Loss Prevention Guide

NORTH
SERVICE, STRENGTH, QUALITY

MARINE FUELS: PREVENTING CLAIMS AND DISPUTES

The North of England P&I Association

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THE NORTH OF ENGLAND P&I ASSOCIATION

Published by The North of England P&I Association Limited
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ISBN 978-0-9955653-3-3

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Printed and bound in the UK

ACKNOWLEDGEMENTS

Parts of this guide are based on The North of England P&I Association's earlier publication, *Bunker Claims Prevention: A Guide to Good Practice* (published in 2000 and revised in 2009 and 2011).The Association is very grateful to the authors of the previous publication: Richard Bracken, Chris Fisher and Mike Salthouse. The Association would also like to thank Braemar Technical Services and Veritas Petroleum Services for providing a technical review and providing images. The BIMCO standard bunker terms and BIMCO bunker clauses are BIMCO copyright and are reproduced with kind permission from BIMCO.

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TERMS OF USE

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Chapter 1

INTRODUCTION

The deterioration in quality of marine fuel oils over recent decades, coupled with increasingly stringent environmental legislation, presents a real challenge for shipowners and operators. Disputes relating to marine fuel oils – commonly referred to as 'bunker fuel' or simply 'bunkers' – show no sign of abating and are increasingly complex.

Shipowners, vessel managers and seafarers must remain alert to the problems associated with the supply of marine fuel oils. Identifying and understanding the issues will allow steps to be taken to ensure their vessels are provided with fuel oil suitable for use by their vessels' power plants and, if any problems do arise, the impact is minimised.

The consequences of burning unsuitable fuel can be very serious. In addition to potentially costly damage to the vessel's engines, a disabled vessel in a congested waterway, in poor weather, carrying an expensive or environmentally sensitive cargo can cause catastrophic damage to life, property and the environment.

As refineries develop their processes to capture more of the higher value light grades of oil, the quality of the residual grades has deteriorated. Combined with blending problems, this has resulted in an increased frequency of vessels being supplied with residual marine fuel oil unsuitable for use.

PURPOSE OF THIS GUIDE

This loss prevention guide tackles fuel **quality, quantity** and **contractual** issues at source by giving those involved in the purchase and use of marine fuel oils a thorough understanding of the problems that they may face.

Bunker disputes can be approached from two distinct viewpoints. There is the viewpoint of those actually operating the vessel — for example, the crew who manage bunkering and are at risk if the vessel is supplied with unsuitable fuel oil. There is also the viewpoint of those ashore, who manage the vessel and may be involved in purchasing the fuel oil. They must know what action should be taken by the crew when dealing with unsuitable fuel oil on board and which parties should be held responsible.

The guide is for everyone who comes across bunker quality and quantity disputes in their working day. It is neither a legal text book nor an engineer's manual, but it does aim to give a basic understanding of the technical and legal implications.

Fig. 1. Bunkering of marine fuel in progress (VPS)

The guide takes each stage in order. It first deals with the nature of fuel oil, its production and resulting characteristics. Consideration is then given to the contracts under which fuel oil may be ordered and its ownership.

Chapters on the loading and handling of fuel oil on board and the ever-increasing environmental legislation are followed by details on evidence collection and the handling of claims.

At the end of the guide are appendices, which include a number of specimen texts and various recommended standard letters.

2020 – A NEW ERA

In the last decade, the industry has seen increasing legislation aimed at curbing emissions from marine diesel engines. The 2015 reduction of sulphur limits in emission control areas and the forthcoming global sulphur cap in 2020 has driven shipowners, engine manufacturers and shipbuilders to think differently and move away from residual fuels.

It has led to the wider use of alternative fuels such as liquefied natural gas (LNG), with some shipowners exploring new innovations in power generation such as hydrogen fuel cells. Vessels in the future may well be 'multi-fuel' and not limited to burning one type of fuel or restricted to one method of generating power. These present both practical and legal challenges, some of which are addressed in this guide.

RESOLVING DISPUTES

Disputes can arise between the various parties involved in bunkering and they generally concern either the quality or the quantity of fuel supplied. In any event, the 'golden rule' for successful resolution of bunker quality and quantity disputes is:

Golden rule for bunker quality and quantity disputes

The success of any bunker quality or quantity dispute will depend upon the quality of evidence collected in support of the claim.

The party with the strongest evidence to support their claim will generally be successful.

This guide outlines the evidence that may be needed to pursue or defend a claim successfully. Some of this valuable evidence is routinely collected on board regardless of any problems arising. Typical examples include on-board bunkering checklists, ullage or sounding reports, bunker delivery notes and fuel analysis reports.

Non-routine evidence collection becomes important if a dispute arises on the quality or quantity of fuel oil supplied. The nature of the evidence required will depend on the problem encountered and may include the laboratory testing of tank contents, the retention and metallurgical analysis of engine components, taking of statements from the vessel's engineers and expert investigation reports.

The purpose of all evidence collection is to provide an accurate picture of what actually happened. Relatively few bunker disputes will involve questions of law and most are based on questions of fact. Without reliable evidence documenting the course of events, the facts will be disputed and proper claims will be less likely to succeed.

Chapter 2

PRODUCTION AND REFINING OF MARINE FUELS

Most marine fuel oils are derived from crude oil, a naturally occurring resource found in many regions of the world. It is important to recognise that crude oils from different sources may very well have different characteristics.

CHARACTERISTICS OF CRUDE OILS

Crude oils are complex compounds of hydrogen and carbon. But it is the structure of the hydrocarbon molecular chains and the proportion of hydrogen and carbon present within them that determines the type of crude oil. Broadly speaking, there are three types.

Paraffinic crude

Paraffinic crude oils have low bitumen content but, as the name suggests, these crude oils also have a large paraffinic component and usually yield more of the lighter (and higher value) distillate products than naphthenic and aromatic crude oils. Crude oils containing straight-chain and branch-chain hydrocarbon structures are referred to as paraffinic crude oils and usually have high pour-points.

Naphthenic crude

Naphthenic based crude oils have a distinctly different atomic structure, which is ring or cyclic in its construction. Naphthenic crude oils have a low pour-point.

Aromatic (asphaltenic) crude

Aromatic crude oils are also referred to asphaltenic crude oils. They contain distinctly different hydrocarbon structures to those found in paraffinic and naphthenic crude oil and contain a benzene ring, which is particularly stable. The residues obtained from these crude oils are ideally suited for use in the construction and road-building industries.

REFINERY PROCESS

Crude oil is not a particularly useful substance in itself but, when refined, a wide range of valuable and useful products can be produced. Valuable refinery products include gases and high-grade distillate products, while low-value products include residual marine fuel oil.

Residual marine fuel oils have been and are still known to marine engineers by several names – sometimes used incorrectly – and these include:

- heavy fuel oil (HFO)
- intermediate fuel (IFO)
- bunker C
- boiler oil
- burner fuel.

Whatever name is used, residual marine fuel oils are, by definition, those products of the refining process which remain after distillation has taken place.

Fig. 2 shows a simple schematic of the refinery process.

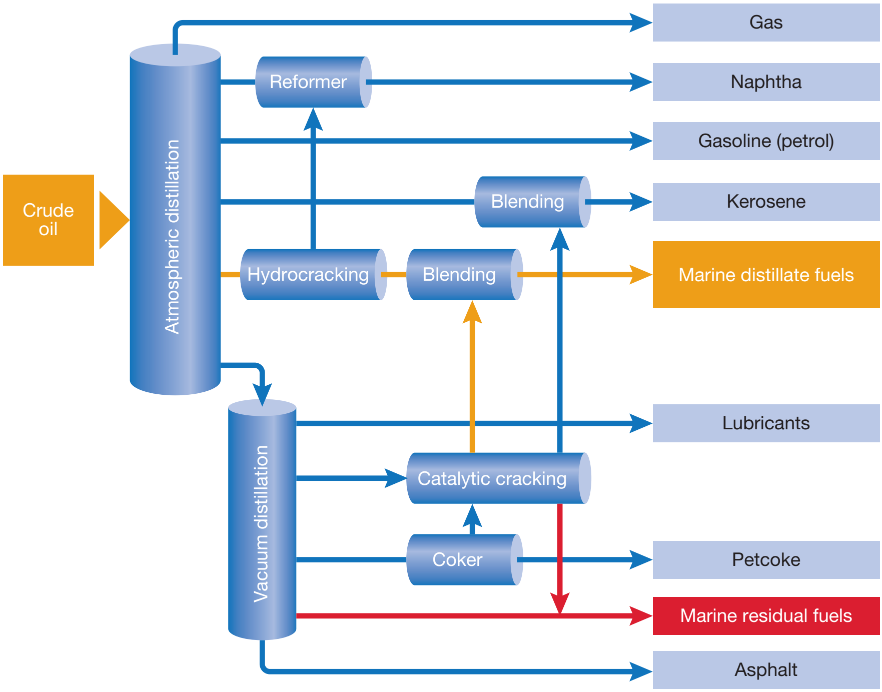

Fig 2. Simplified refinery process

Atmospheric distillation

In very simple terms, distillation is a process of heating and cooling. The crude oil is heated at atmospheric pressure and it separates into its constituent fractions. The lighter fractions boil off before being cooled down once again, collected and condensed back into liquids.

Condensation occurs in the fractionating tower or column, and the products range from gases at the upper end to residues at the lower end.

Vacuum distillation

The residues from atmospheric distillation are further refined to obtain the maximum amount of distillate product from the crude. This is carried out under vacuum conditions and at higher temperatures.

Cracking

Despite the fact that the characteristics of the residues vary greatly depending on the nature of crude oil and the refinery technology adopted, the quality of residual marine fuel oil produced by traditional atmospheric and vacuum distillation was of a predictable quality for many years. Any problems encountered were usually manageable.

But the fuel crisis of the 1970s and 1980s, combined with the ever-increasing demand for distillate oil products, led to refineries developing new, more cost-effective processes. These complemented traditional atmospheric and vacuum distillation and are referred to as secondary refining or 'cracking'.

Simply, cracking is the process of breaking down complex long-chain hydrocarbon molecules into simpler short-chain molecules. Cracking may be achieved by heating under pressure (thermal cracking), hydrocracking or using catalysts (catalytic cracking).

Thermal cracking

In thermal cracking, more products are extracted from the crude oil by raising the pressures and temperatures of the process up to 70 bar and 750°C respectively. The relatively large hydrocarbon molecules 'crack' apart into smaller, lighter fractions.

Vis-breaking

The heavy residues produced by vacuum distillation can be thermally cracked to reduce their viscosity, known as 'vis-breaking'. This has the benefit of reducing the quantity of 'cutter stock' needed, which are lighter oils used to cut residual marine fuel oils to reduce their viscosity.

Catalytic cracking

Fractions containing long-chain hydrocarbon molecules are heated to a very high temperature and then passed over a catalyst, the most common being aluminium hydrosilicate. The chemical bonds in the molecules are broken to form shorter chain hydrocarbon molecules.

The catalysts themselves do not undergo any changes and, due to their high cost, the refineries make great efforts to recover them for re-use. They are commonly very hard, abrasive materials such as aluminium and silicon.

Catalytic cracking results in poorer-quality residues, which are then used for producing marine fuel oil. Furthermore, they can contain remnants of the abrasive catalysts, known as 'cat fines', which can significantly damage engine components.

Hydrocracking

Pressurised and heated to a high temperature, the long-chain molecules crack into short-chain molecules, to which hydrogen atoms attach, creating lighter products.

Coking

This is a very severe thermal cracking process where the residual fuel fraction is destroyed. The boil-off is condensed and usually enters the blending pool or becomes feedstock for hydrocracking. The remaining solid carbon residue is known as petcoke, which is commonly used as fuel in power stations.

Blending

When producing marine residual fuel oils for the market, the refineries may dilute the residual fraction with distillates or cutter stock to meet fuel specifications. This is usually to meet viscosity or sulphur requirements.

MARINE FUEL PRODUCTS

The refinery process creates two of the most commonly burnt fuels on vessels; marine distillate fuel oils (marine gas oil and marine diesel oil) and marine residual fuel oils (heavy fuel oil).

The processes of cracking and blending have had a considerable detrimental effect on the quality and characteristics of marine residual fuel oils. These are addressed in greater detail in subsequent sections of this guide but they typically include:

- increased fuel density
- worsening fuel-stability problems
- problems of sediment in fuel oil
- introduction of catalytic fines (aluminium and silicon)
- poor ignition quality.

Traditionally, the demand for marine residual fuels has far outstripped that for distillates. Marine diesel engines are generally designed to operate on the cheaper and poorer quality residuals. However, the global sulphur cap which enters into force in 2020 is likely to shift this balance. Many vessels may comply by burning distillates, blends, or 'hybrid' products, or they may explore the use of alternative fuels such as LNG.

Refineries could look to provide low-sulphur residual fuels either sourced from 'sweet' crudes or high-sulphur crudes that have undergone a desulphurisation process. Vessels fitted with exhaust-gas-cleaning systems (often referred to as 'scrubbers') should be the only consumers of high-sulphur high-viscosity residual fuel from 2020.

BIOFUELS

In recent decades, the use of fuels derived from sources other than crude oil has increased in many industries.

One such example is the blending of biofuels into traditional refinery products such as heavy fuel oil and marine distillates. Biofuels such as FAME (fatty acid methyl ester) are derived from vegetable fats (e.g. palm oil, coconut oil, rapeseed oil, soya bean oil) and animal fats.

The international standards on marine fuels have traditionally allowed only a '*de minimus*' (trace amount) of biofuel content. But in 2017 new grades of marine distillate fuel were recognised which allow up to 7% FAME biofuel content.

LNG AS A MARINE FUEL

The use of liquefied natural gas (LNG) as a marine fuel is expected to rise in the approach to the International Maritime Organization (IMO) global sulphur cap in 2020.

LNG is a colourless mixture of gases – mostly methane (typically 80 to 95%) – cooled to condense into a liquid.

LNG fuel is sourced from natural gas which is extracted from sub-surface gas fields. This is piped to liquefaction plants where it is cleaned and cooled to temperatures lower than –162°C. In its liquid phase, the volume of the LNG is reduced by a factor of 600 and is stored and transported at low temperatures.

Chapter 3

TYPES AND CHARACTERISTICS OF MARINE FUELS

Historically, problems with the quality of fuel oil supplied to vessels came to prominence in the mid to late 1970s. At that time, shipping companies purchasing fuel oil from suppliers would specify viscosity alone. The solution was to introduce internationally recognised standards for marine fuel quality, which brought a consistent reference to grading and addressed the important quality characteristics of each grade.

GRADES

It remains very common for marine engineers to refer to distillate fuels as ‘MGO’ (marine gas oil) or ‘MDO’ (marine diesel oil) and residuals as ‘HFO’ (heavy fuel oil) or ‘IFO’ (intermediate fuel oil). They are often pre-fixed ‘LS’ and ‘HS’ for low and high sulphur content respectively. This is mirrored in charterparty vessel description and bunker clauses. However, this is not in line with current international classification.

The International Organization for Standardization’s (ISO) specification ISO 8217, entitled *Petroleum products – Fuels (class F) – Specifications of marine fuels*, is the recognised international standard and provides a strict grading system based on the main characteristics of the fuel. Marine distillates are categorised DMX, DMA, DMZ or DMB. The ISO categorisation of residual fuels range from RMA to RMK and is followed by its kinematic viscosity at 50°C. For example, IFO 180 is more properly known as RMG 180 and MDO as DMB.

To confuse matters further, the products recently created for complying with the sulphur regulations have introduced different terminology – and many of these new fuels do not fit within an existing ISO 8217 grade. Some of the lighter products come close to matching the characteristics of the distillate DMB, whereas the heavier products more resemble the residual RMD 80. These new fuels are informally known within the industry as:

- ultra-low-sulphur fuel oil (ULSFO) with 0.1% maximum sulphur content for compliance in emission control areas
- very-low-sulphur fuel oil (VLSFO), which has a 0.5% maximum sulphur content for compliance with the 2020 IMO global sulphur cap.

These can then be suffixed with either ‘RM’ for residual marine fuels and ‘DM’ for distillate marine fuels.

QUALITY CHARACTERISTICS

Marine fuel oils have many characteristics relating to quality. Some have more relevance to residual fuels than distillates and vice versa. The more commonly referenced characteristics are summarised here.

Viscosity

The viscosity of a fuel is its internal resistance to relative movement. Put simply, this is a measure of how it will flow, sometimes described as how 'runny' it is or its 'flowability'. The viscosity of fuel varies with temperature – as it is heated, it will flow more easily. A good analogy is golden syrup: at cool temperatures it will not readily flow, but apply some gentle heat and it pours with ease.

When reference is made to the viscosity of a fuel oil, this generally means the kinematic viscosity of the fuel, which is a measure of the time taken for a specific volume to flow through a test tube under laboratory conditions. Alternatively dynamic viscosity is sometimes used.

Different standard tests and units of measurements have been adopted over the years for measuring kinematic viscosity, including Redwood seconds, Engler degrees and Saybolt seconds. However, the most commonly used unit for kinematic viscosity is the metric standard unit known as the centistoke (cSt), where one centistoke is equivalent to 1 mm^2/s.

As viscosity will alter with change in temperature, it must be measured at a specific reference temperature. The standard temperatures most commonly used are 40°C for distillate fuel oils and 50°C for residual fuel oils.

Viscosity is the important parameter used to determine fuel-heating and injection conditions. Engine manufacturers will specify the optimum viscosity at injection and from this the corresponding heating temperature is determined.

Density

Density is the mass of the oil per unit volume and is usually given in kg/m^3 at 15°C. However, the unitless 'API gravity' is sometimes used in the USA and is always given at 60°F.

The density of a fuel oil which can be consumed in the engines of a vessel is determined largely by the ability of the vessel's fuel treatment equipment. Conventional centrifugal separators (purifiers and clarifiers) which operate with a water seal cannot efficiently remove water from a fuel of density greater than 991 kg/m^3. However, fuels with a density of up to 1,010 kg/m^3 are readily available on the bunker market and these fuels, denoted RMK in ISO 8217, can only be handled by specially designed separators.

The density is a very important factor when calculating the quantity of fuel bunkered or the remains on board (ROB). Fuel oil is transacted by weight in metric tonnes (t, also commonly abbreviated to 'MT') but, in the vast majority of cases, it is only measurable by volume in cubic metres (m^3). Therefore the measured volume must be corrected for temperature before being converted to weight by multiplying this figure by the density.

Ignition quality

The ignition quality of a fuel oil is an indication of its ability to ignite. This influences the time taken between injection into an engine combustion space and the beginning of ignition.

The methods for measuring the ignition quality of distillate and residual fuel oils are different.

For distillates, a test engine with a variable compression ratio is used to determine the cetane index, which is a measure of combustion quality during compression ignition.

The ignition quality of residual fuel oils is predicted by calculation. The most common method is the 'calculated carbon aromaticity index' (CCAI) which was developed by Shell and is derived from the density, viscosity and temperature. Less frequently used is BP's 'calculated ignition index' (CII), which follows a similar method of calculation. Typical values for the CCAI are in the order of 800–870 for residual marine fuel oils. However, some industry bodies are of the opinion that CCAI is not a reliable indicator. Some fuels with low – and therefore desirable – CCAI have been found to have poor ignition and combustion characteristics when consumed and, in some cases, resulted in engine damage.

Furthermore, ignition and combustion can be affected by the pressure and temperature in the combustion chamber. Some engines are more tolerant to poor ignition quality fuels than others. In particular, slow-speed engines are more resistant than medium-speed engines as they give more time for ignition and combustion.

