piston which may disturb the lubricant film and could lead to micro-seizures on the piston rings and liner and cause scuffing. Lower Base Number (BN) lubricant is typically used with low sulfur fuel, e.g., low-BN oil (15-40 BN) on two-stroke engine when 0.10% sulfur fuel is used.

Mitigation measures include:

- Consultation with the engine manufacturer and adherence to their recommendations for compatible lubricants
- Provide suitable counter measures for the fuel inlet valve seat to prevent excessive wear
- Provide suitable counter measures for the piston ring to protect against seizure due to use of non-compatible lubricant
- Provide crew training on the use of lubricant with compliant fuel

VESSEL DESIGN AND MODIFICATION

The requirements for sustained operation on low sulfur, low viscosity fuels will have two major impacts on the design of ships, in addition to the impacts on the engines and boilers. One is on the required fuel tank and piping arrangement for segregation. The other is the suitability of existing equipment for the low sulfur fuel that has different viscosities, densities and handling temperatures. The compliance strategy for sulfur emission compliance globally and inside ECAs will also impact the design and modification consideration for fuel systems on new and existing vessels. The discussion below considers the arrangement for sulfur limit compliance both inside and outside ECAs.

FUEL OIL STORAGE, SETTLING AND SERVICE TANKS, AND SEGREGATION

Service Tanks: Consideration for SOLAS Compliance:
Regulation II-1/26.11 states:

> *Two fuel oil service tanks for each type of fuel used on board necessary for propulsion and vital systems or equivalent arrangements shall be provided on each new ship, with a capacity of at least 8 hours at maximum continuous rating of the propulsion plant and normal operating load at sea of the generator plant. This paragraph applies only to ships constructed after 1 July 1998*

IACS United Interpretation UI SC 123 defines the "type of fuel" as the exact grade of fuel. The "grade" is grouped according to their sulfur content and viscosity as follows:

- Residual Marine Fuel (RMF) refers to fuel oils with a sulfur content above 0.10%, not exceeding 0.50%, that require some form of heating to achieve required injection viscosity for combustion
- Distillate Marine Fuel (DMF) refers to fuel oils with a sulfur content above 0.10%, not exceeding 0.50%, that do not require heating to achieve injection viscosity
- Low Sulfur Residual Marine Fuel (LSRMF) refers to fuel oils with a sulfur content not exceeding 0.10% that require some form of heating to achieve required injection viscosity for combustion
- Low Sulfur Distillate Marine Fuel (LSDMF) refers to fuel oils with a sulfur content not exceeding 0.10% possessing a minimum viscosity of 1.4 cSt at 40°C

As an example, in a case where RMF will be used for global sulfur limit compliance and LSDMF will be used for ECA compliance, the following constraints are to be considered:

1. Main and auxiliary engines and boiler are able to operate with Residual Marine Fuel (LSRMF) (one fuel ship), or
2. Main engine(s) and auxiliary boiler(s) are able to operate on both Residual Marine Fuel (LSRMF) and Distillate Marine Fuels (DMF and LSDMF). Auxiliary can only operate on Distillate Marine Fuel (DMF and LSDMF) (multifuel ship)

Additional details on example tank arrangements can be found in IACS United Interpretation UI SC 123.

Settling Tanks:

The "two settling tank" concept is the most common arrangement. As an example, one settling tank is used for 0.10% maximum sulfur distillate fuel (LSDMF) and the other for 0.50% maximum sulfur fuel (RMF).

Alternatively, two settling tanks for RMF may help to minimize the risk of incompatibility of different RMFs. However, one settling tank for RMF may also serve the purpose for segregation, in this case, the settling tank and the RMF processing system including purifier and transfer piping may be drained and cleaned as necessary before a different RMF is introduced. Operational procedures will need to address this situation.

Storage Tanks:

For ships that use both RMF and LSDMF, at least one storage tank is needed for each type of fuel. In practical design, multiple storage tanks are typically provided.

One of the measures for mitigating incompatibility hazards due to the use of different RMFs is to provide two (or two group) storage tanks for RMFs. Ship-specific needs are to be considered for determining the number and capacity for each group of tanks, such as:

- Fuel consumption for different modes of operation
- Operating duration under each mode for a single leg voyage
- Bunkering schedule

SUITABILITY OF EXISTING ONBOARD FUEL OIL SYSTEM/EQUIPMENT FOR OPERATING WITH GLOBAL SULFUR LIMIT COMPLIANT RMF/DMF

Fuel Oil Transfer/Service System

The low sulfur residual fuel (RMF) for global sulfur limit compliance has a lower viscosity than the heavy fuel oil (HFO) currently used, as discussed previously. As a result, the fuel oil transfer system for HFO may not be suitable for the lower viscosity fuel.