The Institute of Petroleum approved test IP 541 is an alternative (or indeed supplemental) method. The fuel is tested in controlled conditions and provides a more detailed assessment of its ignition and combustion characteristics. It is hoped by some in the industry that this test replaces the existing CCAI and CII calculation methods.

Sulphur

Sulphur is a naturally occurring constituent element found in marine fuels but can be one of the most problematic. The amount of sulphur depends on both the geographical source of the original crude oil and how it has been blended during the refinery process.

Sulphur in fuel oil burns to form sulphur oxides (SOx). In the presence of water, these compounds produce sulphuric acid (H_2SO_4), which not only leads to corrosive wear in the engine but, through acid rain, harms the environment.

High-sulphur fuels can be safely burned in marine diesel engines, subject to environmental legislation such as the International Convention for the Prevention of Pollution from Ships (MARPOL) Annex VI. However, lubricating oil with a higher base number (BN) – therefore more alkaline – should be used to prevent acid attack in the cylinder and combustion spaces. Also, maintaining engine exhaust temperatures above minimum recommended levels will reduce the risk of condensation within the engine and exhaust gas uptakes and prevent acid corrosion.

Shipowners should seek advice from the engine maker and lubricant provider to ensure the BN and feed rate of lubricating oils are suitable for the sulphur content of the fuel in use. Serious engine damage can occur if the lubricating oil is not matched to the fuel oil. For vessels operating in and out of emission control areas, which require changing over from high- to low-sulphur fuels (and vice versa), it may be necessary to carry two grades of cylinder oil.

The sulphur content of marine fuels is subject to both international and regional environmental legislation. This is addressed in more detail in Chapter 9.

Lubricity

Lubricity can be defined as the ability to reduce friction between surfaces in relative motion. Fuels with poor lubricity can lead to increased wear and seizures in engine fuel pumps and injectors.

A fuel's lubricity is affected by the sulphur content. Burning fuels with very low concentrations of sulphur may present a higher risk of engine damage through a lack of lubricity. As such, refineries have added lubricity-enhancing additives to distillates. But in a 2014 paper, engine manufacturer MAN Diesel & Turbo stated that it did not regard the lubricity of the fuel as a major issue and had not experienced any failures due to a lack of lubricity.

Flashpoint

The flashpoint of a fuel is the temperature at which it releases sufficient vapour to ignite when a flame is directly applied. It is determined under laboratory test conditions using the Pensky–Martens closed-cup tester.

The purpose and importance of quoting the flashpoint is shipboard safety. The minimum flashpoint of a fuel oil that can be used or stored on board a vessel is 60°C. This is both a requirement of classification societies ('class') and the International Convention for the Safety of Life at Sea (SOLAS). These rules and regulations also state that fuel stored on board should not be heated to within 10°C of the flashpoint.

The only exception to the 60°C flashpoint rule is when considering emergency or low-flashpoint fuel for use outside the vessel's main engine room or machinery spaces. Typically this fuel will be a distillate fuel used in emergency generators and lifeboat engines. These fuels are limited to a flashpoint of not less than 43°C under SOLAS.

The flashpoint of a fuel oil should not be confused with its auto-ignition temperature. Auto-ignition temperature is the temperature the oil will ignite without a directly applied ignition source. For marine fuel oil this is usually over 250°C. An analysis of maritime fire statistics carried out in 2012 by FOBAS (Lloyd's Register) concluded that, in all likelihood, a shipboard fuel-oil fire will be initiated by the fuel oil coming into contact with a surface above its auto-ignition temperature rather than coming into contact with an open flame or external ignition source.

If a low-flashpoint fuel is taken on board a vessel, the shipowner must advise the vessel's flag state and/or classification society. It may be necessary to retake samples in addition to carrying out a risk assessment. Control measures and preventative actions can be identified and put in place. In some cases de-bunkering may be necessary.

Fig. 3. The flashpoint of a fuel is an important characteristic and should be accurately measured in a laboratory (VPS)

Hydrogen sulphide

Hydrogen sulphide (H_2S) is highly toxic. At low concentrations, the gas has the distinctive smell of rotten eggs. But at higher concentrations, personnel exposed to the gas will experience a loss of sensitivity to the smell so should not wholly rely on their sense of smell. It is extremely hazardous to human health and can prove fatal.

Hydrogen sulphide occurs naturally in crude oil and may be present in refined marine products in both the form of a gas and as a liquid within the fuel. The risks and dangers to health are described in material data safety sheets. Vessel operators should maintain appropriate safety procedures to protect crew who may be exposed to hydrogen sulphide vapour.

Acidity

Fuel oils with a high acidity can initiate and accelerate corrosion damage to marine diesel engines.

Some acidity is expected in marine fuel oils as it is inherent in most crude oils, but the presence of strong acids is not tolerated. The measure of a fuel's acidity is its total acid number (TAN). This measures both the inherent weak organic acids and the undesirable strong inorganic acids.

A high TAN can be an indication of contamination and should be no greater than 2.5 mg KOH/g for residual fuel oils. However, a high TAN can also be due to naturally occurring naphthenic acids originating from the crude and this is not considered to be a problem. Special testing can establish if a fuel oil with a high TAN is naphthenic or if the acids are not natural.

Sediment

Sediment in residual fuels and the heavier distillates (such as DMB – marine diesel oil) is formed through the coagulation of unstable asphaltene molecules. These molecules are inherent to the fuel itself, and their propensity to coagulate is therefore an indication of fuel stability (also see section on compatibility and stability).

The testing for sediment of marine distillates is different to residual fuels. The test for sediment content in distillate fuel is 'total sediment existent' (TSE), also known as 'total sediment by hot filtration'. As the name suggests, the fuel sample is heated and filtered and the amount of dry sludge retained on the filter paper is observed.

The test for residual fuels is the 'total sediment potential' (TSP), also known as 'total sediment aged'. The sample is placed in a hot bath for 24 hours, after which it is shaken vigorously prior to passing through a filter paper.

Fuel oils with a total sediment result of greater than 0.1% are very likely to give rise to fuel-handling problems on board. Typical problems are frequent blocking of filters and overloading of centrifugal separators with sludge.

Carbon residue

The test for carbon residue provides an indication of the level of carbon deposits that form at high temperatures – typically found in the combustion spaces of marine diesel engines.

The carbon residue of a fuel oil is usually given in terms of micro-carbon residue (MCR), but this is a laboratory test result carried out under specified reduced-air conditions and is merely an indicator. The actual amount of carbon deposits found in an engine will be dependent on many related factors including ignition quality, engine set up, maintenance and engine power outputs.

Pour point

The pour point of a fuel oil is the lowest temperature at which a fuel oil will flow. Fuels refined from paraffinic crudes are usually more likely to have higher pour points.

The pour point is important information for vessels' engineers as it determines the minimum temperature at which residual fuel oil can be stored and handled. If fuel is stored at a temperature close to or below the pour point, pumping will become difficult. In extreme circumstances, solidification and stratification will occur. This causes major operational problems as the energy required to change the solid wax back to a liquid is much greater than what can be achieved by a normal shipboard tank heating arrangement.

A rule of thumb for on-board storage is to maintain the fuel at least 10°C above the pour point.

Cloud point and cold filter plugging point

Cloud point and cold filter plugging point influence the performance of distillate fuels in cold temperatures. The cloud point (CP) is the temperature at which wax crystals will begin to form. The cold filter plugging point (CFPP) provides a relative indication of where problems may start to occur during filtration, such as blocking of fuel filters and starvation of fuel to the engine.

New blended or 'hybrid' fuels designed to satisfy the new and forthcoming sulphur requirements are likely to have a high paraffinic content and this can affect its cold flow properties. It is important that in addition to its pour point, the CP and CFPP of a ULSFO and VLSFO is known by the vessel's engineers.

Water

Water content of supplied bunkers varies throughout the world and some ports have a worse reputation than others.

When bunkering fuel, the obvious problem with high water content is one of simple economy. Consider a bunker stem of 1,000 t with water content of 0.5%. This equates to 5 t of water for which the buyer will pay as if it were fuel. At a bunker price of, say, US$500/t, this means that the US$2,500 has been wasted purchasing unusable water.

Water contaminated fuel can also lead to a wide range of problems for the marine engineer. If untreated, it can generate sludge and lead to combustion problems. The type of problem and its severity can often depend on the source of the water. Seawater contamination is potentially more serious than that of freshwater due to its sodium content (see section on vanadium and sodium). Usual sources of freshwater contamination include condensation, leaking steam heating coils, badly set up centrifugal separators and rainwater ingress through poorly maintained tank lids and sounding pipes.

In most cases, water can be removed by allowing sufficient settling time for the fuel oil in the settling tanks. Heating the settling tanks aids separation and the proper set-up and use of centrifugal separators (set up as purifiers) should reduce the water content to acceptable levels.

Ash

Marine fuel oils contain metals and other inorganic elements. They may be naturally occurring materials in the crude oil, or they may be introduced through the refining process or as a result of contamination.

The geographical source of the crude is a factor in the type and amount of naturally occurring material, which is non-combustible and inorganic in nature. Typical constituents include vanadium, silicon, aluminium, nickel, sodium and iron.

Common types of ash-based contamination include sand, rust, scale and general dirt. It usually occurs during periods of fuel storage but it can also happen during distribution.

Vanadium and sodium

Vanadium occurs naturally in crude oil in its soluble form and the content varies depending on the source. Crude oils from Mexico and Venezuela are generally recognised as having the highest levels of vanadium.

Vanadium in fuel oil is not a major problem per se, but it becomes an issue when accompanied by sodium in certain proportions.

Sodium is also found naturally in crude oil. But sodium levels in marine fuel oils usually become significant when there has been seawater contamination. Like vanadium, sodium is not usually problematic on its own but high levels can result in deposits on the engine turbocharger, which require removal by water washing or dry washing of the turbine side.

Vanadium and sodium can, under certain conditions, oxidise during combustion to form sticky, semi-liquid salts. These deposit on high-temperature surfaces such as exhaust valves and exhaust-valve seats. This is referred to as 'high-temperature corrosion' and can cause significant damage to exhaust components and turbochargers.

The exact temperature at which sticky salt deposits form depends on the vanadium to sodium ratio. The most problematic ratio is approximately 3:1 as this requires the lowest temperature for these deposits to form.

Improved engine design, temperature control, good maintenance and improved operation have combatted the damaging effects of vanadium and sodium. Engine manufacturers have introduced corrosion-resistant materials such as stellite and nimonic steels as well as improvements in valve cooling. Older marine diesel engines may be more vulnerable to high-temperature corrosion and this usually means the surface metal temperature of exhaust valve seats and exhaust valve faces must not exceed 450°C.

Aluminium and silicon (cat fines)

Aluminium and silicon can occur naturally in crude oil, but only in trace amounts. The presence of these elements in fuel oil is usually associated with contamination with catalytic fines from the refining process. Alumino-silicates are used as a refining catalyst in the cracking process and spent particles (fines) can then remain in the residual component.

Catalytic fines – often abbreviated to 'cat fines' – are extremely hard and very abrasive. They vary in physical size, usually between 1 micron and 75 microns, and can destroy an engine and its components very quickly. Components particularly susceptible to damage include fuel valves, fuel pumps, cylinder liners and piston rings.

Manufacturers of marine diesel engines generally state a maximum cat fine content of 15 ppm at the fuel inlet. Recent MAN Diesel & Turbo bulletins have even suggested a 10 ppm maximum. These are significantly lower than the limits stated in the international standard ISO 8217. The 2005 edition, which is still commonly referenced in bunker purchase contracts and time charterparties, provides a maximum concentration of 80 ppm. This was reduced to 60 ppm in the 2010 edition, but remains much higher than allowed at the engine.

To achieve a cat fine content that satisfies the engine manufacturer's stated limit, careful shipboard treatment of the fuel oils is needed. This is detailed in the section on fuel treatment in Chapter 8. However, the efficacy of a typical on-board treatment plant, usually consisting of centrifugal separators and filters, has its limits. The hull insurers' Joint Hull Committee advised in 2013 that if a fuel contains more than 50 ppm of catalytic fines, the limitations of on-board fuel treatment equipment – even when running at optimum conditions – mean that the content at injection is unlikely to be reduced enough to meet the recommended levels.

Engineers should be aware that cat fines can build up in the sludge at the bottom of fuel storage and settling tanks, even when fuel deliveries have been within the specification limit. These sediments may be disturbed in heavy weather and very high levels of aluminium and silicon would then be passed through the fuel system. This should be factored in when deciding on frequency of fuel tank cleaning.

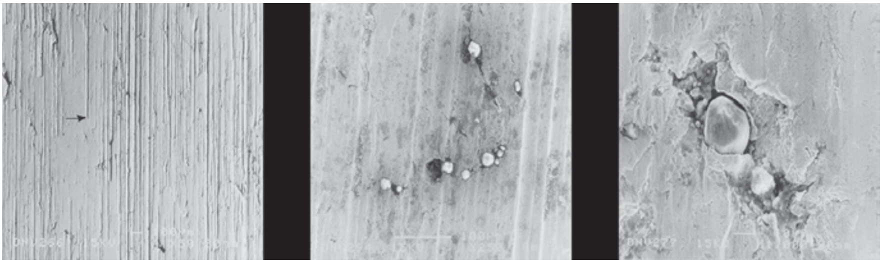

Fig. 4. Microscopic image of cat fines damage to piston ring of main engine (VPS)

Used lubricating oil (ULO)

Fuel oil containing waste lubricants, and the accompanying high levels of metal particles usually found in such lubricants, can damage marine diesel engines. Additives typically found in lubricating oils also increase the ash content of the fuel oil and these reduce the ability of a vessel's on-board centrifugal separators to remove water and cat fines.

The presence of used lubricating oil in fuels can be identified through testing for calcium, phosphorous and zinc. Maximum levels of these elements are listed in ISO 8217.

Compatibility and stability

'Compatibility' and 'stability' are often confused. This is because the problems relating to incompatible fuel oils and poor fuel oil stability are similar and both often result in major sludge build up. However, the terms and their meanings are quite different.

The stability of a fuel oil is its ability to remain in a similar condition to that produced after the refining process. A fuel oil is considered stable if its homogenous mixture remains unaffected during normal storage conditions and does not produce a sludge.

The stability of the asphaltenes in the fuel can deteriorate in two ways. Firstly, through damage to the asphaltene molecular structure – usually from catalytic cracking or vis-breaking during the refinery process. Secondly, when blending with paraffinic cutter stock.

Problems can arise when two incompatible fuels are mixed or blended. Each fuel may be stable within itself but, when mixed, incompatible fuels will produce asphaltenic sludge. It follows that if two mixed fuel oils remain stable, they are termed compatible.

If a fuel oil or fuel mix becomes unstable the consequences can be very serious. Sludge formation can lead to blocked filters, partially choked or blocked fuel lines, large sludge deposits in tanks and centrifugal separators, overloaded fuel systems and poor combustion conditions.

A fuel's sediment content is an indication of its stability. This can be determined by laboratory analysis and ISO 8217 provides the maximum total sediment parameter ('total sediment by hot filtration' for distillates and 'total sediment aged' for residual fuels).

Incompatibility can theoretically be prevented by researching the source of fuel oils, identifying the refining processes and then avoiding mixing fuels from different sources and processes. However, this is almost impossible in practice. Therefore, fuel oils should always be segregated and mixing on board should be avoided as far as practicable. Where possible, bunker new fuel into empty tanks, which will also make it easier to calculate the quantities loaded.

Fig 5. Unstable and incompatible fuel oils can lead to build-up of sludge (VPS)

Fatty acid methyl ester (FAME)

Distillate fuels containing the biofuel FAME – also known as biodiesel – has been used in non-marine applications for a number of years. These fuels may contain soybean oil, rapeseed oil, used frying oils or animal fats mixed with conventional distillate fuel oil.

Traditionally, marine fuels with FAME content have been viewed with caution. This is mainly due to concerns on storage as FAME is hygroscopic, which means it is able to absorb moisture. This can lead to microbial growth in the fuel tanks which permanently damages the fuel and requires intensive cleaning of the vessel's tanks and pipelines. FAME can also adversely affect the cold flow properties of a fuel.

As such, international standards on marine fuels only allowed a trace amount of biofuel content. But in 2017, new grades of marine distillate fuel were recognised which allows up 7% FAME content.

Unusual contaminants

In addition to the contaminants mentioned earlier, there are others which are not included in ISO 8217, notably polypropylene and waste chemicals.

Polypropylene

Polypropylene is a plastic polymer which is both chemically and physically very stable. Consequently, fuel oils contaminated with polypropylene cannot be treated with conventional shipboard processes such as settling, filtration and centrifuging. The most effective way to deal with the problem is to de-bunker.

Polypropylene in fuel oil will quickly block fuel filters and systems. The consequences can be very serious and may lead to loss of propulsion and power blackout with the cause being hard to identify. The source of the contaminant is uncertain, but it is sometimes used to absorb large quantities of water from stored fuel oil.

Standard laboratory testing against ISO 8217 parameters will not detect the presence of polypropylene. It can only be identified and measured by a specific test.

Waste chemicals

Over the last few years many incidents of contamination of bunkers with waste chemicals have been reported and complicated claims ensued.

STANDARDS FOR MARINE FUELS

The first recognised standard for marine fuel oil was published in 1982 by the British Standards Institution (BSI) and was titled BSMA 100:1982. In the same year, the International Council on Combustion Engines (CIMAC) published the first edition of its recommendations on heavy fuel for diesel engines.

The first International Standardization Organization (ISO) standard for fuel oil was published in 1987: *ISO 8217:1987 Petroleum products – Fuels (Class F) – Specifications of marine fuels*. It has been revised a number of times since the first edition and the most recent edition available (in 2018) is ISO 8217:2017.

The standard provides limits on the characteristics of each category (grade) of marine fuel and covers both distillates and residuals. It also specifies the testing criteria for each parameter.

Some of the main features of each of the ISO 8217 editions are outlined in the following sections. It is useful for shipowners and vessel's engineers to know the differences between the different editions as they cannot assume that the most recent version will be the one referenced in a bunker delivery contract or charterparty.

ISO 8217:1996

Similarly with the first edition, the 1996 revision is rarely referenced nowadays. However, at the time it brought the welcome introduction of limits on the acceptable levels of catalytic fines in residual marine fuel oils (80 ppm) and an assessment on stability through testing for total sediment potential.

ISO 8217:2005

The 2005 edition brought further changes and still remains the most widely used and accepted in the industry (in 2018). It is often referenced in bunker purchasing contracts and time charterparties.

The system of fuel categorisation was changed and has roughly remained the same in subsequent editions. The sulphur limit of residual fuels was brought in line with the IMO MARPOL Annex VI global sulphur cap that was in place at the time. Concerns about the contamination of fuel with used lubricating oil were addressed by limiting the levels of zinc, phosphorus and calcium in all grades of residual fuels and marine diesel oil (DMB).

The cetane number for distillates was replaced with the calculated cetane index.

ISO 8217:2010

The 2010 edition contained a number of important additions and changes. The number of fuel oil grades was further amended and new parameters were incorporated.

While the number of grades for distillate fuel oil remained at four, the categories were modified. An additional distillate grade DMZ was added, which has a minimum viscosity of 3 cSt at 40°C but is otherwise identical to DMA. The minimum viscosity for DMA was increased to 2 cSt and a minimum viscosity of 2 cSt introduced for DMB. The previous DMC grade was modified and renamed RMA 10. The number of residual fuel oil grades was increased from 10 to 11. RMF and RMH were removed along with RMA 30. RMG and RMK were expanded to include RMG 180, 500 and 700 and RMK 500 grades respectively.

One of the more significant changes was the lowering of allowable cat fine content in residual fuels. The combined silicon and aluminium content of common residual fuels RMG 180 and 380 was reduced to 60 ppm.

Sulphur limits were removed and reference was made to the applicable statutory sulphur caps imposed by IMO or national authority.

Additional and amended requirements relating to hydrogen sulphide, used lubricating oil components and stability were introduced. It also addressed lubricity of distillate fuel oils and the ignition characteristics and sodium concentration of residual fuel oils.

Clause 5 contained a general requirement to prevent the addition of any substance or chemical waste that could jeopardise the safety of the vessel, the performance of the engines and auxiliary machinery, pose a threat to personnel or which may contribute to or enhance air pollution. It also required fuel to be free of bio-fuels except for a trace amount of FAME material.

ISO 8217:2012

The 2012 edition consisted of an updated test method for hydrogen sulphide.

ISO 8217:2017

The most notable change concerned the addition of FAME biodiesel blends in distillate fuels. A new set of distillate grades was introduced: DFA, DFB and DFZ. These additional grades essentially correspond to the existing distillate grades of DMA, DMB and DMZ but they allow up to 7% FAME content.

FAME has traditionally been considered a contaminant in marine fuels and was previously only allowed in trace amounts. ISO 8217:2012 defined this as a maximum of 0.1%, but the 2017 edition raised these levels to 0.5% for the distillate grades DMA, DMB and DMZ. Excepted is DMX, which must remain free from any FAME content.

This increase of FAME content up to 0.5% caused concern in some parts of the industry. Some parties voiced concern that this constitutes an acceptance that FAME levels would now be tolerated rather than the original intention of making an allowance for the trace contamination of fuel.

The commonly used residual fuels, RMG 180 and RMG 380 were generally unaffected.

Reduced sulphur limits were introduced for most of the distillate fuel grades and cloud point and cold filter plugging point were added to winter grades of DMA and DMZ.

LNG AS A MARINE FUEL

The use of liquefied natural gas (LNG) as a marine fuel is still relatively undeveloped (in 2018). Its use is likely to increase as a bunkering infrastructure develops and it becomes a recognised and viable alternative to traditional marine fuels, driven mainly by the need to comply with the forthcoming IMO global sulphur cap in 2020.

As it stands, there are no standard specifications for LNG as a marine fuel. ISO has appointed a working group – ISO/TC 28/SC 4/WG 17 'Specifications of liquefied natural gas for marine applications' – to investigate whether a standard for marine LNG fuel can be developed.

The characteristics of LNG do vary and buyers should receive a specification sheet and confirm its suitability before bunkering, paying particular regard to composition, density and its combustion properties. Countries that import LNG may source from multiple suppliers for the purposes of security of supply and are therefore not dependent on a single supplier. For example, suppliers in Europe source LNG from more than 10 different gas fields. This can result in variations over time in the composition of the LNG in the storage tanks.

Typical LNG quality characteristics that receiving vessels should be aware of are outlined in the following sections.

Methane (CH4)

Methane is the primary constituent of LNG. The quality of LNG can referred to as being 'lean' (methane >95%) or 'rich' (methane <95%). Lean LNG has a relatively low calorific value whereas rich LNG contains a greater proportion of heavier hydrocarbons which gives it a higher calorific value.

Methane number

In addition to the percentage composition of methane, LNG is also referenced by its methane number – an indicator of the ignition quality when vaporised. This is a scale of 0 to 100 based on the combustion characteristics of methane (100) and hydrogen (0).

The methane number is determined by the composition of the LNG and has direct relevance to its performance with Otto cycle gas engines, with particular regard to engine 'knock'. If the methane number of a fuel is too low, the engine performance can be adversely affected and can lead to damage.

Other hydrocarbons

Although LNG mostly consists of methane, other hydrocarbons are usually present in much smaller proportions. The amount and type of these hydrocarbon compounds depend on the source of the LNG and the requirements of the market it is destined for.

The main influence of these other hydrocarbons is on the calorific value of the LNG. Hydrocarbons with a greater number of carbon atoms provide more heat energy when compared with methane.

Typically found hydrocarbons include:

- ethane (C_2H_6)
- butane (C_4H_{10})
- hexane (C_6H_{14})
- propane (C_3H_8)
- pentane (C_5H_{12})
- heptane (C_7H_{16}).

Calorific value

The calorific value is the amount of energy produced by the complete combustion of the fuel. It can be provided in either imperial units (BTU/scf) or metric units (MJ/m^3). It is therefore an important characteristic of LNG, so much that calorific value is used as the basis of buying and selling when in bulk.

Calorific value is given by either:

- higher heating value (HHV) – also known as the gross calorific value
- lower heating value (LHV) – also known as the nett calorific value.

The HHV and LHV are calculated differently. They both measure the heat recovered when a metered amount of gas is burnt and the combustion products cooled, but the HHV includes measuring latent heat whereas LHV does not.

Wobbe Index

The Wobbe index (or Wobbe number) is often referenced in LNG specifications and contracts. It is a function of the calorific value and the density of the LNG. This calculation provides a measure of the amount of calorific heat flowing through a burner nozzle of a specific size in a given time.

The index is used as an indicator of whether a burner will be able to run on an alternative fuel source without modification. If the Wobbe index is the same for two fuels, despite their different compositions, a burner will deliver the same amount of heat energy.

Density

Density alone has limited value as a characteristic of LNG, but it is required to calculate the Wobbe Index and the mass of fuel.

Trace components

Compounds that are damaging, toxic or corrosive should be restricted to trace levels.

Nitrogen (N_2)

Nitrogen contains no combustion energy and at high levels can cause storage and quality issues. Nitrogen boils at –196°C when at atmospheric pressure, so it is the most volatile component in LNG. This can lead to rapid mixing and vaporisation. As such, the nitrogen content in LNG should be limited to 1%.

Sulphur (S) and sulphur compounds

Typical sulphur levels in LNG are less than 0.004% of sulphur by mass. Sulphur compounds, which include hydrogen sulphide (H_2S), are removed during the production process to trace levels.

Water

LNG is stored at very low temperatures. Therefore any excess water has the potential to solidify and block pipework and equipment as the temperature is reduced to –162°C. A typical limit on water content for LNG fuel is 0.01 ppm.

Carbon dioxide (CO_2)

Like water, carbon dioxide has the potential to solidify and block pipework and equipment at the low temperatures required for LNG storage. A typical limit is 50 ppm.

Mercury (Hg)

Excessive levels of mercury in LNG will damage aluminium components in the system. It is typically limited to 10 ng/Nm^3.

BTEX

BTEX is an abbreviation used for four compounds found petroleum products. These are benzene, toluene, ethylbenzene and xylenes. They are considered pollutants and if released into the atmosphere can cause severe damage to human health. The total BTEX content in LNG fuel is typically limited to 10 ppm.

Chapter 4

PURCHASING MARINE FUELS

SPECIFYING THE RIGHT FUEL

When a shipowner, manager or charterer is ordering bunkers for a vessel, it is strongly recommended they insist the fuel is supplied in accordance with the most recent edition of ISO 8217 – the international standard for marine distillate and residual fuels. This is just as important when drafting and agreeing charterparties.

The bunker clause should refer to the required grade as per ISO 8217 rather than the generic terms used for fuel. For example, if a vessel's engine burns residual fuel with a viscosity of 180 cst at 50°C, then 'RMG 180' should be stipulated in accordance with the required (preferably latest) edition of ISO 8217. It should not be simply described as 'IFO'.

Extra caution is advised when a standard other than ISO 8217 is proposed or used in the charterparty. Some national based standards do not identify the fuel for marine use and, as a consequence, may not be suitable. A good example is that ISO 8217 and SOLAS both require the minimum flashpoint for marine bunker fuel to be 60°C. Other standards not specifically intended for marine fuel (such as automotive fuel) may allow a flashpoint significantly lower than 60°C.

It is important to remember that more recent editions of ISO 8217 do not provide a maximum on the sulphur content for residual fuels. They merely refer to the fact that statutory environmental legislation shall apply. This is in contrast to the earlier editions of ISO 8217, which do state the maximum sulphur content for each grade, but these values are unlikely to align with current environmental legislation.

Therefore, to avoid confusion when agreeing bunkers or drafting rider clauses in charterparties:

1. stipulate the grade as per ISO 8217
2. stipulate which edition of ISO 8217 (preferably the latest)
3. stipulate the maximum sulphur content.

Those responsible for purchasing fuel or for inserting bunker clauses in charterparties are strongly urged to liaise closely with their technical departments to ensure they identify the correct ship-specific fuel oil specification. Most engine manufacturers can provide shipowners with extensive details of the quality of fuel oil required for optimum combustion in their engines. This information, together with ship-specific handling, treatment and storage requirements, should be referred to when specifying fuel oil requirements to charterers, bunker brokers or bunker suppliers.

New fuels – ULSFO and VLSFO

The introduction in January 2015 of the revised sulphur limits for marine fuels for use in MARPOL Annex VI emission control areas (ECAs) led to the market providing some new types of fuels. This market is expected to expand when the global sulphur cap enters into force on 1 January 2020.

For vessels not fitted with abatement technologies, such as an approved exhaust gas cleaning system (SOx scrubber), bunker buyers need to decide whether to use new blended or 'hybrid' low-sulphur products as an alternative to traditional low-sulphur distillates, such as marine gas oil (MGO).

The new fuels are generally referred to as 'ultra-low-sulphur fuel oil' (ULSFO), with 0.1% maximum sulphur content, and 'very-low-sulphur fuel oil' (VLSFO), which has a 0.5% maximum sulphur content. These are often suffixed with either 'RM' for residual marine fuels and 'DM' for distillate marine fuels.

A charterer needs to give careful thought and consideration when proposing the use of the new alternative products. Many of the new fuels do not easily fit into the grades specified in ISO 8217 as they are usually specially designed and produced by the oil companies. In some cases, the products are formed by blending distillate and residual products from existing refinery streams.

Bunker quality clauses in the charterparty cannot therefore rely on referencing ISO 8217 standards as they will not be appropriate. The clauses will require careful wording to ensure the fuel is fit for use in the vessel's plant. A further complication is that a number of engine manufacturers have yet to issue 'no objection' letters for all of the alternative fuels available.

There will always be cases where regulations and documentation lag innovation and industry needs. Therefore further guidance may be needed if a blend or hybrid fuel does not meet the criteria of ISO 8217 and a letter of no objection has not been issued by the engine manufacturer.

Summary of bunker specification

In summary, when purchasing fuel or if drafting bunker clauses in charterparties, the following should be undertaken.

- Identify a fuel specification that is suitable for the vessel and its plant.
- Specify internationally recognised standards, such as the latest version of ISO 8217.
- Provide an exact description of the product or grade required, such as RME 180, RMG 180 or RMK 380.
- Specify maximum allowable sulphur limit.

Fig. 6. Typical bunker supply vessel – often referred to as a 'bunker barge' (VPS)

DELIVERY CONTRACTS

The purchaser of the fuel – usually the shipowner or time charterer – may enter into a direct contractual relationship with a bunker supplier or bunker trader. It is also common for the supply of fuel oil to be arranged through a bunker broker.

Where a broker is used, the purchaser will request a quote from one or more bunker brokers. They will in turn contact suppliers or traders and invite offers to supply the fuel oil. After negotiation, one of the offers will be accepted. In these circumstances the bunker broker is an agent of the purchaser of the fuel oil. As such, the ship operator will only have a claim against the broker when the broker has exceeded the terms of its authority or has failed to carry out its role with due care.

If there is a breach of contract on the part of the supplier, such as when the supplier provides poor quality fuel oil or the wrong quantity, the broker will not be liable to the purchaser unless there are exceptional circumstances. Examples of such exceptional circumstances are:

- where the broker has induced the purchaser to enter into the bunker delivery contract by making representations which it knew to be untrue at the time they were made
- where the purchaser has specified a certain characteristic, such as maximum sulphur content, and the broker has failed to pass this information to the supplier.

Whether the contract is direct with a trader or supplier, or concluded via a broker, a contract comes into existence when an offer is accepted. This will normally be evidenced by an email confirming the terms agreed – otherwise known as the 'confirmation of stem'. While this sets out the main terms of the contract, it will not generally be an exhaustive list of contract terms. Commonly the details of the contract will be set out in standard terms and conditions, which one party will ask to be incorporated into the contract. Invariably, the terms and conditions incorporated are those of the supplier.

Terms of the contract

As the confirmation of stem does not state all the terms of the contract, the parties then need to agree the detailed terms to be set out in the contract. As a matter of English law, the terms of the contract will derive from three sources.

1. Terms expressly agreed between the parties — the confirmation of stem.
2. Terms incorporated into the contract — usually the supplier's own standard terms and conditions.
3. Terms implied by law.

Each of these is explored in more detail in the following sections.

CONFIRMATION OF STEM

Terms expressly agreed between the parties will normally be evidenced by the correspondence confirming the stem. In the event of a dispute as to what may or may not have been agreed between the parties, it may be necessary to examine the correspondence which led to the confirmation of stem.

Commonly, the confirmation of stem will provide for the following:

- price
- place and date of supply
- amount of fuel oil ordered
- quality by reference to a standard specification
- incorporation of standard terms and conditions.

This simply provides the bare bones of the contract. The detail will be provided by standard terms and conditions, which are normally incorporated into the supply contract.

SUPPLIER'S STANDARD TERMS AND CONDITIONS

Standard terms and conditions can be incorporated into the contract in three ways.

- They may be incorporated by a specific reference, usually contained in the confirmation of stem.
- There may have been previous dealings between the parties, during which the supplier's terms and conditions were consistently used.
- More rarely, they may be incorporated through what is considered customary in that particular trade. In other words, the parties are aware that such conditions are habitually imposed in that trade and aware of the substance of those conditions.

A supplier's standard terms will commonly contain provisions relating to:

- the admissibility of evidence
- the time within which claims must be brought by the purchaser ('time bar')
- the law applicable to the supply contract.

In the event of a dispute — and even where no dispute arises — these terms are essential to the smooth operation of the contract. The purchaser should always ask to be supplied with a copy of the terms and conditions before concluding the contract.

Suppliers' standards terms have often been considered onerous on the buyer and too far in favour of the supplier. For many years, attempts to create a standard bunker contract that could be used across the industry were unsuccessful, but the 'BIMCO Terms 2015 Standard Bunker Contract' looks to remedy this. Although this contract has not gained widespread industry usage – most suppliers prefer their own terms and conditions – it nevertheless provides a starting point for negotiations. It serves as a useful reference for the purchaser of marine fuel oils wanting a more balanced, operator-friendly document. An updated version, 'BIMCO Bunker Terms 2018', has now been adopted by BIMCO's Documentary Committee but has not yet been released publicly (in 2018).

Terms, conditions and clauses of note

Suppliers' terms and conditions generally adopt similar layouts and will include terms dealing with the following aspects of the supply of fuel oil.

Payment

Normally, the terms and conditions will state the manner and timing by which payment should be made. In the event of a late payment, this may include a contractual right to interest.

Example of late-payment clause

In respect of all sums which are overdue the buyer shall be liable to pay to the company interest calculated at 2% per calendar month pro-rated and compounded on a daily basis from the due date until receipt by the company of sufficient cleared funds. Accrued interest and costs and/or expenses incurred by the company in requesting payment of outstanding amounts will be added at monthly intervals to and become part of the outstanding sum. In the event that this contractually agreed rate of interest is in excess of that permitted by relevant law there shall be substituted the maximum rate so permitted.

Evidence

Standard terms and conditions will often seek to limit the evidence that may be admitted in the event of a quality or quantity dispute arising between the parties. The procedures are often long and complicated and the consequences of failing to comply severe. The following clause is taken from a typical supplier's conditions.

Example of evidence clause

It is a pre-condition to the company's liability for any quality claim that at the time notice of claim is given the set of samples retained by the physical supplier are available for analysis by a reputable independent testing laboratory, approved by the company, in accordance with established procedures and the analysis is carried out in the presence of a representative of the company. The buyer hereby acknowledges that the sealed samples retained by the physical supplier are representative of the product delivered and that the company has no duty to consider any other independently produced samples. The results of the analysis shall be final, binding and conclusive on all parties. In the event that the physical supplier is unable or unwilling to make available for analysis the samples within seven days from the date of delivery or such shorter period as may be specified in the confirmation, the company will accept the buyer's set of sealed samples provided by the physical supplier as representative of the product delivered for analysis in accordance with the provisions of this clause, provided that the buyer's request in writing to the physical supplier for the sealed samples is copied to the company at the same time the request is sent to the physical supplier.

Sampling

Sampling requirements, and identifying who must be present at the time samples are drawn, are all commonly regulated by the standard terms and conditions. The following is an example.

Example of sampling clause

It is the duty of the buyer to instruct the physical supplier to take three representative samples of every consignment and load of the product on commencement of delivery in accordance with the custom at the point of delivery. The three representative samples must be sealed and labelled and the label signed by a representative of the physical supplier and by an officer of the vessel and/or other senior representative of the buyer. One set of the physical supplier's samples shall be retained by the buyer and one set by the physical supplier, each to be retained for a minimum of 60 days after delivery to the vessel. The third sample shall be retained by the vessel in accordance with the provisions of MARPOL 73/78, Annex VI. The third sample may only be used for the purposes of confirming the sulphur content of the marine fuel and such other matters as are specifically set out in MARPOL annex VI, 18.

MARPOL Annex VI imposes specific requirements on ship operators to retain a sample taken from the bunker manifold of the receiving vessel. It must be held on board for a period of not less than twelve months from the time of delivery. The sample should be sealed and its label signed by both the supplier's representative and the master or officer in charge of bunkering. IMO Resolution MEPC. 182(59) *Guidelines for the sampling of fuel oil for determination of compliance with revised Annex VI of MARPOL* provides useful guidance.

Some suppliers' standard terms and conditions make reference to the MARPOL requirement, but some do not. This can lead to a conflict between the sampling requirements agreed under the bunker delivery contract and those required by law.

Time limit

Standard terms and conditions nearly always stipulate a time limit within which claims should be brought. Although these may be subject to a test of reasonableness imposed by legislation, purchasers should always make best efforts to submit their claim within the stipulated time limit. An example of a trader's terms with regard to time limits is as follows.

Example of time-limit clause

Time limits: because the company is frequently placed under strict time limits by its suppliers for presentation of claims, it is necessary that it too must impose rigid time limits on receiving notice of claims from its customers. In consequence of the company's strict time limits, customers should ensure that they maintain their own equally strict internal checking and reporting procedures. It must be clearly understood that the company will not relax its time limit in any circumstances. The time limit for receipt by the company of notice of a quality claim is seven days from the date of delivery or such shorter period as is specified in the confirmation.

Normally such clauses are enforceable and it is important that any time limits are observed.

Lien clause

A lien is a right to withhold the property of another until the price — in this case for the fuel oil — is paid. A typical lien clause might read as follows.

Example of lien clause

Where product is supplied to a vessel, in addition to any other security, the agreement is entered into and product supplied upon the faith and credit of the vessel. It is agreed and acknowledged that a lien over the vessel is thereby created for the price of the product supplied and that the company in agreeing to deliver product to the vessel does so relying upon the faith and credit of the vessel. The customer, if not the owner of the vessel, hereby expressly warrants that he has the authority of the owner to pledge the vessel's credit as aforesaid and that he has given notice of the provisions of this clause to the owner. The company shall not be bound by any attempt by any person to restrict limit or prohibit its lien or liens attaching to a vessel unless notice in writing of the same is given to the company before it sends its confirmation to the customer.