Typical hazards may include:

- Fuel transfer pump damage due to the reduced lubricity of the lower sulfur fuel
- Leakage from flanged pipe joints due to the lower viscosity fuel

The following may be considered for the evaluation of the existing system's suitability:

- Confirm compatibility of fuel transfer system and new fuel with the manufacturer
- Performing a pressure test on the fuel transfer system to identify any leakage and take corrective actions accordingly

The transfer system may require modification to address the need for segregating RMF and DMF, or segregation of different RMFs. This needs to be evaluated based on the provision of fuel storage tanks, settling tanks and in conjunction with operational procedure for a specific ship.

Fuel Oil Purification/Fuel Oil Heating/Cooling System

Fuel purification, heating and cooling are associated with the transition to lower sulfur residual fuel (RMF) and fuel switching between RMF and distillate marine fuel (DMF), generally including centrifugal separation by purifier and viscosity control.

As discussed in the Fuel Quality section, one concern with the use of RMF is the cat fines content. The refinery process may result in a reduction of the size of the cat fines. It then becomes more difficult to remove the smaller size particles by shipboard purifier, as the purifier relies on gravity for separation of the fines.

Purifiers operating under optimized conditions will be able to remove cat fines more effectively. The factors that may affect the purifier performance are:

- Stability of fuel flow
- Appropriate fuel flow rate
- Stability of temperature (viscosity)
- Appropriate temperature (viscosity)
- Appropriate choice of gravity disc (awareness of gravity data)
- Intervals between de-sludging

The purifier manufacturers' guidance needs to be followed, taking into consideration of the factors that may affect the performance of the purifier.

Combustion Equipment (Engines)

Compatibility of existing equipment with the sulfur limit compliant fuel is associated with lower sulfur content, lower viscosity and fuel quality (e.g., cat fines). Typical problem issues include:

- Excessive wear of the piston ring/liner due to high cat fines leading to blow-by/scuffing resulting in engine under-performance
- Lower viscosity causing ineffective performance of fuel pumps
- Lower viscosity, lower lubricity and entrained cat fines causing injector body wear/damage leading to potential engine performance issues, emission issues and carbon deposits
- Exhaust valve high temperature due to engine performance, leading to high burnout and potential turbo charger damage
- For cylinder oil, the use of an inappropriate BN, causing corrosion or lube oil additive deposits

Mitigation measures could include:

- Installation of fine filter before engine to limit ingress of cat fines
- Regular overhauling of fuel system equipment as per the manufacturer's recommendations
- Crew training on use of fuel with low sulfur content, addressing cold flow properties, compatibility, changeover, viscosity and use of proper lubrication
- Providing appropriate spare parts for system and engines
- Performing drain oil sampling and monitoring as per engine manufacturer recommendations to ensure that lubricants and low sulfur fuel are compatible
- Provision of two types of fuel on board for emergencies to ensure an uninterrupted supply of fuel
- Providing appropriate viscosity control, such as fuel heating/cooling
- Using lubricating oil with an appropriate BN compatible with fuel with different sulfur content

It is important that equipment manufacturers such as the engine builder are consulted and their guidelines are followed for the use of appropriate fuels and lubricant.

Combustion Equipment (Boiler)

Boilers designed for use heavy fuel oil may not suitable for burning low sulfur distillate fuels such as MGO. Such boilers, burners/equipment and fuel systems may require modification when switching to the low sulfur distillate marine fuel needed for entering ECAs.

In order for the existing boiler to burn the distillate fuel, the owner/operator needs to consult the boiler manufacturer and associated systems provider(s) or other competent designer recognized by the boiler manufacturer or designer to determine whether or not their existing fuel systems/arrangements require modifications or additional safeguards regarding the intended use of MGO fuels.

The ABS Marine Fuel Advisory provides further information regarding the considerations to be taken into account for the use of distillate fuel for boilers under Appendix 2.