The concept of a lien is often misunderstood – and a lien clause such as in the example may not be as effective as it seems. But it is usually included in the standard terms and conditions as its inclusion can only benefit the position of the supplier where, for whatever reason, it has not been paid for the fuel supplied.

Where the delivery contract is between the shipowner and the supplier and is subject to English law, the contractual notice of lien can, at best, give the supplier a contractual right to arrest the vessel. However, the right would have existed anyway by virtue of section 20 of the Supreme Court Act 1981, which deals with the admiralty jurisdiction of the High Court. This section provides that where a buyer is the owner of the vessel and has failed to make payment to the seller, the vessel can be arrested to obtain jurisdiction and security for the claim.

The situation is different when the shipowner is not a party to the supply contract, such as when the fuel oil was purchased by a time charterer. Then, as a matter of English law, the seller's rights are not generally enhanced by the inclusion of a clause giving a right of lien over the vessel. Unless the shipowner has knowledge of the lien clause and has agreed to be bound by it (which is unlikely), a time charterer purchaser has no authority to bind the shipowner into such a clause.

Moreover, because a shipowner is not a party to the bunker delivery contract and is not liable for the claim *in personam* (i.e. the person against whom a court action would be brought), the supplier would not have a right to arrest the vessel for security and/or to establish jurisdiction for its claim. However, this is not the case in certain other jurisdictions.

Retention-of-title clause

The terms and conditions will often determine the point at which the ownership of the bunkers passes from one to another. This may be at the vessel's manifold, but it may also be that the supplier will seek to retain ownership of the bunkers until payment has been made.

In *Forsythe International (UK) Ltd* v *Silver Shipping Co. Ltd and Petrolglobe International Ltd (The Saetta)* [1993] 2 Lloyds Rep 268, the time charterer failed to pay the supplier for the fuel delivered. A 'retention-of-title' clause provided that the fuel oil was to remain the sole and absolute property of the seller until such time as the buyer had paid the agreed price. As no price was paid, ownership of the fuel oil on board the vessel did not pass to the charterer. The validity of the clause was accepted by the parties and the courts generally will uphold such clauses.

It follows that if a shipowner burns fuel oil which has not been paid for and is subject to a retention-of-title clause, it may be liable to the bunker supplier for wrongfully using the fuel oil in a way that is inconsistent with the supplier's rights (the tort of conversion, meaning to interfere with the property of another). Consequently, the shipowner may have to compensate the supplier for the value of the bunkers used.

TERMS IMPLIED BY LAW

Specific terms may be implied by law into the contract. English law will imply a term into a contract when it is customary in that particular trade or in the following circumstances.

Contract cannot function without implied term

The nature and extent of the implied term will be considered in light of the 'officious bystander' test. In other words, if the parties were confronted with the problem they now face, what term would an unconnected outsider consider to have been part of the contract at the time the parties completed their bargain? Where one party's standard terms and conditions have been incorporated into the bunker delivery contract, it is unlikely that there will be any need to imply a term because most aspects of the bunkering operation will have been dealt with in the standard terms and conditions.

Operation of other legislation

Many jurisdictions enact legislation to protect parties from unreasonable terms in supply contracts. These include consumers and those who contract on the other parties' written or standard terms of business.

The UK, for example, has the Unfair Contract Terms Act 1977, which applies a test of reasonableness before the terms are enforceable. However, such legislation is of limited value as it does not apply to international supply contracts (that is where one of the parties is not domiciled within the UK and English law governs the contract solely because a term of the contract provides it is to be governed by English law). In practice, the legislation will only apply where the supplier and purchaser are English companies.

The shipowner may have a remedy in English law under the Misrepresentation Act 1967. This legislation requires a prior misrepresentation. An example is if a supplier wrongly described a fuel oil as being a particular grade and this induced the shipowner to enter into the contract. If a contract contains a term that seeks to exclude the supplier's liability by reason of the misrepresentation or restrict the remedy available to the shipowner, that term will only be effective if it satisfies the test of reasonableness.

The test of reasonableness is the same as that set out in section 11(1) of the Unfair Contract Terms Act 1977, as follows.

UK Unfair Contract Terms Act 1977

11(1) the term shall have been a fair and reasonable one to be included having regard to the circumstances which were, or ought reasonably to have been, known to or in the contemplation of the parties when the contract was made.

There had been a long-held view that, where a contract is governed by English law, certain terms will be incorporated by the Sale of Goods Act 1979 (as amended by the Sale and Supply of Goods Act 1994).

However, the position was clarified after bunker supplier and trader OW Bunker group (OWB) filed for bankruptcy in 2014, which led to some shipowners facing duplicate demands for payment from the group's sub-contractors. A test case in London arbitration, *Res Cogitans*, held that the bunker supply contract was not governed by the Sale of Goods Act and that OWB could enforce its right to payment even though it had not physically supplied the bunkers.

The case was ultimately brought to the UK Supreme Court and the shipowner's appeal was dismissed. The Supreme Court held that a bunker sale contract cannot be regarded as a straightforward agreement to transfer the property in bunkers, to which the

Sale of Goods Act 1979 would apply. A contract containing a 'retention of title' clause and an express right to consume the bunkers during the credit period was not a contract of sale within the meaning of section 2 of the Sale of Goods Act 1979.

As a consequence, a shipowner or charterer that contracted with OWB remained exposed to paying not only OWB, but also the contracted physical supplier in those instances where the supplier has been granted a lien under local law.

Furthermore, implied terms from the Sale of Goods Act 1979, such as 'satisfactory quality' or 'reasonably fit for the purpose' will not apply to a bunker supply contract.

The extent or ability to imply other terms into the supply contract will depend on the language of the contract and future interpretations by the courts. Contracts subject to the laws of other countries may, however, incorporate or imply terms as to quality, fitness for use, or similar by law.

Choice of jurisdiction

Standard terms and conditions normally include a clause on choice of law and jurisdiction. A majority of charterparties and bunker supply contracts provide for English law and jurisdiction. The main reasons for this is to take advantage of the large body of existing case law which enables the parties to determine with a measure of certainty their respective rights and obligations.

Such a clause is essential due to the number of countries with laws relevant to a bunker delivery contract. Where a jurisdiction has not been selected in the bunker delivery contract, then legal advice should be sought to determine which country's laws will apply.

The courts in some countries may consider themselves to have jurisdiction over any dispute where the:

- physical supplier is resident
- ship operator is resident
- contract was concluded
- vessel has been arrested
- vessel is registered.

For the sake of certainty, it is in the interests of both parties that the courts of one jurisdiction are empowered to resolve disputes between the parties. Where a particular jurisdiction has not been chosen, it will not be possible to define the extent of either party's obligations. A variety of additional obligations may be imposed upon one or both of the parties, of which neither had notice, and may only come to light once litigation has been commenced in a particular jurisdiction. There is also the possibility of proceedings being commenced in a second jurisdiction that is more favourable to one of the parties, with an inevitable increase in legal costs.

BUNKERS SUPPLIED BY CHARTERER

Under a voyage charterparty, the charterer has little control over day-to-day operation of the vessel and it is the shipowner who purchases the fuel oil. Under a time charterparty, however, it is the charterer's obligation to arrange supply of fuel oil to the vessel. As such, it is the time charterer that concludes the bunker delivery contract with the supplier and there is no direct contractual relationship between the shipowner and the bunker supplier.

While it may be possible for the shipowner to hold the supplier liable in tort — for example, if the supplier was negligent in the supply of fuel oil to the vessel — it will usually be easier to proceed against the time charterer where there is a contractual relationship.

Ownership of fuel

When a vessel has been supplied with off-specification fuel oil, it becomes important to know who owns it. Even off-specification fuel oil has considerable value and, while the safety of the vessel, crew and cargo must always come first, the shipowner cannot simply disregard ownership of the fuel oil when dealing with it.

It is common for time charterparties to provide that the fuel oil will be bought and paid for by the charterer during the currency of the time charter. Clause 2 of 1946 New York Produce Exchange (NYPE 1946) charterparty states the following.

NYPE 1946 clause 2

'the charterers shall provide and pay for all the fuel except as otherwise agreed'.

Modern charterparties are even more specific. Clause 9 of the latest version of NYPE (2015) deals specifically with bunkers and provides three options on supply and ownership of bunkers. The first option is for the charterer to take over and pay for all bunkers remaining on board on delivery of the vessel, and the owner takes over and pays for all bunkers remaining on board on redelivery. The two further alternatives allow the owner to retain responsibility for the bunkers and apply the costs to the charterer's first hire payment, or agree for the charterer to redeliver the vessel with the same quantity on board as on delivery.

The BPTIME 3 and GENTIME charterparties provide the following.

BPTIME 3 clause 15

15.2 Charterers shall provide and/or pay for:

15.2.1 all fuels of a quality suitable for burning in the vessel's engines and auxiliaries (which shall comply with the description in part 1 section J) except for quantities of fuel consumed while the Vessel is off-hire.

GENTIME clause 6

(c) The Charterers shall purchase the fuels onboard at delivery at the price stated in Box 21

(d) Bunkering — The Charterers shall supply fuel of the specifications and grades stated in Box 23. The fuels shall be of a stable and homogenous nature and unless otherwise agreed in writing shall comply with ISO standard 8217:1996 or any subsequent amendments thereof as well as with the relevant provisions of MARPOL.

Although a charterer will normally own the fuel oil during the period of a time charterparty, it may be subject to retention-of-title clauses in the bunker supply contract. In such cases, ownership of the fuel oil will be determined in accordance with the terms of the retention clause. If unpaid, the bunkers may remain the property of the supplier.

Time charterparties generally provide that ownership of the fuel oil passes back to the shipowner on redelivery of the vessel. The shipowner will then be obliged to pay for the fuel oil remaining on board at redelivery. The price is usually determined by a term of the charterparty.

Where the charterparty is brought to an end earlier than anticipated, such as withdrawal by the shipowner or repudiation by one of the parties, ownership of the fuel oil will depend upon the wording of the charterparty. A specific clause will be needed to transfer ownership of the fuel oil to the shipowner upon termination of the charter other than by way of a proper redelivery.

A shipowner that terminates a charterparty by exercising its right to withdraw, might not own the fuel oil on board the vessel (see *Forsythe International (UK) Ltd v. Silver Shipping Co. Ltd and Petrolglobe International Ltd* (The *Saetta*) [1993] 2 Lloyds Rep 268 and The *Span Terza* [1987] 1 Lloyds Rep 119 HL). If the shipowner then uses – or otherwise deals with – the fuel oil remaining on board the vessel, it will be liable to pay the charterer for the value of the fuel oil.

The value is determined by the price paid by the charterer or (if different) the price charged by the nearest bunker facilities at the time the charterparty came to an end. The shipowner may also be liable in tort for dealing with the property of another in a manner inconsistent with that party's ownership of the property (the tort of conversion).

Claims brought by a supplier

As it is common for the time charterer to take ownership of the fuel and provide bunkers, it follows that the shipowner will not be a party to the bunker delivery contract.

As a matter of English law, the shipowner derives no rights from a bunker delivery contract between a time charterer and a bunker supplier. Conversely, the bunker supplier will have no rights against the shipowner or the vessel, regardless of the apparent inclusion of any such rights in the bunker delivery contract. This is because neither the shipowner nor the vessel is a party to that contract. Equally, the time charterer has no authority to bind the shipowner into that contract.

The English legal position is included in NYPE 1946 clause 18 and NYPE 2015 clause 23.

NYPE 1946 clause 18

Charterers will not suffer, nor permit to be continued, any lien or encumbrance incurred by them or their agents which might have priority over the title and interest of the owners in the vessel.

NYPE 2015 clause 23

The Charterers will not directly or indirectly suffer, nor permit to be continued, any lien or encumbrance, which might have priority over the title and interest of the Owners in the Vessel. The Charterers undertake that during the period of this Charter Party, they will not procure any supplies or necessaries or services, including any port expenses and bunkers, on the credit of the Owners.

In certain jurisdictions the supply of fuel oil to a vessel may give the supplier a maritime lien claim against the ship. In the USA, provided the bunker delivery contract is subject to US law (or the laws of a country which recognise a bunker supplier's claim as a maritime lien), the supplier will be allowed to enforce its claim against the vessel.

To protect the vessel against such claims, a shipowner may seek to endorse the bunker delivery note (BDN) with a 'prohibition of lien' notice. An example of such a notice is included in Appendix III. On its own, the effect of such notice is questionable. The supply may already have taken place before the prohibition of lien is brought to the attention of the supplier and if so, it is unlikely that its terms will have any effect on the bunker supply terms.

It is therefore good practice to draw to the bunker supplier's attention the fact that the fuel oil is supplied for the account of the time charterer alone before the supply takes place. The vessel is then provided with fuel oil by the supplier in the knowledge that no lien attaches to the vessel.

However, the bunker supplier may refuse to deliver fuel unless its right to enforce a claim against the vessel for the price of the fuel is preserved. While time charterparties commonly provide that the master is obliged to follow the orders and directions of the charterer as regards the employment of the vessel, they also include a clause such as the aforementioned NYPE 1946 clause 18 and NYPE 2015 clause 23. Any clause in a bunker delivery contract giving the right to enforce a supplier's claim against the vessel would clearly be a breach of such a term.

Despite a clear breach, the better view is that the time charterer can order the vessel to take fuel oil from a particular supplier notwithstanding that this may lead to the creation of a lien over the vessel – itself a breach of contract.

English law, which will often govern the charterparty, will consider that the shipowner's rights are protected by its right to an indemnity from the charterer in respect of any loss that it may suffer by virtue of the bunker supplier exercising its lien. However, if the time charterer becomes insolvent before paying a bunker supplier, this right of indemnity will be of little use.

Contractual procedures

The supply of bunkers under a time charterparty will be regulated by two, often contradictory, sets of procedures: those contained in the charterparty, and those in the bunker delivery contract.

A shipowner's obligations under the charterparty will remain constant; but those under the bunker delivery contract are likely to vary with each supply, assuming different suppliers are used each time.

When a bunker quality or quantity dispute arises, the most important contract to the time charterer will be the bunker delivery contract with the supplier. If the time charterer is to make a successful recovery from the supplier, then there must be strict adherence to the claims procedure in that contract. It is therefore important that a charterer ensures that the shipowner and the vessel's crew comply with the procedures contained in the bunker delivery contract.

The charterer can do this by the following.

- Becoming familiar at an early stage (pre-supply) with the claims procedure and evidence-gathering provisions of the bunker delivery contract. The master should then be given specific instructions before bunkering to ensure compliance with those procedures.

- Making sure that the charterparty contains a clause which requires the shipowner to report any bunker quality or quantity concerns immediately to the charterer, or to the bunker supplier's representatives by means of a notice of protest.
- Ensuring that bunker samples are taken and analysed by a reputable laboratory for all supplies made under the charterparty.

Charterer's obligations on supplying bunkers

A shipowner should provide the time charterer with a detailed specification of the grade of fuel oil that the vessel is able to use. The requirement to supply fuel oil of a particular specification should then be included in the time charterparty. If a charterer subsequently fails to provide fuel oil of the agreed specification, it will be in breach of contract and liable to the shipowner for losses caused by that breach.

The extent of the charterer's obligations to supply fuel oil capable of being used by the vessel has not yet been determined by the English courts. It is very possible that a charterer could supply fuel that meets the agreed specification but is found to be unsuitable for use by the vessel. The shipowner needs to protect itself against such an event, as explained in the following sections.

Bunker quality clauses

Much will depend upon the wording of the charterparty. A clause which provides that the fuel oil supplied by the charterer must not only meet the particular specification, but also be suitable or fit for the vessel in question, provides the most protection.

A clause with this effect can be found in clause 9 of both the NYPE 1993 and NYPE 2015 forms. However, BIMCO has created a suite of bunker clauses for use in time charterparties. Rather than replace existing clauses in standard charterparty forms, they are a means of supplementing them with bunker provisions that are missing or poorly worded. They cover matters relating to delivery or redelivery bunkers, bunkering operations, sampling, fuel testing programmes and trading in emission control areas.

An example of such a clause is the bunker quality-control clause recommended by BIMCO (see Appendix I).

Where the charterparty does not contain a specific clause, the arbitrator (as most such disputes will be dealt with under the arbitration agreement in the charterparty) will have to determine the scope of the charterer's obligations to supply fuel oil which both meets the contractually agreed specification and is fit for use by the vessel. The approach taken by arbitrators when defining the nature and scope of such a clause has not been consistent, so that any one of the following may subsequently be found to apply.

- The charterer is under an absolute duty to provide proper fuel oil.
- The charterer is only under the obligation to use due diligence to see that the proper fuel oil is supplied.
- The charterer is merely under an obligation to ensure the supply comes from a reputable supplier.

In the absence of a well-drafted clause, the only means of determining which of the three alternatives forms part of the charterparty will be by arbitration or litigation.

Invariably, this is a time-consuming and costly process and it is therefore in everyone's interest that a well-drafted clause is included at the outset in the charterparty.

2020 global sulphur cap: effect on charterparties

Although the new global sulphur cap will not arrive until 2020, forward planning is essential to avoid painful charterparty disputes at redelivery.

The bunker quality clause may need to be reviewed in most charterparties and there are a number of additional charterparty issues that are likely to be affected by the new low-sulphur regime.

The nature of the issues will depend on the method of compliance, such as burning distillate, blended or hybrid fuels or if using an exhaust gas cleaning system. Typical issues to consider include the following.

- Describing fuels in a charterparty or a bunker supply contract as 'low sulphur' or 'high sulphur' will not be good enough. Post-2020 there will be:
  - 0.1%S fuel – for use in ECAs and any other applicable regional/domestic legislation
  - 0.5%S fuel – for global use outside ECAs
  - >0.5%S fuel – for use by vessels fitted with exhaust gas cleaning systems (scrubbers).
- Agreeing quantities and prices of fuel remaining on board at redelivery.
- How to manage any high-sulphur fuel on board that can no longer be used or is not allowed to remain on board.
- If exhaust gas cleaning systems are being considered, then installation, allocation of costs and any associated delay or deviation will need to be agreed.
- Any need to change the fuel prices that have been agreed in the charterparty.
- Agree responsibilities and payment for any necessary cleaning of fuel tanks.
- Suitability of bunker quality clause if using a blend or hybrid fuel that is not covered by ISO8217.
- Any effect on performance warranties.
- Availability of suitable and compliant fuel during the vessel's chosen trade.

Unspecified characteristics

The production of marine fuel oils to meet changing demands is an evolving process. Even with a well-drafted charterparty clause, problems can arise where fuel oils are introduced with new characteristics. This could be as a result of changes in the refining process or responding to new environmental regulation.

For example, the introduction of used lubricants into fuel oil was a source of considerable concern in the 1990s. The international standard in place at the time, ISO 8217:1996, did not address used lubricating oil content. Therefore fuels that were otherwise within specification were often contaminated by substances such as used lubricating oils that could render the fuel unsuitable for use.

In the US District Court case of *Kalamos Shipping* v *Chemoil Corporation*, it was held that, as a matter of fact, the ISO 8217:1996 standard which had been ordered by Kalamos did not exclude used lubricants (contamination with used lubricating oil was addressed in ISO 8217:2005 and it continues to be specified in subsequent editions). Two reputable firms of bunker chemists also disagreed on the percentage of lubricants that may be present in the fuel before the fuel was unsuitable for use by the vessel. It was decided by the court that a marine fuel oil may comprise up to 5% by volume of used lubricants.

However, the US decision contrasted with that of the arbitrator in London arbitration 1/88 LMLN 214, where chloro-compound contaminants found in the fuel oil were not mentioned in the specification used (BSMA 100).

London arbitration 1/88 LMLN 214

It was therefore reasonable to imply into the charterparty in order to give it commercial efficacy, that any fuel which the charterers should supply pursuant to the obligations under clause 2 [of a NYPE 1946 form] should be reasonably fit for use in the main engine of the vessel with particular reference to stability and to its chlor content ... a charterers' obligation to provide bunkers which were reasonably fit was an absolute obligation. It was a contractual obligation and contractual promises are by their nature absolute.

Presently, there are no English court decisions on the subject. However, English case law — *Fal Bunkering Co. Ltd* v *Gerrard Chartering A/S* (1990) — suggests that the fact that the fuel specification is set out in the charterparty does not shift the requirement that the fuel must also be suitable for use by the vessel.

Breach by the charterer

Where a time charterer fails to supply fuel oil in accordance with the terms of the charterparty, the charterer will be liable to the shipowner in damages for breach of contract.

A shipowner must then decide whether or not the fuel oil can be consumed on board. As the fuel oil will normally remain the charterer's property under a time charterparty, the shipowner should involve the time charterer in that decision-making process. The shipowner should also liaise with the charterer to ensure that all necessary steps are taken to protect the charterer's position under the bunker delivery contract.

Where there is significant risk that the vessel cannot safely use the fuel oil supplied by the charterer, the shipowner should ask the charterer to arrange for the vessel to be de-bunkered and re-supplied. However, it may be necessary for the shipowner to mitigate its losses and to arrange the de-bunkering and resupply of the vessel for its own account when a charterer refuses to do so. The cost of de-bunkering and resupplying the vessel with suitable fuel oil would then be included in any claim brought by the shipowner against the charterer.

Under most time charterparties the vessel would remain on-hire for the periods spent de-bunkering and re-bunkering because there would be no deficiency within the meaning of the off-hire clause. Even if the off-hire clause is drafted sufficiently wide to include the time lost de-bunkering, it is likely that the shipowner would be able to recover any off-hire by way of damages. This is because the loss of time was caused by the charterer's breach in failing to supply fuel oil suitable for use by the vessel's engines.

After de-bunkering, the unsuitable fuel may need to be stored ashore. It is likely that the shipowner may wish to minimise storage costs and look to dispose of it. It may be possible to sell the de-bunkered fuel and monies received can be offset against the cost of replacement fuel. It is important to note that the shipowner does not own the fuel and can only sell it with the fuel owner's consent. Where the fuel owner does not consent, it may be possible to make an application to the court in the country where the fuel is being stored to order a sale.

It is often in the charterer's best interest to assist the shipowner in the removal of unsuitable fuel oil from the vessel. Despite the fact that a charterer may be in breach of its obligations to supply fuel oil of a particular grade under the charterparty, it may be able to pass on that liability to the supplier under the bunker delivery contract. The charterer should consider whether it wishes to reject the fuel oil and claim against the supplier for any liability it incurs to the shipowner, together with any loss it has made disposing of the off-specification fuel oil.

LNG AS A MARINE FUEL

Currently (in 2018), there are no internationally recognised purchase contracts or standard specifications for LNG as a marine fuel.

Therefore delivery contracts and charterparty clauses on LNG bunker quality cannot rely on referencing a recognised quality standard. Certainly any reference to ISO 8217 standards will not be appropriate.

LNG bunker delivery contracts

Early adopters are entering into long-term delivery contacts with preferred partners. This is in contrast to the usual practice associated with conventional marine fuels, where there is no long-term relationship with a supplier or delivery provider. LNG fuelled vessels operating on short-sea or domestic routes will have LNG delivered at the same place by the same company. Vessels operating internationally or on a liner service may be engaged in a long-term supply contract with the LNG producer as well as the third party providing the delivery services.

Shipowners entering into long-term contracts should ensure there is a clear allocation of responsibilities. It may be prudent to consult the P&I club to ensure the terms are not too onerous on the shipowner, which may in turn impact P&I cover.

Shipowners can determine their requirements on the quality of LNG by consulting with the engine manufacturers, such as a minimum methane number (MN), lower heating value (LHV), the maximum amount of hydrocarbons other than methane, and limits on trace components. But as the composition of LNG varies quite significantly around the world, the scope of parameters on composition cannot be too narrow. These requirements can then form the basis of a fuel quality clause in a charterparty.

In addition to quality criteria, LNG bunker contracts will need to address quantity and how it is measured. Bulk LNG is sold on an energy basis, typically in British thermal units (Btu) or MJ/Nm^3, unlike LNG for road transport fuel which is sold either by mass or volume.

BIMCO's future work programme currently (2018) includes giving consideration to creating an LNG Bunker Purchase Contract.

Charterparties

The terms of a time charterparty may put an obligation on the charterer to provide suitable bunkers to the vessel.

The shipowner must be very clear on the LNG fuel requirements of the vessel, mirroring those for bunker delivery contracts. Both parties must also be aware of the limited infrastructure and availability of LNG as a marine fuel when determining trading areas.

In addition to the charterer's obligation to supply the vessel with the right fuel, there is a risk that LNG bunkering operations could affect cargo operations. Port authorities allowing LNG bunkering will only allow simultaneous operations (SIMOPS) to be conducted subject to a risk assessment.

Furthermore, some ports may only allow LNG bunkering to be carried out at certain berths or the delivery methods may be limited to trucks, which is much slower than a transfer from a bunker vessel. Any such restrictions could impact cargo operations and lead to delays. These factors should be considered when fixing both time and voyage charterparties.

Vessel performance

The composition of LNG fuel has a direct influence on the performance of the engine(s) consuming it. In turn, this affects the speed and consumption of the vessel on a voyage.

LNG with high methane content might have a lower calorific value than LNG with lower methane content. This means that more fuel must be consumed to achieve comparable power output. This potential for variations in performance must be taken into consideration when agreeing any vessel performance warranties in the charterparty.

The influence of calorific value must also be considered when planning a voyage. As is usual when passage planning, the expected fuel consumption must be determined and the master satisfied that sufficient reserves are on board. If the planning does not account for the higher consumption rates experienced by a fuel with a lower calorific value, and an incident results because of this, then the shipowner is open to allegations of failing to exercise due diligence to ensure seaworthiness at the commencement of the voyage.

Calorific value also has a direct relevance on contracts of carriage (bill of lading) where, under the Hague and Hague-Visby Rules, there is an explicit obligation on the carrier regarding seaworthiness. Furthermore, in the event of an incident that leads to the shipowner declaring general average, cargo interests may refuse contributions if they successfully prove this particular failure to exercise due diligence.

Determining the actual composition of the fuel in use is of course made much more challenging when the tank contains a mixture of previous bunkers with different characteristics.

Terminal's conditions of use

Vessels wishing to undertake LNG bunkering operations within a port, terminal or when engaging with a bunker provider may find themselves having to agree conditions of use.

The conditions of use enforced by some terminals and providers are particularly onerous on the vessel, sometime imposing strict liability. This means the vessel is liable for costs and expenses incurred from an incident regardless of fault.

A shipowner presented with such conditions of use should consult its P&I club for further guidance to ensure cover remains unaffected.

Chapter 5

BUNKERING

SAFE HANDLING

Fuel oils are potentially hazardous so it is vital for everyone involved in shipboard bunkering operations to appreciate the risks and consider the importance of handling fuel oils with care.

Material safety data sheets (MSDS) provided by the bunker suppliers and producers should be passed to the master or chief engineer before any transfer begins, and the vessel's crew should familiarise themselves with their contents. Providing a MSDS is a legal requirement in many countries, and the crew should ensure they are obtained from the bunker suppliers. IMO has published guidance on their content in IMO Resolution MSC.286(86) *Recommendations for Material Safety Data Sheets (MSDS) for MARPOL Annex I Oil Cargo and Oil Fuel.*

Shipboard personnel are usually well aware of the risks involved in handling fuel oils and the injuries and illnesses that may result. Contact with marine fuels can lead to a range of skin disorders, such as dermatitis, and it is also understood that some fuel oils contain carcinogenic polycyclic aromatic hydrocarbons.

The MSDS should contain a wide range of information including personal protective equipment (PPE) requirements together with advice on the use of barrier creams and other protective equipment. All those involved in handling fuel oils should ensure that they wear adequate PPE including boiler suits, suitable gloves, goggles and non-slip, static-free safety shoes (see North's loss prevention guide *Personal Injury Prevention: A Guide to Good Practice*).

Fuel is sometimes transferred at temperatures that can cause burns. Fuel pipes, pumps, tanks and other equipment used in the system can become very hot. Certain fuel transfer lines may also be fitted with steam trace-heating lines, which can cause severe burns to seafarers who are not using PPE or if the pipes are not lagged correctly.

The main risks involved in handling fuel oils can be summarised as follows.

- Fuel oils can produce dangerous vapours which may be flammable, poisonous (hydrogen sulphide) and asphyxiating.
- Fuel system components can reach high temperatures – bunker tanks are heated to about 40–50°C to allow easier transfer. The fuel is then further heated prior to consumption to temperatures approaching 150°C.
- Fuel oil which comes into direct contact with the skin may cause skin disorders.

Fig. 7. The use of correct personal protective equipment is an essential part of shipboard bunkering procedures (VPS)

GENERAL PROCEDURES AND STANDARDS

Assessing the risks involved in bunkering operations leads to suitable control measures and the development of procedures. These measures and procedures aim to prevent or mitigate the effects of:

- bunker pollution incidents and spills
- fire or explosion
- incidents that lead to harm to human health
- bunker quantity disputes
- bunker quality disputes.

The basic procedure for loading conventional marine fuel oils is essentially the same for any vessel. But there are of course variations depending on vessel type, size and charterparty requirements.

All shipboard operations and procedures should be prepared with extreme care and due regard given to the practical implications for the vessel and its crew. Company-wide bunkering procedures can be very useful, but the individual chief engineer should ensure a detailed, yet workable, bunker loading plan is prepared for each operation, based on a risk assessment.

The task of loading fuel oil on board a vessel begins well before the bunker hose flanges are 'faced up' to the vessel's manifold. The plan begins by ensuring the system is in sound condition with alarms, emergency shutdowns and relief valves in good working order and tested in accordance with recognised industry standards.

All shipboard bunkering procedures should be carefully planned. Regardless if taking from a bunker barge or a shore pipeline, fuel oil transfers should not commence until everyone involved is fully briefed and satisfied with the arrangements.

Although not universally practiced, an internationally recognised standard exists. ISO 13739:2010 *Petroleum products — Procedures for transfer of bunkers to vessels* provides instruction on pre-delivery, delivery and post-delivery checks and documentation. Several efforts at establishing a standard process have gained local acceptance, including the Singapore Bunker Procedure and the ASTM Bunkering Protocol of 1993.

However, the seafarer should follow the bunkering procedures laid down in the vessel's safety management system as required by the ISM Code. These procedures may well be based on the previously mentioned standards.

International Safety Management Code

Most people involved in the shipping industry are familiar with the International Safety Management (ISM) Code. The ISM Code impacts on bunkering in a number of ways and several sections are particularly pertinent.

ISM Code sections relevant to bunkering	
1.4	Functional requirements for a safety management system (SMS)
2	Safety and environmental protection policy
6	Resources and personnel
7	Development of plans for shipboard operations
8	Emergency preparedness
10	Maintenance of the vessel and equipment.

Perhaps the most significant section of the ISM Code in relation to bunkering is section 7, which states the following.

ISM Code section 7
The Company should establish procedures, plans and instructions, including checklists as appropriate, for key shipboard operations concerning the safety of the personnel, vessel and protection of the environment. The various tasks should be defined and assigned to qualified personnel.

Although bunkering is not specifically mentioned in the ISM Code, few would dispute that it is a 'key shipboard operation'. To ensure compliance with the Code, all vessels should have documented risk assessments, detailed bunkering procedures and spill-response plans in which the crew are drilled.

Fig. 8. Preparing for bunkering (VPS)

BUNKER CHECKLIST

A bunker checklist acts as an aide-memoir for the crew carrying out the bunkering operation, supplementing the formal procedures laid down in the vessel's safety management system (SMS).

The checks and tasks start before the bunker barge arrives or connecting to a shore line. An example of the checks found in a typical set of bunkering procedures follow below and may form the basis of a ship-specific checklist.

Prior to bunkering	
Check planned maintenance system – ensure all maintenance of the fuel oil system and its components are up to date.	
Confirm date of the last hydrostatic pressure test of the bunker manifold (tested and recorded in compliance with the SMS requirements and USCG regulations – typically pressure testing is to 1.5 times the recommended working pressure).	
Ensure manifold pressure gauges and flowmeters are in full working order.	
Confirm loading plan and discuss with all persons involved – identify tanks nominated for bunkering, maximum filling levels and sequence of loading.	
Ensure overflow tank is empty and, if appropriate, internally transfer bunkers remaining on board to ensure the fullest possible fuel oil segregation and maximum loading capacity.	
Ensure settling and service tanks are sufficiently full.	
Check availability of ship-specific ullage/sounding tables (with trim-correction information) and temperature correction tables.	

Prior to bunkering	
Note bunker flowmeter reading and carry out a full set of fuel tank soundings and calculations to determine accurately the quantity of bunkers remaining on board.	
Check all equipment required in the bunkering operation is fully operational and ready for use – including sounding tapes, remote level indicators and temperature reading devices.	
Test operation of bunker tank high-level alarms and overflow alarms.	
Check communication links between bunker station, bridge and engine room.	
Test equipment such as intrinsically safe radios and ensure they are fully charged with spare batteries readily available.	
Check all fuel tank sounding caps and weighted cocks are free to operate then ensure they are closed and secure.	
Check tank vent heads are free from obstruction and gauzes and floats are in good order.	
Check all pollution prevention (SOPEP) equipment is ready to deploy and in good condition.	
Check reducers and flange faces at the bunker station are in good order with a supply of suitable new flange joints and gaskets.	
Inspect all other bunker manifolds on the vessel (such as the opposite bunker station) and check the valves are closed and the manifold blank is fitted properly with the correct number of bolts and gasket.	
Ensure bunker system schematic is prominently displayed at the bunker station.	
Check fire-fighting equipment (both fixed and portable) is readily available and in good working order.	
Ensure ‘no smoking’ and ‘no naked flames’ notices are prominently displayed	
Check all personnel involved in the bunkering operation are wearing appropriate PPE.	
All other safety equipment, deck lighting and mooring equipment have been checked and are in good working order.	
Ensure bunker line filter and fuel oil transfer pump filters are clean.	
Check sampling devices are in place and properly installed, with sample bottles and labels available.	
Ensure all save-alls and drip trays are drained, clean and oil free and, where appropriate, plugs ready for use.	
Plug deck scuppers as appropriate.	
Check bunker station lifting equipment used for hose handling is in place and in good order.	
Suspend all hot work operations.	

Connecting	
Ensure the supplying vessel is properly moored and secured alongside the receiving vessel.	
Show red bravo flag and red masthead light.	
Establish safe access between supplying vessel and bunker station.	
Check condition of supplier's bunker hose and couplings, requesting to see certification and testing records as required.	
Check weight of bunker hose does not exceed safe working load of vessel's lifting equipment.	
Ensure the bunker hose is blanked before passing from the supplying vessel into the bunker station.	
Ensure bunker station manifold valve is shut before removing blank.	
Confirm that the hose is connected to the bunker manifold using new gaskets and that all holes are fitted with the correctly sized bolts which are adequately tightened.	
Ensure the bunker hose is satisfactorily supported.	
Check there is sufficient allowance for movement of the hose – the two vessels' draughts may alter during the transfer or may move as a result of sea conditions or wake from passing vessels.	
Witness a full set of soundings of the supplying vessel's tanks, including those tanks not nominated for transfer, record forward and aft draughts and record flowmeter totaliser.	

Before commencing bunkering	
If not already received, review the bunker specification sheet and MSDS provided by the supplying vessel.	
Confirm quantity (and unit of measurement) and agree maximum loading rates and manifold pressure with the supplying vessel.	
Discuss bunker loading plan with the supplier.	
Establish supplier's own emergency spill response plan and equipment.	
Agree methods of communication between the receiving and supplying vessel and confirm signal for: • emergency stop • slow down • faster • stop.	
Agree method for emptying hose upon completion – blowing through or vacuum back onto supplying vessel.	
Ensure system is set up ready for receiving into the nominated tanks.	

At commencement	
Commence bunkering at a slow rate and gradually increase in accordance with agreed maximum rate and maximum allowable manifold pressure.	

During bunkering	
Ensure the bunker station remains manned throughout the transfer.	
Continuously monitor mooring arrangements.	
Continuously monitor hose and connections for leakage.	
Continuously monitor the flow rate and manifold pressure.	
Ensure samples are drawn and collected throughout – samples must be representative of the full stem and sufficient collected to fill at least four sample bottles.	
Carry out regular on-board tests of the fuel – including water content, density, kinematic viscosity, stability/compatibility and cat fine content.	
Provide supplier with ample warning for reducing rate when topping off tanks.	
Ensure sufficient space in the final tank for blowing through.	

Upon completion	
Confirm supplying vessel has stopped pumping and bunker manifold pressure is at zero.	
When line has been blown through or vacuumed, close bunker manifold valve.	
Note bunker flowmeter reading and carry out a full set of soundings and calculations of the bunker tanks to determine quantity on board and therefore determine quantity received.	
Agree figures with supplying vessel – if necessary witness full set of soundings of all its tanks and calculate the supplier's remains on board.	
If figures agreed, sign the bunker delivery note.	
When satisfied that the hose is fully drained, disconnect and replace blanks with gasket on both bunker manifold and bunker hose.	
Decant main sample into at least four individual sample bottles – label, sign and seal each bottle and: • give one sample to the supplier • prepare one sample for laboratory testing • retain one sample on board in case of any future quality dispute • retain one 'MARPOL' sample (not to be used for commercial quality disputes – only tested for Annex VI compliance under strict conditions).	
Reinstate fuel transfer system.	
Enter details of the bunkering operation in the oil record book, engine log book and any applicable fuel transfer logs.	
Despatch one fuel sample to laboratory for testing.	

BUNKER DELIVERY NOTE

The bunker delivery note (BDN) – formerly referred to as the 'bunker delivery receipt' (BDR) – documents the quantity and grade of fuel delivered by a supplier and acts as proof of receipt. It is issued and signed by the bunker supplier and presented to the vessel for signing by the chief engineer.

The BDN must be issued in accordance with MARPOL Annex VI and be accompanied with a signed and sealed representative sample of the fuel delivered. The information to be included in the BDN is as follows.

- Name and IMO number of receiving vessel.
- Port of bunkering.
- Date of commencement of delivery.
- Name, address, and telephone number of marine fuel oil supplier.
- Product name(s) delivered.
- Quantity in tonnes (t) (with corresponding volume and applied density).
- Density at 15°C (kg/m^3).
- Sulphur content by mass (%m/m).
- A declaration signed and certified by the fuel oil supplier's representative that the fuel oil supplied conforms to the applicable regulations of MARPOL Annex VI.

Seal identification numbers for the samples drawn are usually recorded on the BDN.

The BDN must be retained on board for three years after delivery of the stem and be readily available for inspection at all reasonable times.