OPERATIONAL CONSIDERATIONS

FUEL SYSTEM CLEANING

The use of high viscosity high sulfur fuel oil (HFO) results in the formation of semi-solid substances containing sediments and asphaltene sludge in various parts of the fuel oil service system including pipelines, settling and service tanks. To avoid compatibility and stability issues while transitioning from Heavy Fuel Oil (HFO) to 0.50% residual marine fuel (RMF), cleaning of the fuel system is required.

Options for cleaning the fuel oil system are:

- Chemical additives introduced in the bunkered fuel to dissolve the sludge formation and deposits on the pipe wall, tank wall and at the tank bottom
- Bunker MGO and use it to dissolve and flush away the sludge in the HFO tank and fuel oil piping
- Use a tank cleaning machine, similar to that used for crude oil tank cleaning, with disposal of the sludge to shore reception facility or barge.
- Manual tank cleaning

The time required to clean tanks and the fuel oil system will depend on a number of factors including:

- Size and number of tanks
- Type of fuel previously used
- Time since the last cleaning
- Method used for previous cleaning
- Extent of the sludge formation and deposits in the fuel oil system
- Method selected for cleaning

General time estimates (as referenced in IMO ISWG-AP 1-2-11) for the cleaning options are noted below.

Option	Typical Time-Frame	Notes
Manual Cleaning during Dry Docking	• 2 to 4 days per tank • 2 to 5 days to flush pipework after resuming service	• Tanks to be drained before the cleaning process • Safety aspects for crew entering enclosed spaces to be addressed • Residuals from tank cleaning to be disposed of appropriately
Manual Cleaning during Service by ship's crew	• 4 to 7 days per tank • 2 to 5 days to flush pipework	
Cleaning with Specialized Additives	• Depends on additive; may require a gradual clean-up over 5+ bunkers	• Additives clean the complete fuel oil system including settling and storage tanks • May lead to increased levels of sludge and sediment; requires close monitoring • Once compliant fuel is introduced to the system, sulfur fuel analysis should be completed to verify compliance

If after cleaning, HFO has to be added to a vessel due to non-availability of compliant fuel, there is a potential for contamination of the fuel oil system. The buildup of HFO residuals will depend on how many times each tank is loaded with HFO after the tank cleaning and how long the ship has to operate with the fuel. If the tank is loaded with HFO once and the fuel used without delay, the risk of sulfur non-compliance on the next refilling can be reduced by loading a product with a sulfur content below the 0.50% limit.

The following may be considered for mitigating the hazard due to contamination from previously-loaded HFO:

- Development of specific instructions for bunkering and use of compliant fuel for the first time (e.g. flushing of the fuel system in addition to tank cleaning) to prevent any contamination or compatibility issues due to commingling of the different fuel types
- Testing of the storage tank bottom sludge content, and exercising special care to handle sludge and cat fines during cleaning of tanks
- Close attention is to be paid to the fuel oil system including the purifier to confirm no clogging or damage occurs as a result of the tank cleaning activities
- Use of tank content dilution to avoid confined space entry, thus reducing asphyxiation hazard
- Development of a specific cleaning plan for each service tank to avoid any impact on commercial operations, as service tank cleaning requires complete shutdown of operations.

FUEL SWITCHING

Fuel switching may involve changing over from one RMF to another for fuel segregation and switching between RMF and LSDMF or vice versa when a ship enters and leaves an ECA.

The concern for RMF switching is the mixing of different RMSs in fuel systems and equipment. A ship which does not have a tank and piping arrangement that permits physical segregation of fuel beyond the storage tanks will have to develop procedures to avoid fuel mixing. This procedure will have to be ship-specific based on tank and piping arrangements and the ships operation pattern. For instance, if only one settling tank is provided, when this tank and associated piping, transfer pump and purifier are being drained and cleaned, the fuel oil will not be transferred to day tank(s). The time required for cleaning work and the preparation of the transfer system for filing fuel oil day tank needs to have a sufficient time margin to ensure the continuity of fuel supply to engines to keep the ship in safe operation.

When a ship enters or leaves an ECA, fuel switching between RMF and LSRMF or LSDMF will need to be performed.

A fuel switching procedure as required in MARPOL Annex VI Regulation 14.6 is to be developed based on the evaluation of the suitability of the shipboard system and equipment for the lower sulfur fuel. Modification needs to be done based on the evaluation result, if necessary.

As mentioned earlier, issues associated with fuel switching from RMF to LSDMF include:

- Inappropriate base number lubricating oil for the crankcase and cylinder, causing corrosion or deposits in the cylinder
- Lower lubricity due to lower sulfur content which may cause fuel pump seizures
- Lower viscosity causing ineffective performance of fuel pumps

The engine manufacturer is to be consulted and the respective guidance followed for the selection of appropriate lubricating oil, required viscosity and fuel quality.

The fuel switching procedure should cover safety precautions, control of viscosity, appropriate engine power for the fuel switching process, thermal shock avoidance, procedures for switching with fuel mixing, purifier operational parameter adjustment, lubricating oil switch, and flow rate adjustment. Section 5 of the ABS Marine Fuel Advisory 2018 specifically addresses fuel-switching requirements and may be referred to for further information.

FUEL OIL PROCUREMENT

Unavailability of the compliant fuel can lead to potential operation, regulatory and financial impacts. Practice for the procurement of bunker fuel may be optimized for quality assurance. For better awareness of the fuel being used and the associated implications to the safety of ships due to the fuel characteristics and quality, the following may be considered to mitigate the potential hazard:

- Develop/enhance fuel purchasing procedure and provide plan of action if the compliant fuel is not available
- Bunkered fuel should in general comply with ISO 8271. It is necessary to identify the edition of ISO 8217 being referenced by the supplier and/or define the fuel specification in the contract for bunker fuel. For instance, the limit for cat fines was reduced from 80 ppm in the 2005 edition to 60 ppm in the 2010 and later editions
- The bunker fuel contract may include specification for additional testing for the identification of any unusual components
- Follow the approach in MEPC. 1/Circ.875/Add.1, *Guidance on Best Practice for Fuel Suppliers*, including:
  - Quality control during production of bunkers
  - Quality control in the supply chain
  - Bunker transport, storage and transfer
  - Delivery to ship (bunkering operations)
  - Representative sampling
  - Testing and interpretation of test results in supply chain
  - Documentation – Contracting – Dispute resolution
- Refer to industry associations developed charter party bunker clause, such as:
  - BIMCO 2020 Marine Sulphur Content Clause for Time Charter Parties
  - BIMCO 2020 Fuel Transition Clause for Time Charter Parties
  - INTERTANKO Bunker Compliance Clause for Time Charterparties

DOCUMENTATION AND REPORTING

SHIP IMPLEMENTATION PLAN (SIP)

IMO paper MEPC.1/Circ.878, entitled *Guidance on the Development of a Ship Implementation Plan for the Consistent Implementation of the 0.50% Sulphur Limit under MARPOL Annex VI* provides a framework for documenting compliant arrangements.

A well-defined Ship Implementation Plan will help to mitigate the risk associated with the transition from the current use of heavy fuel oil to 0.50% max sulfur fuel by addressing the following:

- Risk assessment and mitigation plan (on the impact of new fuels)
- Fuel oil system modifications (if needed) and tank cleaning
- Fuel oil capacity and segregation capability
- Procurement of compliant fuel
- Fuel oil changeover plan
- Documentation and reporting

FUEL OIL MANAGEMENT PLAN

ABS has published a template for the development of Fuel Oil Management Plan (FOMP) as Appendix III to the ABS Marine Fuel Oil Advisory, 2018. The FOMP covers the requirements of Regulation 14 and 18 of MARPOL Annex VI, MEPC.182(59), EU Directives, 13 CCR (Code of California Regulation) and the ABS Guide for the Environmental Protection Notation for Vessels. The template provides assistance in the development of a vessel-specific FOMP based on the fuel oil piping system, main and auxiliary engines and other related equipment.

The Fuel Oil Management Plan template is available at:
https://ww2.eagle.org/content/dam/eagle/rules-and-resources/forms/fomp-review.docx

FUEL OIL NON-AVAILABILITY REPORTING (FONAR)

In case the compliant fuel oil cannot be obtained despite best efforts, the ship's master/Company must take following actions:

- Present a record of actions taken to attempt to bunker correct fuel oil and provide evidence of an attempt to purchase compliant fuel oil in accordance with its voyage plan and, if it was not made available where planned, that attempts were made to locate alternative sources for such fuel oil and that despite best efforts to obtain compliant fuel oil, no such fuel oil was made available for purchase; and
- Best efforts to procure compliant fuel oil should be made including but not limited to investigating alternate sources of fuel oil prior to commencing the voyage. If, despite best efforts, it is not possible to procure compliant fuel oil, the master/owner must immediately notify the port State Administration in the port of arrival and the flag Administration (regulation 18.2.4 of MARPOL Annex VI).