LETTER OF PROTEST

In the event of a dispute between the vessel and the bunker supplier, it is important that the master of the receiving vessel raises this matter promptly and issues a letter of protest. The chief engineer should also make appropriate remarks in the log book.

The letter of protest should include the following points.

- Date and time fuel oil was loaded.
- Name of bunker supplier.
- Name of both receiving vessel and supplying barge or facility.
- Shortage amount – by volume and in percentage of ordered stem.
- Grade of fuel oil ordered.
- BDN reference number.

The letter of protest should be directed to the barge master or the facility representative. The shipowner or manager should be copied in as should any other interested parties such as the bunker trader or bunker supplier and the time charterer if they have arranged and purchased the fuel. The vessel's crew should then seek the signature and official stamp of the barge master or shore representative.

Many bunker suppliers incorporate very short time bars in their contracts and it is vital that any protest is registered within the specified time frame. It may be very difficult to determine fuel oil quality within the time bars, which can be as short as 24 hours.

Example of letters are given in Appendix II.

Quantity disputes

If there is a disagreement on quantity, the vessel should have the option of issuing a letter of protest and/or making remarks on the BDN. It may be appropriate to appoint an independent surveyor to carry out a full bunker survey, as this will provide important evidence in the event of a dispute.

BIMCO Standard Bunker Contract 2015 addresses quantity disagreements in clause 6, providing guidance on how to raise a protest. Furthermore, it advises that the receiving vessel should only sign for volume delivered at the actual temperature of the delivered fuel.

Extract from BIMCO Standard Bunker Contract 2015

6. Documentation

(b) Once the delivery is completed and quantities measured, a BDN shall be signed and stamped by the Master of the Vessel or the Master's authorised representative, and returned to the Sellers, or their representative, as acknowledgement of the actual volume and the actual delivery temperature only and a duplicate copy shall be retained by the Master of the Vessel…

(c) In the event the Master of the Vessel is not satisfied with the sampling, quantity or any other matter concerning the Marine Fuels or their delivery, the Master shall on completion of delivery:
   i. make appropriate remarks in the BDN detailing the complaints and/or referring to a separate letter of protest; or
   ii. if remarks in the BDN are not permitted, issue a separate letter of protest, receipt of either of which shall be acknowledged in writing by the Sellers' representative.

The clause may appear to contradict the requirements of MARPOL Annex VI regulation 18.5, which requires the quantity in tonnes to be included in the BDN rather than the volume at a given temperature. A BDN signed by the receiving vessel's master or their representative is an acknowledgement of receipt of delivery only and could be argued that it is not an agreement of the weight (mass) figures provided by the supplier.

Clause 9 concerns claims procedures, stating that claims regarding short delivery must be brought within 14 days from date of delivery. However, contracts that are not based on the BIMCO standard terms may have shorter time bars. Prompt action is therefore vital if a short delivery is suspected.

LNG AS A MARINE FUEL

Industry groups such as the Society for Gas as a Marine Fuel (SGMF) and the International Association of Ports and Harbors (IAPH) have published excellent guidance on LNG bunkering. Their guidance includes comprehensive LNG bunker checklists, with the IAPH issuing advice and checklists specific to each type of bunkering operation ('truck-to-ship', 'shore-to-ship' and 'ship-to-ship').

An international standard exists on LNG bunkering arrangements for vessels not covered by the IGC Code. ISO 20519:2017 *Ships and marine technology -- Specification for bunkering of liquefied natural gas fuelled vessels* provides standards on hardware, procedures, record-keeping and training.

However, some vessels have adopted a different approach to refuelling, particularly when short calls in port do not allow sufficient time to transfer LNG into its storage tanks. These vessels load and stow on deck ISO tank containers containing LNG and transfer the contents to the storage tanks while on passage. The spent tank containers are then discharged at a later port.

Safe bunkering

LNG presents very different risks to that of traditional marine fuels. It is cryogenic in nature, therefore the risks associated with extreme cold temperatures and heat transfer must be assessed and managed to ensure the integrity and safety of the vessel and its tanks.

The behaviour and flammability characteristics of LNG are also very different. Add the potential dangers introduced by 'rollover' – where different density layers change position – then it is clear that LNG transfers must be planned carefully and carried out by trained and competent people.

Cryogenic hazards

The low temperatures associated with LNG will cause standard steel to become brittle and at risk of fracture. Materials with superior cold temperature properties – such as 'cryogenic steel' – are therefore used where there is direct contact with LNG or where a spill could occur.

The transfer and storage temperature of LNG at –162°C is clearly hazardous to human health. If the skin comes into contact with LNG, the high rate of vaporisation will cause severe cold burns and frostbite.

Risk of fire and explosion

LNG burns when it vaporises into its gas phase, consisting mostly of methane vapour. The flammability range for methane is generally between 5 and 15% by volume in a mixture with air.

When gas clouds escape, ignition can occur at the edge of the cloud if an ignition source is present. Importantly, the minimum ignition energy for methane is almost 100 times lower than that of a marine distillate fuels such as MGO. This means only a tiny spark is needed to ignite methane – so small that the spark is not visible to the naked eye in daylight.

In very general terms, a methane gas fire can be considered to be one of the following: a flash fire, an explosion, a jet fire or a boiling liquid expanding vapour explosion (BLEVE).

A flash fire is when the gas cloud burns relatively slowly in an open area without generating any significant over-pressure. If a flammable mixture of methane and air ignites in a confined area, the initial combustion may lead to a much more severe over-pressure explosion. Jet fires result from pressurised releases, such as leaks from type C cylindrical tanks, and can be extremely destructive.

BLEVE is associated mostly with storage of LNG in pressurised containers such as type C tanks. It occurs when an external heat source is present – such as a fire surrounding a storage tank – and the tank contents expand. When the pressure is too great, the tank ruptures and the LNG vaporises at a very high rate and leads to a violent explosion.

Although methane has a low flashpoint, its auto-ignition temperature is significantly higher than that of conventional marine fuel oils. This means that methane is not readily ignited when it comes into contact with hot surfaces, such as exposed exhaust pipes and manifolds. This is in contrast to marine fuel oils, which can ignite at such temperatures and result in severe and devastating engine room fires.

Safety and security zones

Prior to bunkering, a safety zone and a security zone should be established. These zones are usually determined and enforced by the port authority.

A safety zone is a designated area surrounding the receiving vessel's bunker station and the supplying vessel or installation. This is a restricted area where activities are limited, sources of ignition are eliminated and only trained persons can enter.

A security zone encompasses a larger area, and prevents other vessels or persons from coming into close proximity of the receiving vessel and the delivery vessel or installation during bunkering.

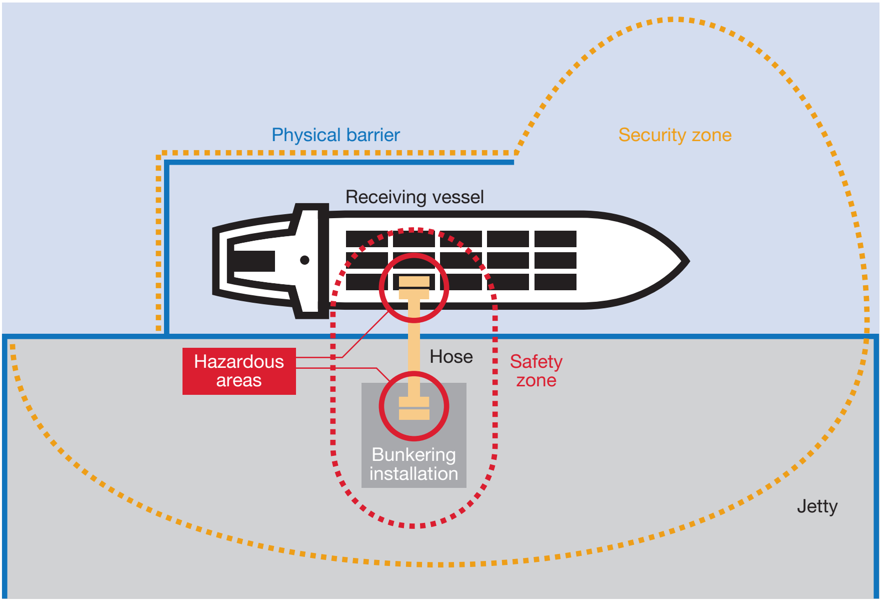

Fig. 9. Typical arrangement of safety and security zones

The positions and magnitudes of both the safety and security zones are subject to a risk assessment and depend on the nature of the bunkering operation (truck-to-ship, ship-to-ship or shore-to-ship) and the location. Factors to consider when assessing the risk include the following.

- What external activities could affect safety, such as vessel movements and other traffic, and their proximity to the bunkering operation?
- Details of any simultaneous operations, either on board or ashore.
- If bunkering from another vessel, it should be positioned so its vent mast is not near any openings on the receiving vessel.

- Formation, size and the direction of travel of a gas cloud in the event of a credible leak.
- Details of the activities and necessary personnel required within the safety and security zones.
- Emergency response plans.
- Access to the vessel by emergency services.
- Port regulations.

Compatibility assessment

Prior to bunkering, an assessment must be made to ensure compatibility between the supplying vessel or installation and the receiving vessel.

This verifies that each party's systems and equipment are compatible as well as their processes and procedures. Areas that are not compatible and present a potentially unsafe condition are identified and addressed as appropriate.

The International Society of Classification Societies (IACS) provides a minimum scope of items that should be checked for compatibility in its Recommendation No. 142 (www.iacs.org.uk/download/1962). Such items include communication systems, connections, emergency shutdown arrangements and mooring equipment.

Emergency response

The receiving vessel, supplying facility and the port or terminal will have an emergency response plan (ERP) for certain scenarios when bunkering LNG fuel. The ISM Code requires the receiving vessel to have an effective emergency response as part of its SMS.

The plans can be based on recognised industry guidance as well as the resulting control measures that are identified following risk assessments and compatibility assessments. Examples of situations to be covered by the ERP include:

- actual release of vapour from identified leakage points – taking into account how much gas could be lost and at what rate, based on what is reasonably foreseeable
- activation of a vapour leakage detection alarm
- actual report of fire in the safety zone
- actual report of fire in the security zone
- blackout – a loss of electrical power on receiving vessel or the supplying facility
- excessive movement between receiving vessel and supplying facility
- uncontrolled venting of vapour by the receiving vessel or the supplying facility.

SIMOPS

Port authorities will only allow simultaneous operations (SIMOPS) to take place during bunkering if the risk has been suitably assessed and found to be acceptable.

The risk therefore depends on the nature of the operation. This may involve cargo loading or unloading operations, movement of dangerous goods, stores, passenger embarkation and disembarkation, and the bunkering of other fuels.

It also depends on the nature and size of any reasonably foreseeable releases of gas as well as the predicted direction of movement which may take it close to ignition sources. For example, when bunkering a container vessel, any vapour leakage could disperse towards the electrical components of a gantry crane.

Emergency shutdowns (ESD)

A link between the supply and the receiving vessel must be in place that shuts down the transfer in the event or threat of an emergency.

A typical emergency shutdown (ESD) will stop any transfer pumps upon activation. An ESD system might have a staged process in which the first alert – say, a tank high-level alarm – shuts down the transfer in a controlled manner. For example, it would stop the pump but leave the manifold valves on the supply and receiving vessel open to prevent any over-pressurisation in the hose. A second alert – for example when detecting a vapour release – may shut the manifold valves as well as the pump and could trigger an emergency de-coupling.

The transfer hose should be connected with a breakaway coupling (BRC). This is usually fitted at the receiving vessel's manifold. Upon activation of the emergency release system (ERS), either manually or automatically, a rapid disconnection of the coupling will occur. The BRC incorporates a self-closing valve at each end, resulting in minimal amounts of vapour escaping. Persons involved in the bunkering operation should be aware of the risk of backlash if the ERS is activated and avoid being in the vicinity of the hose during transfer.

It is therefore important to check that the ESD and ERS activation methods (sometimes referred to as emergency shutdown links) on the supplying vessel or installation and the receiving vessel are compatible and tested. Typical links use pneumatic, electric (SIGTTO 5 pin connector) and fibre-optic signals.

Bunkering checklists

Harmonised checklists specific to the type of bunkering operation have been developed and issued by the International Association of Ports and Harbors (IAPH). These checklists, with accompanying guidance have been adopted by a number of ports around the world.

The IAPH checklists comprehensively cover three scenarios (truck-to-ship, ship-to-ship and shore-to-ship) and each encompasses planning, pre-transfer actions, simultaneous operations and completing the transfer. Each stage must be checked and signed by representatives of the receiving vessel, the bunker delivery company and the terminal.

Bunker delivery note

IMO and the European Sustainable Shipping Forum (ESSF) have defined a standard LNG BDN which can be used to document the LNG composition. This standard format BDN has been incorporated within the IGF Code.

LNG-BUNKER DELIVERY NOTE*
LNG AS FUEL FOR

SHIP NAME: **IMO NO:**

Date of delivery:

1. LNG-Properties

Methane number**	–	
Lower calorific (heating) value	MJ/kg	
Higher calorific (heating) value	MJ/kg	
Wobbe Indices Ws / Wi	MJ/m3	
Density	kg/m3	
Pressure	MPa (abs)	
LNG temperature delivered	°C	
LNG temperature in storage tank(s)	°C	
Pressure in storage tank(s)	MPa (abs)	

2. LNG-Composition

Methane, CH4	% (kg/kg)	
Ethane, C2H6	% (kg/kg)	
Isobutane I C4H10	% (kg/kg)	
N-Butane n C4H10	% (kg/kg)	
Pentane, C5H12	% (kg/kg)	
Hexane, C6H14	% (kg/kg)	
Heptane, C7H16	% (kg/kg)	
Nitrogen, N2	% (kg/kg)	
Sulphur, S	% (kg/kg)	
negligible<5ppm hydrogen sulphide, hydrogen, ammonia, chlorine, fluorine, water		

3. Net Total delivered: __________ t, __________ MJ __________ m3
Net Liquid delivery: __________ GJ

4. Signature(s):

Supplier Company Name, contact details: __________

Signature: __________ Place/Port __________ date: __________

Receiver: ____________________

* The LNG properties and composition allow the operator to act in accordance with the known properties of the gas and any operational limitation linked to that.

** Preferably above 70 and referring to the used methane number calculation method in DIN EN 16726. This does not necessarily reflect the methane number that goes into the engine.

Fig. 10. Example LNG bunker delivery note from IMO IGF Code

Chapter 6

QUANTITY MEASUREMENT

Disputes often concern the quantity of fuel remaining on board after bunkering or at the time of redelivering a vessel after a charter period. Even when bunker prices are low, disagreements over quantity calculations can involve large sums of money.

Therefore it is very important to measure and calculate the remains on board properly and accurately.

When bunkering, correct determination of the amount of fuel delivered depends hugely on the accurate measurement of remains on board before and after the bunker operation. This applies not only to the receiving vessel but also to the supplying facility or barge.

METHODS OF DETERMINING QUANTITY

Different vessels will have different methods of determining quantity. Some may rely on handwritten forms and hardcopy conversion tables, whereas some may use spreadsheets or bespoke software. In all cases, the principles remain the same.

Quantity by gauging

The basic methodology is to measure either the depth of fuel in the tank (sounding) or the space between the surface of the fuel and the top of the tank (ullaging). These measurements are converted to volume, then weight.

Fig. 11. Surveyor carrying out tank sounding to determine quantity (VPS)

Gauging of all tanks

Soundings, ullages or gauge readings should be taken for all tanks in the fuel system before and after bunkering, regardless of whether they are nominated for bunkering or not. This should include any overflow tanks and settling and service tanks.

The same applies to the storage tanks of any supplying vessel. A supplier may try to discourage a receiving vessel's crew from measuring all of their tanks, giving excuses that they are empty or not nominated. These explanations should not be accepted at face value – check all tanks regardless.

If carrying out soundings rather than ullages, water paste should be applied to the sounding tape each time. The paste alerts the engineer of any free water that has separated from the fuel within the tank. The height of this free water can be measured and subtracted from the total sounding measurement.

It is vital that the temperature of the fuel in each tank is measured and recorded. The temperature has a direct influence on the volume of the contents and is used in determining the volume correction factor later.

Calculate the observed volume

Soundings and ullages provide a measurement of the height of the contents of a tank at that specific time and conditions. These measurements need converting to find out the actual volume of the tank contents.

Unless the sounding pipe for a tank is exactly in the middle of a tank and located on the vessel's centreline, the measured height of the contents will vary depending on a vessel's angle of heel and trim.

Each vessel and bunker barge will have an individual set of sounding tables, sometimes referred to as tank calibration tables. Presented in a tabular format, these provide the volume of the contents for corresponding soundings or ullages at given values of heel and trim for each tank.

The data in the tables is provided in set increments of height, trim and heel. In most cases interpolation is required by the crew to calculate accurately the volume in m^3. For example, a sounding might be measured at 72 cm but the sounding table provides volumes only for soundings of 70 cm and 75 cm. To calculate the volume at 72 cm, it would be necessary to add 2/5 of the difference to the volume at 70 cm.

Calculate the weight

Marine fuel is traded by mass, not by volume – although it is generally referred to as 'weight'. This is because volume varies with temperature and different fuels have different densities. As such, bunker purchasing contracts and charterparties refer to weight or mass – usually in tonnes – to provide consistency and assurance.

From the observed volume, the gross standard volume at 15°C (in m^3) is calculated by applying a volume correction factor (VCF). The VCF can be found in ASTM/API Table 54B or ISO 91:2017 *(Petroleum and related products – Temperature and pressure volume correction factors (petroleum measurement tables) and standard reference conditions).*

To determine the VCF, the density of the fuel must be known. Although the density of the fuel can be tested on board using simple apparatus, it is usual to use the density given by the supplier on the BDN.

The gross standard volume at 15°C is then converted to weight in air by applying the weight correction factor (WCF), which can be found using ASTM/API Table 56.

Calculate the totals

The weights are added to provide the total remains on board for each product.

Tank	Sounding (m)	T.O.V. Total Observed Vol (m³)	Water (m³)	G.O.V. Gross Observed Vol (m³)	Density (15°in Vac)	Temp°C	VCF (Vol Corr Factor)	Gross Standard Volume (m³)	WCF weight corr fact	Metric Tons
1P	2.71	100.000	0.0	100.000	0.9600	30.0	0.98933	98.930	0.9589	94.864
1S	0.00	0.000	0.0	0.000	0.9870	28.0	0.99108	0.000		0.000
2P	3.41	320.630	0.0	320.630	0.9907	28.0	0.99112	317.780	0.9896	314.475
2S	2.62	182.800	0.0	182.800	0.9746	40.0	0.98252	179.600	0.9735	174.841
SETT 1		0.000	0.0	0.000	0.9870	70.0	0.96196	0.000		0.000
SETT 2		15.900	0.0	15.900	0.9870	75.0	0.95847	15.240	0.9859	15.025
SERV 1		2.180	0.0	2.180	0.9870	70.0	0.96196	2.100	0.9857	2.070
SERV 2		22.200	0.0	22.200	0.9870	85.0	0.95146	21.120	0.9859	20.822
O/FLOW	0.28	0.440	0.0	0.440	0.9870	42.0	0.98142	0.430	0.9860	0.424
			0.0	0.000	0.9908		1.01019	0.000		0.000
		644.150	0.0	644.150				635.200		622.521

Fig. 12. Example bunker survey report showing calculations of remains on board

When bunkering, the total remains on board before the transfer is subtracted from the total remains upon completion to provide the amount stemmed. A similar process is carried out on the supplying vessel. The figures can be compared with any flowmeters in use and, if the receiving vessel and supplier are in agreement, the BDN can be signed.