The master/Company should submit fuel oil non-availability report (FONAR) as soon as it is found that it will not be able to procure and use compliant fuel oil.

To facilitate the fuel oil non-availability report, a standard format for the reporting is to be developed.

The draft Guidelines for Consistent Implementation of the 0.50% Sulphur Limit Under MARPOL Annex VI, which includes an Appendix for fuel oil non-availability reporting, is expected to be submitted to MEPC 74, to be held from 13 May to 17 May 2019.

CREW TRAINING

Initial and periodic training will help the crew to increase awareness of the challenges associated with compliance with post-2020 operations using 0.50% maximum sulfur fuel and the respective mitigation measures, such as:

- Characteristics of the 0.50% max sulfur fuel regarding compatibility, stability, density, viscosity, pour point, and lubricant compatibility, etc. for proper handling and application of the fuel
- Operational challenges of 2020 sulfur limit compliance
- Fuel switching considerations where such switching may be necessary, e.g., entering and leaving ECAs
- Compatibility of onboard equipment with the 0.50% max sulfur fuel with respective to viscosity, density, etc.
- Safety hazards associated with the flashpoint and mitigation measures
- Unusual components in the 0.50% max sulfur fuel

POST 2020 CARRIAGE OF HFO

To support implementation, compliance and port state enforcement of the 01 January 2020 fuel sulfur limit, IMO has moved to ban the carriage of high sulfur HFO. With the exception of vessels which are fitted with a scrubber, the MEPC committee has indicated that the carriage of high sulfur HFO for on-board combustion will be prohibited effective 01 March 2020.

ABS SUPPORT

ABS can assist owners and operators as they consider the practical implications of the use of compliant fuel. This includes:

- Facilitating Compliant Fuel Workshops using Hazard Identification (HAZID) methodologies, to identify the implications, characterize the risk and determine means of risk mitigation during the change to compliant fuel
- Supporting development of Ship Implementation Plans
- Supporting development/updates to Fuel Oil Management Plans
- Issuing a Statement of Fact on completion of tank cleaning activities

The ABS Advisory on Marine Fuel Oil, available on the ABS website at www.eagle.org provides additional guidance regarding compliant fuels.

APPENDIX 1: LIST OF ITEMS TO CONSIDER WHEN TRANSITIONING FROM HIGH SULFUR TO SULFUR LIMIT COMPLIANT FUEL

ITEMS TO CONSIDER	
A.	**Concern: Fuel Compatibility**
1.	Segregate fuel tanks and piping
2.	Develop procedures for testing for fuel compatibility, including laboratory and onboard testing
3.	Develop procedures for tank cleaning prior to loading different fuels
4.	Develop procedures to prevent different fuel blends being introduced into the same tank
5.	Training crew to increase their awareness regarding the properties of the fuels being carried
6.	Develop a fuel management plan
B.	**Concern: Fuel Stability**
7.	Arrange piping for the storage tank to allow recirculation of the stored fuel to prevent asphaltene buildup
8.	Complete regular sampling when the fuels are stored for an extended period of time
C.	**Concern: Fuel Cat Fines**
9.	Optimize onboard treatment, e.g., maintain the optimum operational conditions for the purifiers, centrifuge and filters
10.	Install fine filter before engine
11.	Develop operating procedures to handle cat fines in the fuel. This can include monitoring and optimizing the temperature of settling tanks, providing additional time for settling, adjusting the flow rate and increasing the sampling frequency
12.	Install settling and service tanks with slop bottom as a means to remove cat fines
13.	Clean/drain service and settling tanks on a regular basis
14.	Implement policies to ensure fuel is always tested before use
15.	Complete a purification system test whenever new fuel is introduced to verify purification system setting
D.	**Concern: Fuel Density**
16.	Adjust purifier setting for different density fuel for its optimized operation
17.	Calibrate mass based tank gauging system according to fuel density for accurate reading

E.	**Concern: Fuel Flashpoint**
18.	Incorporate ability to bypass heater or heat tracing
19.	Install automatic shutdown of heating upon detection of high temperature limit (typically 10°C below flashpoint)
20.	Install automatic shutdown of heating if the heating element is not submerged (no fuel flow or low oil level)
21.	Identify additional hazardous areas
22.	Avoid uncertified electrical equipment in the vicinity of fuel tank vent outlet
F.	**Concern: Fuel Ignition and Combustion Characteristics**
23.	Verify the Calculated Carbon Aromaticity Index (CCAI) of the sulfur limit compliant fuel in line with the ISO 8217 specification. The CCAI is the ignition characteristic of residual fuel, determined in accordance with ISO 8217. In engine applications where the ignition quality is particularly critical, a basis for suppliers and purchasers of residual fuels is to be agreed on tighter ignition quality characteristics
G.	**Concern: Unusual Components in the Fuel**
24.	Conduct testing, such as Gas Chromatography–Mass Spectrometry (GCMS) testing, in addition to standard test in ISO 8217
25.	Perform a test run on one generator engine to identify any issues in running the engine with the fuel, before providing the fuel to all engines
H.	**Concern: Fuel Pour Point**
26.	Confirm the cold flow characteristics are suitable for the ship's design and intended voyage
27.	Provide heating arrangements for the fuel
I.	**Concern: Fuel Viscosity**
28.	Maintain required distillate fuel oil temperatures for the appropriate fuel oil viscosity (e.g. coolers)
29.	Provide automatic control system for viscosity and temperature monitoring to maintain required viscosity
30.	Install equipment suitable for handling distillate low sulfur fuel
31.	Complete tightness test on fuel system
J.	**Concern: Fuel-Lubricant Compatibility**
32.	Consult with the engine manufacturer and follow their recommendation for compatible lubricants
33.	Provide suitable counter measures for fuel inlet valve seat to prevent excessive wear
34.	Provide suitable counter measures for piston ring to protect against seizure due to use of non-compatible lubricant
35.	Develop crew training on use of lubricant with compliant fuel
K.	**Concern: Vessel Design/Modification**
36.	Duplicate service tanks for 0.50% maximum sulfur residual fuel (RMF) and 0.10% maximum sulfur distillate fuel (LSDMF) respectively
37.	Incorporate "two settling tank" concept, one for 0.50% maximum sulfur RMF and one for 0.10% maximum sulfur LSDMF
38.	Incorporate at least one storage tank for each type of fuel considering two types of RMF and one LSDMF
39.	Provide designated piping and equipment for RMF and LSDMF
40.	Provide storage capacity for RMF and LSDMF considering: • The fuel consumption for different modes of operation • Operating duration under each mode for a single leg voyage • Bunkering schedule
41.	Install fine filter before engine to limit cat fines entering the engine
42.	Provide appropriate viscosity control, such as fuel heating/cooling

L.	**Concern: Suitability of Existing System/Equipment**
43.	Assess fuel oil transfer/service System: • Review the compatibility of fuel transfer/service system with new fuel with manufacturers • Perform a pressure test on the fuel transfer/service system to identify any leakage and take corrective actions accordingly
44.	Optimize operation of purifiers taking into consideration of the following: • Stability of fuel flow • Appropriate fuel flow rate • Stability of temperature (viscosity) • Appropriate temperature (viscosity) • Appropriate choice of gravity disc (awareness of gravity data) • Intervals between de-sludging
45.	Assess engine suitability for Low Sulfur Fuel: • Install fine filter before engine to limit cat fines entering the engine • Complete regular overhauling of fuel system equipment as per the manufacturer's recommendations • Train crew regarding use of fuel with low sulfur content, addressing cold flow properties, compatibility, changeover, viscosity and use of proper lubrication • Provide appropriate spare parts for system and engines • Perform drain oil sampling and monitoring as per engine manufacturer recommendations to ensure that lubricants and low sulfur fuel are compatible • Provide two types of fuel on board for emergencies to ensure uninterrupted supply of fuel to engine • Provide appropriate viscosity control, such as fuel heating/cooling • Use lubricating oil with appropriate BN compatible with fuel with different sulfur content
M.	**Concern: Operational Considerations**
46.	Fuel oil system cleaning taking into consideration the following: • Develop specific instructions for bunkering and use of compliant fuel for the first time (e.g. flushing of the fuel system in addition to tank cleaning) to prevent any contamination or compatibility issues due to commingling of the different fuel types • Test the storage tank bottom sludge content and use special care to handle sludge and cat fines during cleaning of tanks for introduction of new fuel • Close attention to be paid to the fuel oil system including the purifier to confirm no clogging or damage occurs as a result of the tank cleaning activities • Use tank content dilution to avoid confined space entry, reducing asphyxiation hazard • Develop specific cleaning plan for each service tank to avoid any impact on commercial operations of vessel as service tank cleaning will require complete shutdown of operations
47.	When completing fuel switching operations consider the following: • Assess system/equipment suitability for low sulfur fuel • Select lubricant compatible with the low sulfur fuel • Develop switching procedure • Train crew for fuel switching operation • Monitor and adjust operation parameters, e.g., viscosity control, ship power reduction, thermal shock avoidance, low sulfur fuel gassing prevention, auxiliary operating status (purifier status)
48.	Fuel Oil Procurement: • Develop fuel purchasing procedure • Identify the specific edition of ISO 8217 being referenced by the supplier and/or define the fuel specification in the contract for bunker fuel • Consider conducting additional testing for the identification of any unusual components • Follow MEPC. 1/Circ.875/Add.1, *Guidance on Best Practice for Fuel Suppliers* • Include charter party bunker clause developed by industry associations