When a vessel operates under a time charter, the total remains on board are also calculated and agreed at the time of on-hire and when drafting the final statement at the time of off-hire.

Quantity by flowmeter

Most flowmeters in shipboard use measure the fuel by volume, providing a rate of delivery in m^3/hour and a totaliser in m^3.

For the reasons detailed previously, volume is not a reliable measure for determining the amount of fuel bunkered as it varies with temperature and different fuels have different densities. Flowmeter readings in m^3 will require conversion to weight by applying correction factors, namely the VCF and WCF.

Volumetric flowmeters should not be solely relied upon to provide an accurate measure of the volume of fuel delivered. They require regular maintenance and can be vulnerable to damage or inaccuracies. The engineers on a receiving vessel will rarely have confidence that the flowmeter on a bunker barge will be fully functional and accurate.

MASS FLOW METERS

Flowmeters that measure the mass of fuel rather than its volume are becoming more widely used. In Singapore, the use of mass flow meters (MFM) for bunkering operations became mandatory for suppliers from 1 January 2017.

A benefit of using a MFM is that it should remove errors made during the quantity calculation process. From the taking of tank soundings (or ullages), adjusting for trim and interpretation of the vessel's tank calibration tables, to the adjustment for temperature and density and the application of correction factors, the traditional quantity calculation method introduces several opportunities for errors.

The use of a properly calibrated MFM should go a long way to prevent quantity disputes. However, the ship's crew should not relax their bunkering procedures or fall into a false sense of security just because the supplying bunker barge is fitted with a MFM. They should continue to follow usual best practices on quantity verification. The receiving vessel's crew should still carry out their usual checks on the supplying vessel, but also pay particular attention to the MFM's security seals, record the meter readings and ensure no meter bypassing arrangements are apparent.

When a MFM is in use, the vessel's engineers should still remain vigilant to the possibility of excessive water in the bunkered fuel as a MFM may not be able to differentiate.

Mass flow meter operation

MFMs generally work on the principle discovered by Gustave Coriolis in the nineteenth century where the deflection of a moving mass as viewed from a rotating reference point is considered.

In a modern MFM, the rotating reference point is replaced by a vibrational reference. The mass flow of the fluid is then based on the interaction of Coriolis forces generated.

Fig. 13 shows a curved-tube type MFM.

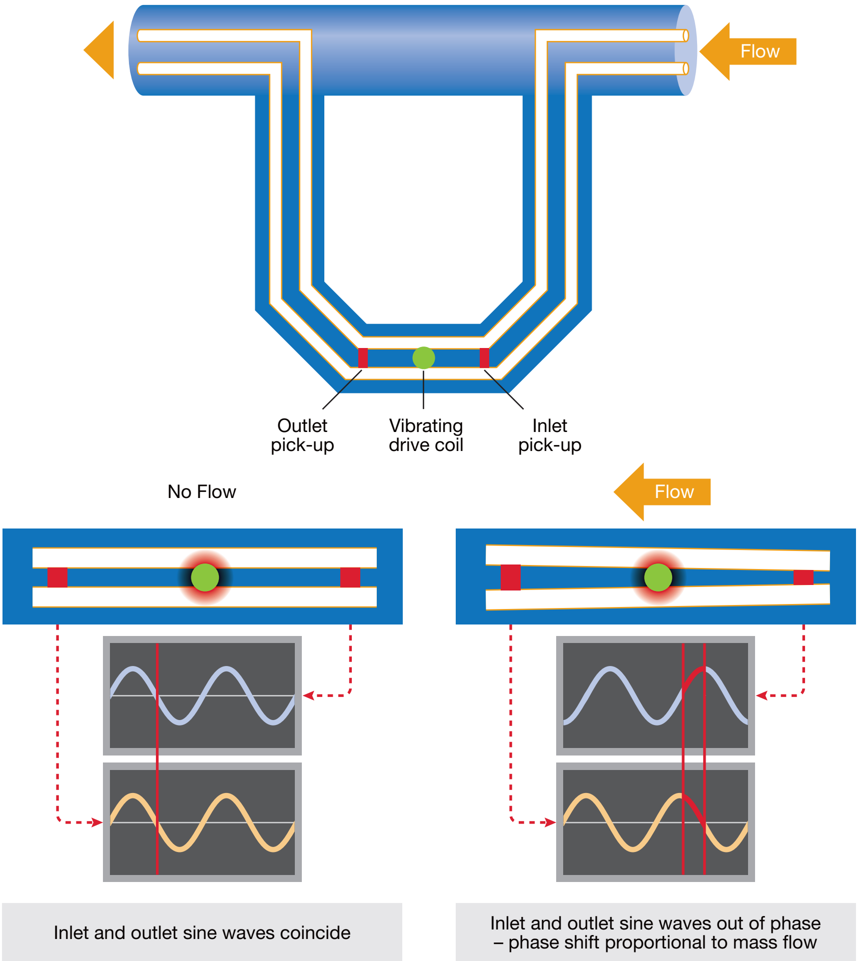

Fig. 13. How a mass flow meter works

The fluid enters the meter and the flow is split in two, with half the flow through each curved tube running parallel to each other. A drive coil induces vibration and the tubes oscillate at their natural frequency. The resultant waveforms are measured by pick-ups at the inlet and outlet.

If there is no-flow, then there is no deflection of the tubes as there is no generation of Coriolis forces. Therefore the waveforms at inlet and outlet are ‘in phase’.

When flow is introduced, there is a deflection in the tubes caused by the generated Coriolis forces resisting the induced vibration. The measured waveforms at inlet and outlet become ‘out of phase’ with each other and this phase shift is proportional to mass flow.

BUNKER SURVEYS

It is common for a shipowner or time charterer to appoint an independent surveyor to carry out a bunker survey to protect their interests.

Independent bunker surveys are usually carried out at the time of vessel delivery and re-delivery (or as close as possible to these times) to establish the quantities on board the vessel. Most disputes between an owner and a charterer come to light at the end of the charter period when the final hire calculations are negotiated. This may include a remittance to a charterer for any remaining bunkers on board the vessel or an additional payment to the owner if any of its own fuel was consumed during the charter period.

An independent surveyor may also be requested to carry out a survey for any bunkering operations occurring during the charter period or if a dispute has arisen over quantity upon the completion of bunkers.

A surveyor's vigilance and local expertise is invaluable during bunkering operations, particularly in ports where the more disreputable bunker supplier may employ certain practices to deceive the receiving vessel.

When handling a dispute over bunker quantities, one of the most vital pieces of evidence is the bunker survey report and the importance of its accuracy cannot be overstated. The ability of an owner or a charterer to bring forward a claim or defend a dispute successfully will be significantly hampered by:

- a poorly conducted or incomplete survey
- a report that lacks detail
- a report that contains errors.

The vessel's crew should remember that the presence of an independent surveyor does not diminish their own responsibilities. It is important that the crew also measure and calculate quantities in accordance with their own written procedures. It has been noted on numerous occasions that the crew have taken a step back and relied solely on the surveyor's figures. This may contravene their own safety management procedures and does not allow for a check against the surveyor's calculations, which may contain errors.

FUEL FOUL PLAY

There are a number of different ways to try and cheat the other party when it comes to fuel quantity. In some cases a bunker supplier might try to deliver less than the stated amount on the BDN, or a vessel might hide bunkers from a time charterer that has ownership of the fuel.

Some of the more common methods are given here.

Aeration – the 'cappuccino effect'

The cappuccino effect occurs when air is entrained into the fuel oil during the bunkering process and therefore increases the observed volume of the stem. As bunkers are purchased by weight but traditionally calculated by measuring the volume (m^3) and applying correction factors to calculate weight (t), the application of air to increase the volume can be exploited by the more unscrupulous bunker supplier.

Incidents of cappuccino bunkers are rare, but they are difficult to detect. In most cases, the crew only notice a discrepancy a few days after bunkering when the bubbles have collapsed and the volume settles at a lower value.

Spotting the signs of cappuccino bunkers is challenging for the crew. But the following might act as an alert that air is being introduced into the bunkers:

- bubbles on the sounding tape when gauging
- jerking and gurgling of the bunker hose during bunkering – not to be confused with the expected movement when stripping tanks or the final blow through
- erratic pressure gauge readings at the manifold
- improper use of line blowing arrangements that could be used to entrain air into the fuel.

It has been suggested by some that tank lids should be removed and a visual inspection is carried out to check for bubbles on the surface. In most cases this is an impractical measure, but if the tank lid is accessible then it is an option to be considered if aeration of bunkers is suspected.

The benefit of a mass flow meter is that the entrained air will not be an influencing factor when measuring the mass flow of the fuel.

Fig. 14. Tank lid removed to reveal evidence of aerated 'cappuccino' bunkers

Short delivery by bunker supplier

In addition to cappuccino bunkers, there are other ways a supplier can mislead a vessel into thinking they have received more than actually delivered.

These may include:

- lines that return fuel back into the barge's tanks after first passing through the flowmeter
- modified measuring equipment such as doctored sounding tapes that give false readings
- non-original or doctored tank calibration tables that provide false values of volume for given soundings
- hidden compartments within the barge's tanks which allow apparently empty tanks to contain fuel.

Some of the tricks used by less reputable bunker suppliers are extremely difficult to spot. If there are concerns, the crew should consider issuing a letter of protest.

Crew hiding bunkers

A reasonably rare occurrence is that of crew hiding bunkers on board the vessel. There are several different motivations for concealing fuel on board. Traditionally, it was quite common for a vessel's chief engineer to hold a small amount extra to what was declared in the official records. The motive was not to defraud any other party, but acted merely as an unofficial precautionary reserve in case the engine consumption at some point was much greater than expected. This is sometimes known as keeping some bunkers 'up the sleeve'.

Unfortunately, there are numerous instances where the motive is less innocent. It has been known for the crew to illegally sell undeclared bunkers for their own financial gain.

A popular method employed by crew wishing to deceive surveyors is to insert pipes within bunker tank sounding pipes. The inserted pipe is closed at the bottom; therefore it can be filled to contain the quantity of fuel that they want the surveyor to find.

It is difficult to spot these pipe inserts. However, some tell-tale signs are freshly cracked paint or any recent repainting in way of the flanges of the sounding pipes.

Fig. 15. Removing an insert within a sounding pipe (Maritech Commercial Inc.)

LNG AS A MARINE FUEL

The means to measure the quantity of bunkered LNG are similar in principle to that of traditional marine fuel oils. Essentially this is quantity determination by:

- measuring the flow rate during transfer (mass or volume)
- measuring tank contents before and after transfer and then calculating the difference.

Measuring flow

The flow rate can be measured in terms of mass or volume.

Mass flow measurement

Typical mass flow measurement devices work on the Coriolis principle as described previously. This method is particularly attractive to LNG measurement as there are no moving parts that would otherwise be adversely affected by the cryogenic temperatures involved.

Volumetric flow measurement

Ultrasonic flowmeter units directly measure the velocity of the fluid passing the transfer pipeline. The measured velocity can be simply converted to volumetric flow rate by multiplying it with the cross-sectional area of the pipe.

The accuracy of flow measurement devices can be adversely affected if both phases are present, that is there is both liquid and vapour in the line.

Measuring tank contents

Similarly, the contents of a storage tank can be measured in terms of mass or volume. However, this can be difficult to measure accurately if LNG is being consumed from the nominated storage tank at the same time as bunkering. This also applies to a supplying vessel as that may be using the LNG intended for transfer as fuel for its own engines.

Mass measurement

When receiving bunkers from a road tanker, the total mass (weight) can be measured by means of a vehicle weighbridge before and after transfer. The difference will be the total mass transferred. Alternatively, storage tanks may be installed with load cells that directly measure its weight.

Volume measurement

The level of LNG in a storage tank is measured before and after transfer. The difference simply equates to the amount transferred.

Similar to the process for bunkering conventional fuel oils, the level measurements are corrected for ship list and trim before conversion to volume. However, there may also be a need to apply a correction factor for temperature to calculate the volume accurately. This is because the storage tank can physically contract when at the cryogenic temperatures needed for LNG.

Measuring vapour returns

LNG storage tanks are designated by type, namely membrane tanks or independent tanks termed type A, type B and type C.

Membrane tanks and types A and B tanks are designed to only withstand relatively low pressures. Therefore any vapour generated – known as boil-off gas – must be managed. When bunkering, this may mean that the vapour is returned to the supplying vessel or installation where it is subsequently re-liquefied.

Receiving vessels fitted with cylindrical type C tanks will usually not need to return any vapour back to the supplier as they are constructed to withstand the pressures generated by the boil-off gas. This vapour remains in the storage tank and is compressed or liquefied by the incoming LNG.

Boil-off gas has a financial value and, if it is being returned to the supplier, it may need to be measured and quantified. This can be achieved by installing flowmeters in the receiving vessel's vapour return line or by measuring the volume of boil-off gas displaced during filling.

Chapter 7

FUEL SAMPLING AND TESTING

Poor quality fuel or the wrong grade of fuel can cause significant damage to a marine diesel engine and can lead to major disruption to the vessel's operations and lengthy delays. This is why the process of sampling and analysing fuel oil is one of the most important aspects of bunkering and fuel management.

As well as giving valuable information to the vessel's engineers, it provides the most important piece of evidence in any bunker quality dispute. It is probably true to say that most quality disputes will, at some stage, rely upon the analysis of a representative sample taken at the time of bunkering.

Fuel sampling is also required to prove compliance with statutory legislation. MARPOL Annex VI requires representative samples to be drawn during bunkering and kept on board, available for testing of sulphur content when ordered by the port state. Similarly, some administrations can demand samples are drawn from the engine inlet to check that the fuel in use complies with their domestic or regional sulphur regulations.

This chapter considers sampling methods and fuel testing – both on board and in the laboratory.

SAMPLING

The main objective of sampling is to obtain a truly representative sample of the fuel. When bunkering, this refers to a sample being representative of the full stem delivered. But in the case of testing for environmental compliance, this can also mean the sample is representative of the fuel in use.

One of the major problems facing shipowners and on-board engineers in their efforts to obtain a representative sample is that marine residual fuel oils are generally not homogeneous. Blending is common and, on some occasions, this is actually done during transfer to the vessel – a process known as 'in-line blending'. This practice should be avoided wherever possible unless high-shear mixing devices are used.

Bunkering sampling methods

There are currently no universally accepted standards on the sampling of fuel bunkers. However, some guidance on sampling equipment and sampling procedures can be found in ISO 13739 *Procedures for transfer of bunkers to vessels*.

IMO has published sampling guidelines that directly relate to checking compliance with MARPOL Annex VI in MEPC. 182(59) *Guidelines for the sampling of fuel oil for determination of compliance with revised Annex VI of MARPOL*. With the guidance included in ISO 13739, these can provide a suitable basis for a ship operator's own procedures on sampling.

It is common practice for both the receiving vessel and bunker supplier to collect samples, with a view to exchanging one bottle upon completion. Prior to commencing bunkering, each party should inspect the other's sampling arrangements and arrange to witness each other's sampling.

In addition to any samples provided by the supplier, it is good practice for the receiving vessel to draw a minimum of four samples during bunkering – three for commercial purposes and one for environmental compliance requirements.

1. One sample to be retained on board in case of any future commercial disputes relating to quality.
2. One sample to be given to the supplier.
3. One sample to be dispatched for testing by a fuel laboratory.
4. One 'MARPOL' sample to be retained on board.

The receiving vessel must retain the MARPOL sample until the fuel oil is substantially consumed but not less than 12 months from delivery. The MARPOL sample must be sealed and signed by the supplier's representative and the receiving vessel's master or officer in charge of the bunker operation.

The MARPOL sample must only be used for verifying compliance with MARPOL sulphur limits under the direction of the flag or port state (or their competent authority). It cannot be used for commercial purposes. In other words, the sample cannot be tested for the purpose of settling a dispute on quality that has arisen under contract.

There is sometimes confusion as to where the MARPOL sample should be drawn – from the bunker barge or the receiving vessel. The 2009 guidelines on sampling provided in MEPC.182(59) states that the MARPOL sample should be obtained at the receiving vessel's inlet bunker manifold. However, some jurisdictions may have a different approach, either leaving it to the supplier and buyer to agree or stating that the sample must be drawn from the supplier's discharge manifold.

Traditionally, samples were taken using the manual spot sampling method. But concerns on the limited ability to provide a representative sample led to the development of other methods. To ensure a representative sample is taken when bunkering, a shipowner now has three main options on sampling:

- a manual in-line continuous drip sampler
- an automatic flow-proportional sampler
- an automatic time-proportional sampler.

In-line continuous drip samplers are by far the most commonly fitted device for receiving vessels. These require the careful setting of the needle valve to ensure a constant drip is maintained throughout bunkering, and to ensure that the final amount collected is not only representative of the full stem but sufficient to fill all the sample bottles.

The sampler should be designed so that the sample is drawn across the full diameter of the bunker manifold. This ensures the sample is drawn from the area of normal laminar flow (parallel, streamlined and non-turbulent). If the sample is drawn directly from the internal face of the pipe where the velocity is low – known as the boundary layer – then the sample will not be representative.

Automatic samplers are less common but they are effective at drawing samples when the bunker manifold is under a partial vacuum. This is in contrast to manual samplers, which require the manifold to be positively pressurised to draw a sample.

Fig. 16. Fitting a sampling container to the bunker manifold (VPS)

Fig 17. Filling sample bottles for dispatch to laboratory for testing (VPS)

The receiving vessel's sampling device is fitted to the bunker manifold and connects to a disposable sampling container. This sampling container should be weathertight, clean and have a capacity of at least 5 litres – enough to fulfil commercial and mandatory sampling requirements. After bunkering, the bulk sample should be thoroughly mixed before decanting into individual sample bottles, filling each bottle a little at a time. If this is not done, the samples will have different quality characteristics and this will cause confusion when testing.

If the fuel is delivered by more than one barge or by several road tankers, samples should be collected for each.

Shipowners should be able to verify the source of any samples and demonstrate how they were obtained to show that they fully represent the fuel oil delivered. Routine sampling and the collection of accurate and relevant records will provide useful evidence that the vessel and its crew have adopted industry best practice.

Fuel system sampling methods

Certain circumstances can dictate the need for further sampling and analysis of fuel already on board the vessel. Such circumstances include when checking the suitability of the fuel for consumption, verifying the efficiency of the on-board treatment plant or when requested by port state officials.

Tank sampling

In the event of problematic fuel oil being loaded or fuel oil problems becoming apparent when engines are running, it may be necessary to conduct post-bunkering sampling. There are challenges in collecting samples from within a tank, particularly if the fuel has undergone stratification. This usually requires sampling from three different levels in the tanks.

Fuel treatment plant sampling

Concerns on the cat fine (Al + Si) content of a fuel might highlight the need to monitor the effectiveness of the on-board fuel treatment plant. A typical example is when bunkers have been purchased in accordance with ISO 8217:2005 – which allows a cat fine content of 80 mg/kg – and the engine manufacturer states a maximum limit of 15 mg/kg at the engine.

If the treatment plant is not operating optimally, the risk of cat fine damage to the engine is significantly increased. Therefore, it may be appropriate to check the performance of the centrifugal separators (purifiers and clarifiers) by taking samples at the inlet and discharge for laboratory analysis.

It is increasingly common for shipowners to carry out fuel system audits on their vessels. This includes checking the effectiveness of the treatment plant and in-line filters and requires sampling as described.