N. Concern: Crew Training
49. Provide initial and periodic crew training addressing: • Characteristics of the 0.50% max sulfur fuel regarding compatibility, stability, density, viscosity, pour point, and lubricant compatibility, etc. for proper handling and application of the fuel • Operational challenges of 2020 sulfur limit compliance • Fuel switching considerations where such switching may be necessary, e.g., entering and leaving ECAs • Compatibility of onboard equipment with the 0.50% max sulfur fuel with respective to viscosity, density, etc. • Safety hazards associated with the flashpoint and mitigation measures • Unusual components in the 0.50% max sulfur fuel

ACRONYMS:

BIMCO:	Baltic and International Maritime Council
CCAI:	Calculated Carbon Aromaticity Index
CCR:	Code of California Regulation
cSt:	Centistokes
DMF:	Distillate Marine Fuel with sulfur content not exceeding 0.50%
ECA:	Emission Control Area
EU:	European Union
FOMP:	Fuel Oil Management Plan
GCMS:	Gas Chromatography–Mass Spectrometry
HAZID:	Hazard Identification
HAZOP:	Hazard and Operability
HFO:	Heavy Fuel Oil with sulfur content more than 0.50%
IACS:	International Association of Classification Societies
INTERTANKO:	International Association of Independent Tanker Owners
ISGOTT:	International Safety Guide for Oil Tankers and Terminals
LSDMF:	Low Sulfur Distillate Marine Fuel with sulfur content not exceeding 0.10%
LSRMF:	Low Sulfur Residual Marine Fuel with sulfur content not exceeding 0.10%
MEPC:	Marine Environment Protection Committee
MGO:	Marine Gas Oil
PPR:	Sub-Committee on Pollution Prevention and Response
RMF:	Residual Marine Fuel with sulfur content not exceeding 0.50%
SIP:	Ship Implementation Plan
UI:	Unified Interpretation
VGO:	Vacuum Gas Oil

REFERENCES:

ABS Publication:
ABS Marine Fuel Advisory, 2018

IACS Document:
IACS UI SC123, Machinery Installations – Service Tank

IMO Documents:
IMO MSC 100/8/2, Safety Implications and Respective Challenges associated with 2020 Compliant Fuels

IMO MEPC.1/Circ.875, Guidance on Best Practice for Fuel Oil Purchasers/Users for Assuring the Quality of Fuel Oil Used on Board Ships, 26 April 2018

IMO MEPC.1/Circ.875/Add.1, Guidance on Best Practice for Fuel Oil Suppliers for Assuring the Quality of Fuel Oil delivered to ships, 9 November 2018

IMO MEPC.1/Circ. 878, Guidance on the Development of a Ship Implementation Plan for the Consistent Implementation of the 0.50% Sulphur Limit under MARPOL Annex X VI

IMO MEPC.1/Circ.880, Reporting of Availability of Compliant Fuel Oils in Accordance with Regulation 18.1 of MARPOL Annex VI

IMO MEPC 73/5/3, Draft Best Practice for Member States/Coastal States

IMO MEPC.182(59) 2009 Guidelines for the Sampling of Fuel Oil for Determination of Compliance with the Revised MARPOL Annex VI

IMO MEPC.305(73) Ban on HFO Carriage (Amendments to regulation 14 of MARPOL Annex VI and the form of the Supplement to the IAPP Certificate)

IMO Resolution A.1050(27), Revised Recommendations for Entering Enclosed Spaces Aboard Ships

IMO ISWG-AP, 1/2/11, Development of Draft Guidelines for Consistent Implementation of Regulation 14.1.3 of MARPOL Annex VI

Draft amendments to MEPC.1/Circ.864, Guidelines for Onboard Sampling for the Verification of the Sulphur Content of the Fuel Oil used on board Ships

FONAR Report (Fuel Oil Non-Availability Report (as part of Draft Guidelines for consistent implementation of the 0.50% Sulphur Limit Under MARPOL Annex VI)

Draft Guidelines for Consistent Implementation of the 0.50% Sulphur Limit Under MARPOL Annex VI

Draft amendments to 2009 Guidelines for Port State Control under the revised MARPOL Annex VI (resolution MEPC .181(59))

Draft amendments to existing 2010 Guidelines for Monitoring the Worldwide Average Sulphur Content of Fuel Oils supplied for use on board Ships (Resolution MEPC.192(61), as amended by resolution MEPC .273(69)

Amendments to regulation 14 of MARPOL Annex VI to require a dedicated sampling point for fuel oil (to be finalized by PPR 6)

Regional Requirements:
USCG Policy Letter CG-CVC Policy Letter 12-04 dated July 25, 2012, Guidelines for Compliance and Enforcement of the Emission Control Areas Establish within the United States Jurisdiction as Designated in MARPOL Annex VI Regulation 14

Interim Guidance on the Non-Availability of Compliant Fuel for the North American Emission Control Area

State of California, The Ocean-Going Vessel (OGV) Fuel Regulation (13 CCR § 2299.2/17 CCR § 93118.2)

EU Sulphur Directive 1999/32/EC, as amended by Directives 2005/33/EC and 2009/30/EC (codified under Directive EU 2016/802/EU)

Industry Guidance:
Energy Institute, HM 50 Guidelines for the Cleaning of Tanks and Lines for Marine Tank Vessels carrying Petroleum and Refined Products, 3rd Edition, March 2014

ISO 8217:2017, Petroleum Products – Fuels (Class F) – Specifications of Marine Fuels

ISO Statement regarding ISO 8217 for 0.50% max Sulphur Fuel Oils (Statement by ISO as per PPR Document PPR 6/8 Annex 6)

BIMCO 2020 Marine Sulphur Content Clause for Time Charter Parties

BIMCO 2020 Fuel Transition Clause for Time Charter Parties

INTERTANKO Bunker Compliance Clause for Time Charterparties

ISGOTT International Safety Guide for Oil Tankers and Terminals, 5th Edition

CONTACT INFORMATION

NORTH AMERICA REGION

1701 City Plaza Drive
Spring, TX 77389, USA
Tel: +1-281-877-6000
Email: ABS-Amer@eagle.org

SOUTH AMERICA REGION

Rua Acre, nº 15 - 11º floor, Centro
Rio de Janeiro 20081-000, Brazil
Tel: +55 21 2276-3535
Email: ABSRio@eagle.org

EUROPE AND AFRICA REGION

ABS House, No. 1 Frying Pan Alley
London E1 7HR, UK
Tel: +44-20-7247-3255
Email: ABS-Eur@eagle.org

MIDDLE EAST REGION

Al Joud Center, 1st floor, Suite # 111
Sheikh Zayed Road
P.O. Box 24860, Dubai, UAE
Tel: +971 4 330 6000
Email: ABSDubai@eagle.org

GREATER CHINA REGION

5th Floor, Silver Tower
No. 85 Taoyuan Road, Huangpu District
Shanghai 200021, P.R. China
Tel: +86 21 23270888
Email: ABSGreaterChina@eagle.org

NORTH PACIFIC REGION

11th Floor, Kyobo Life Insurance Bldg.
7, Chungjang-daero, Jung-Gu
Busan 48939, Korea, Republic of
Tel: +82 51 460 4197
Email: ABSNorthPacific@eagle.org

SOUTH PACIFIC REGION

438 Alexandra Road
#08-00 Alexandra Point, Singapore 119958
Tel: +65 6276 8700
Email: ABS-Pac@eagle.org

www.eagle.org