Dedicated sampling points should be identified at each part of the system. This ensures samples are taken from the same place each time and adds consistency to the process and confidence in the test results. To make sure the samples are representative, the sample points should not be located in sections where there is the potential for dead legs or the bottom of filter pots, where low-flow conditions exist and debris could accumulate.

Sampling must be carried out in a safe manner. The location has to be accessible and measures taken to reduce the risk of pressurised fuel spraying onto a person or a hot surface. Poorly positioned sampling points can also lead to oil staining of machinery and fuel in the bilges.

When deciding on sample points, assess the risk – the sample must be representative and the process must be safe.

Environmental compliance sampling

Vessels are subject to a number of fuel sulphur regulatory regimes such as the MARPOL Annex VI emission control areas (ECAs) and regional and domestic legislation. It is becoming increasingly common for port state inspectors to sample and test the fuels on visiting vessels to check for compliance with their applicable sulphur regulations.

As already stated, the designated MARPOL sample taken during bunkering only relates to verifying compliance with MARPOL Annex VI. Therefore local authorities will look to obtain samples of the fuel actually in use to verify compliance with their regulations.

In most cases, a sample of the fuel from the engine inlet manifold must be obtained. This requires drawing a spot sample of fuel under pressure at roughly 7–10 bar, which may also be heated to a relatively high temperature. Drawing very hot pressurised fuel presents dangers and, if not careful, an uncontrolled spray could be emitted that can lead to burns injuries and/or an engine room fire.

Guidance on sampling is provided in European Commission Decision (EU) 2015/253, which applies to vessels at berth or at anchorage in EU and European Economic Area (EEA) ports. The sample taken by the port state control officer should be drawn from the fuel service system using a dedicated sample valve. This sample valve must be approved by the vessel's flag state.

If there is not a flag-state-approved sampling valve, a sample can be taken from an alternative sampling point provided the following criteria are met.

- The sampling point is easily and safely accessible.
- Consideration is given to the different fuel grades that may be in use and the potential for cross-contamination.
- The sample is taken downstream of the fuel service tank.
- The sample should be taken as close as possible to the engine or boiler, taking into consideration the flow rate, temperature and pressure behind the sampling point.
- The sampling point should be proposed by the vessel's representative – it must then be accepted by the inspector.

The port state control officer may take more than one sample if there is a possibility of fuel cross-contamination or there are multiple service tanks. The size of the sample drawn from each sampling point should be sufficient to fill three sample bottles. These bottles are then sealed with a unique identification number. Two of the bottles are sent to a laboratory for analysis and the third bottle is retained on the vessel for 12 months.

Labelling and custody control

It is not uncommon for shipowners to invest in good sampling equipment only to find that, in the event of a dispute, any samples taken are of limited value because the sample bottle label is incorrectly completed or missing.

Samples are vitally important in any bunker dispute and the bottles should be clearly labelled, sealed and preserved. All samples should be treated with care if they are to provide the evidence bunker quality disputes require.

The labels should contain the following information.

- Name and IMO number of the receiving vessel.
- Port of bunkering.
- Name of bunker supplier.
- Name of bunker barge, tanker or installation.
- Date of delivery.
- Sampling method.
- Where the sample was drawn.
- Grade of fuel oil.
- Name and signature of the supplier's representative.
- Name and signature of the receiver's representative.
- Details of seal identification.

The individual bottle seal numbers will of course be different for each sample bottle. These numbers, together with the samples, should be distributed to the various interested parties. A record of all the sample bottle seal numbers and sample recipients should be retained by the vessel.

If a bunker supplier offers a receiving vessel a sample that was not witnessed being obtained, then this should be accepted by the chief engineer 'for receipt only, source unknown'.

It is of course important that the sample actually gets delivered to the laboratory intact and is free from tampering. The sample should be dispatched through the ship's appointed agent and via a reliable courier. The details of the dispatch and transfer of custody should be documented accordingly. It should not be left in the custody of a party with a conflicting interest.

Fig. 18. Example of an on-board sampling kit

TESTING

The samples obtained during bunkering or taken directly from the fuel system can be sent to a reputable laboratory to test against the parameters of ISO 8217 and any other relevant characteristics. However, simple on-board tests can provide a vital early alert of problems before using the fuel.

Both on-board and laboratory testing play an important role and shipowners should use them to their best effect. Each is considered in more detail here.

On-board testing

Even though fuel samples are dispatched without delay after bunkering to a laboratory for testing, the crew might not know the results for several days – especially at certain ports where courier services are limited or unreliable.

Nevertheless, the new fuel should not be used before its quality characteristics are known. Company procedures should reflect this, ensuring there are sufficient reserves of old fuel on board to allow time for laboratory testing of the new fuel.

In reality there will be instances where the crew have to start using the new fuel before knowing the laboratory results. In these situations, the engineers should make best efforts to satisfy themselves that the fuel is safe to use.

When a bunker sample is sent to an independent laboratory, it is to test the fuel against the parameters in ISO 8217. Quite clearly this involves specialist equipment and complex testing techniques that can only be carried out in a laboratory. But there are some quick and simple tests that can be carried out on board by the vessel's engineers, both during bunkering and prior to using the fuel.

On-board testing will not fully substitute laboratory analysis. However, the technology is available to provide an early warning and level of confidence on those occasions where a fuel has to be used before the laboratory results are available. On-board testing kits can be sourced directly from the manufacturers. They can also be provided by major oil suppliers and fuel-testing companies if engaged in a service contract.

Some of the tests are well established and have been used by marine engineers during bunkering operations for decades.

- *Water content.* Water-in-oil test kits work by measuring the pressure created in a small container when a reagent of calcium hydride reacts with any water present in the fuel. This pressure is then converted to a percentage water content reading.

- *Kinematic viscosity.* Simple flowsticks can provide a 'go or no-go' result by comparing the flow characteristics of the sample with a reference oil. Portable heated viscometers can provide accurate results at the required reference temperature (e.g. cst at 50°C).
- *Density.* Kits with heated baths for use with hydrometers can provide reasonably accurate density measurements at a range of temperatures, which can then be converted to density at 15°C in a vacuum.
- *Stability / compatibility.* A stability / compatibility test is often neglected and numerous incidents could have been prevented if it had been carried out. It checks that a residual fuel is stable and if it is compatible with other fuels. The test in its simplest form is easy to do, although special on-board testing equipment is available which speeds up the process. A droplet of fuel (or a droplet of mixed fuel) is applied to a piece of blotting paper and left to dry. If it is homogenous when dried – that is no distinct dark and light areas – then there can be a reasonable degree of confidence it is stable and/or compatible.
- *Cat fine content.* Until recently, vessel engineers were unable to test for cat fines on board. However, new testing equipment has been developed that can allow a rough estimate to be made. These work by centrifuging a fuel sample that has been treated with reagent. After centrifuging, the cat fines are then held in suspension in clear fluid and a visual comparison can be made against a chart. Although accuracy is limited, it can provide a very effective warning at the time of bunkering or before a fuel is used.
- *Sulphur content:* A very recent development is the introduction of the portable sulphur testing device. Using X-ray fluorescence technology, the device can determine the chemical composition of the fuel.

Fig. 19. A simple on-board stability / compatibility test can avoid choked purifiers (Braemar Salvage Association)

Fig. 20. On-board testing kit for cat fines (Parker Kittiwake)

Laboratory analysis

Laboratory testing of fuel satisfies two important requirements.

Firstly, it provides valuable guidance to the vessel's engineers on how to store, handle and burn the fuel. Accurate test results can be turned around quickly in these days of modern communications and it gives the vessel information and guidance on pre-heating requirements, the set-up of centrifugal separators, and provides an early indication of potential fuel oil handling and combustion problems.

Secondly, independent laboratory analysis results provide important evidence in the event of a bunker-related dispute. It is extremely difficult to collect such quality evidence retrospectively.

Fig. 21. Independent laboratory analysis is essential to verify fuel quality (VPS)

As a minimum, laboratory analysis should include testing for all the parameters identified in ISO 8217.

If crew has concerns on the bunker quality, or if laboratory analysis reveals any off-specification parameters, they should advise the shipowner and consult the engine manufacturer for immediate advice. Fuel analysis service providers generally give advice relating to the use of fuel oil on board as do independent bunker specialists and technical consultants.

On a more routine basis, the chief engineer should compare the analysis report against the order specification and the ISO 8217 edition referenced in any bunker contract or charterparty. Reports should also be retained on board for comparison purposes and may also be used for mapping trends as part of any fuel management audit programme in place.

When the full characteristics of the fuel oil become known, the fuel can be managed accordingly. Problems can then be avoided, either by careful yet effective treatment on board the vessel or, in more serious cases, by de-bunkering.

Fig. 22 shows a typical fuel oil analysis report.

Testinglab Corporation Ltd.				
Test reference ID	F400005184			
Information provided from sample label				
Vessel	Mv Newcastle Brown			
Product	RMG380			
Bunkering port	Antwerp			
Bunkering date	30/10/2017			
Date sample received	31/10/2017			
Date sample tested	31/10/2017			
Bunker supplier	European Bunker Traders Inc			
Bunker delivery vessel or installation	Mv Bunker Magic			
Seal number	0726231			
Seal status on receipt	Intact			
Information from Bunker Delivery Note (BDN)				
	Units	Method	Value	ISO 8217:2017 specification
Density @ 15°C	kg/m³		987.3	
Viscosity @ 50°C	mm²/s		350	
Sulphur	%(m/m)		2.3	
Quantity	MT		1200	
Sample Test Results				
Density @ 15°C	kg/m³	ISO12185	986.3	991.0
Kinematic Viscosity @ 50°C	mm²/s	ISO3104	365	380
Sulphur	%(m/m)	ISO 8754	2.26	Statutory Req.
Total Sediment Aged	%(m/m)	ISO10307-2	0.01	0.10
CCAI	-		848	870
Micro Carbon Residue	%(m/m)	ISO10370	12.50	18.00
Pour Point	°C	ISO 3016	12.0	30.0
Flashpoint	°C	ISO3680	>70.0	60.0
Water	%(v/v)	ISO3733	0.10	0.50
Ash	%(m/m)	ISO6245	0.04	0.10
Vanadium	mg/kg	IP501	91	350
Sodium	mg/kg	IP501	37	100
Aluminium + Silicon	mg/kg	IP501	32	60
Zinc	mg/kg	IP501	3	15
Phosphorus	mg/kg	IP501	1	15
Calcium	mg/kg	IP501	11	30
Iron	mg/kg	IP501	20	
Nickel	mg/kg	IP501	35	
Magnesium	mg/kg	IP501	2	
Lead	mg/kg	IP501	1	
Notes and Operational Advice	Results compared with ISO specification RMG 380. Based on this sample the specification is met Approximate fuel temperature: Injection: 145°C for 10 cSt, 130°C for 15 cSt Transfer: 45°C			

Fig. 22. Example fuel oil analysis report

Confidence in test results

There are many laboratories throughout the world that can undertake detailed fuel oil analysis against recognised test methods. Laboratories which have ISO 17025 accreditation should give confidence in their ability to provide reliable results.

Test repeatability and reproducibility are very important. 'Repeatability' relates to differences in results obtained when testing the same fuel oil using the same apparatus and operator. 'Reproducibility' refers to differences in results obtained when testing the same fuel oil using different apparatus and operators.

A single test cannot determine the true value of a characteristic with 100% certainty. Therefore ISO 8217 refers to ISO 4259, which provides details on the precision of each test, consisting of the values for repeatability and reproducibility. It states that a single test result will be considered within specification if it is not more than 0.59 x R (reproducibility factor) outside the limit. This provides a 95% confidence in a single test result.

If a test result falls outside of both the specification limit and the 95% confidence level, the buyer will have good grounds to allege the supplied fuel is out of specification and the supplier is in breach of the terms of the bunker purchase contract.

The International Bunker Industry Association (IBIA) has published a guide *Evaluate the Merits of a Bunker Claim*. This sets out useful information on test precision and evaluation of test results against specification limits and methods for claim resolution. Details can be found on the IBIA website at https://ibia.net/.

LNG AS A MARINE FUEL

There are currently no quality determination tests that can be carried out by crew on bunkered LNG fuel. However, samples should be taken that are representative of the stem. A sample should be retained in a suitable location and another sent for laboratory analysis.

Sampling

Taking representative samples of LNG is challenging. The sample should be drawn from the transfer line as close as possible to the manifold, and collected as soon as possible upon completion of bunkering. If left too late, the sample may deteriorate through the effects of aging or weathering and will not be representative of the stem.

Retained samples

Samples should be retained for future analysis in the event of any dispute over the quality of the bunkered LNG. These samples are purely for commercial purposes and, as things stand, are not needed to satisfy any requirements under maritime environmental legislation.

The samples are generally held by the LNG supplier rather than the receiving vessel, and the number of samples held is usually stipulated in the purchase contract. The contract will also specify the minimum period of time the samples should be retained, which is typically 90 days.

Samples of the fuel are taken in its gas phase as it is not practical to retain samples in its liquid form. Furthermore, testing is carried out on the vapour using a gas chromatograph rather than testing the fuel in its liquid phase. This requires the drawn LNG sample to be passed through an in-line vaporiser sampling system, where it is instantaneously flashed off into a gas.

Despite the sample being collected as a vapour, it must not vaporise before reaching the vaporiser sampling system. If it vaporises beforehand, it could distort the gas composition. The lighter components, namely nitrogen and methane, boil off more quickly than the heavier hydrocarbon components and this could lead to an inaccurate analysis.

Laboratory testing

The in-line sampling unit vaporises the LNG into a gas and this is transferred to a laboratory where its composition is measured. This is carried out using a gas chromatograph, which separates the sample mixture into its individual components and then measures each one individually.

In addition to the detailed analysis of the composition, a gas chromatograph will provide important measurements of density, calorific value and Wobbe index.

Chapter 8

ON-BOARD STORAGE AND TREATMENT

Fuel oil loaded onto a vessel requires care. It must be stored correctly to maintain quality and its 'pump-ability', and most fuels will require on-board treatment before it can be consumed in the main or auxiliary engines.

A failure to store and treat bunkers properly on the vessel can lead to an otherwise on-specification fuel causing severe damage to the engines as well as lengthy repairs and laborious cleaning tasks.

This chapter considers the life of a conventional marine fuel after it has been bunkered – from storage tank to the inlet manifold of an engine.

FUEL STORAGE AND TRANSFER SYSTEMS

This section concerns the system from storage tank to settling tank.

Traditionally, vessels were designed with separate systems for heavy fuel oil and gas oil (or diesel oil). Depending on the shipowner's needs, gas-oil systems may be used for low-sulphur fuels or there might be the ability to split the heavy-fuel-oil system into 'high-sulphur' and 'low-sulphur' sub-systems. However, this usually requires the vessel to have two heavy-fuel-oil settling tanks and two heavy-fuel-oil service tanks.

Typical storage and transfer system for heavy fuel oil

Heavy fuel oil is bunkered directly into the storage tanks from the bunker station. Any over-pressurisation of the bunker main line is relieved into the overflow tank via a safety valve.

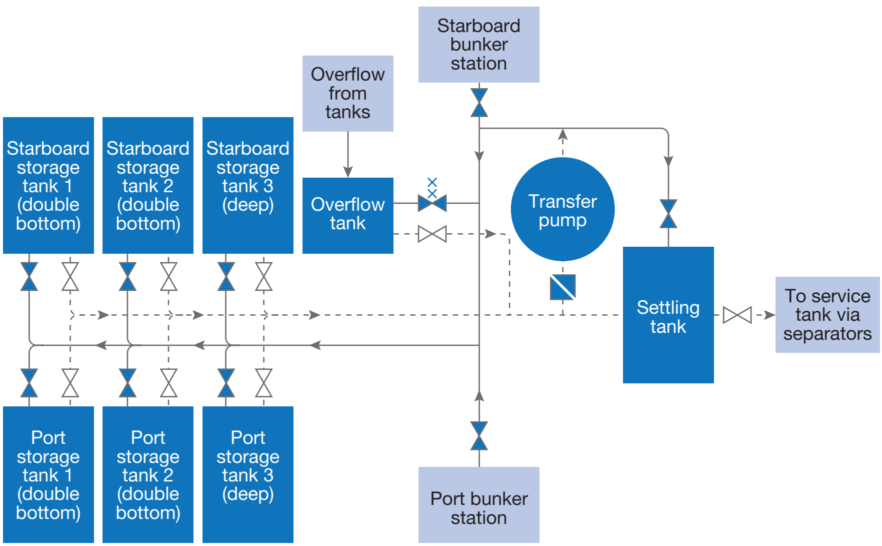

Fig. 23. Example of a heavy-fuel-oil storage and transfer system

If any of the storage tanks are over-filled during bunkering, this too will feed into the dedicated overflow tank. Therefore it is very important that the overflow tank is empty before bunkering operations and the high-level or flow indicator alarms are operational and regularly tested.

Typical storage and transfer system for gas oil and diesel oil

The storage and transfer system for gas oil and diesel oil is similar to that for the heavy-fuel-oil system. However, it is usual for existing vessels to have significantly less capacity for marine diesel oil (MDO) or marine gas oil (MGO).

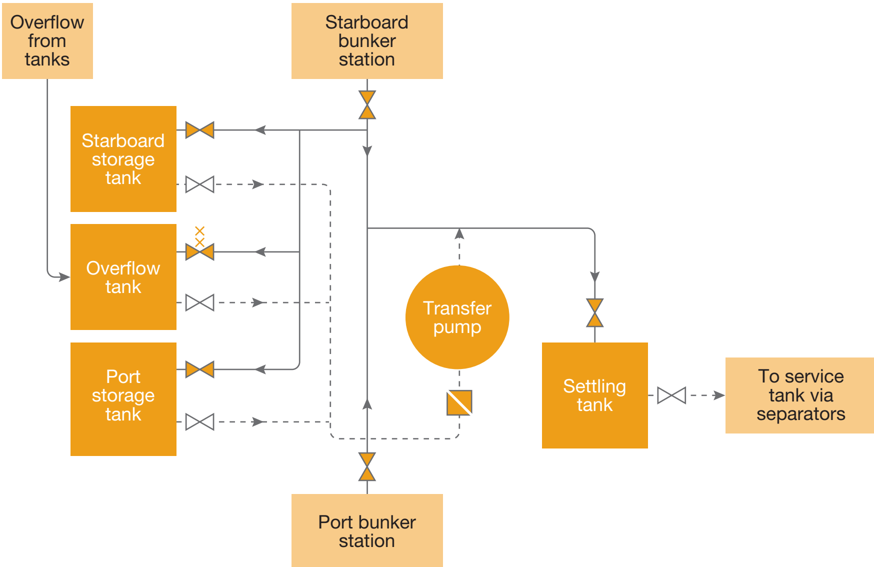

Fig. 24. Example of a gas-oil / diesel-oil storage and transfer system

Storage

The fuel is stored in designated tanks – usually double-bottom or deep tanks. They are fitted with heating coils to prevent the contents solidifying. It is therefore important that the temperature of the fuel's pour point (and cloud point for distillates) is known. This value can be found from the laboratory analysis carried out after bunkering and it is usual for the laboratory report to recommend minimum storage and transfer temperatures.

It is essential that the tank contents are maintained above the fuel's pour point. If the temperature falls below the pour point, the risk of solidification or wax formation is high. In some cases, even the re-application of heat will not re-liquefy the oil and the only remaining solution is to manually dig the contents out of the tank – a disruptive and time-consuming endeavour that could put the vessel out of service or off-hire.

Fuel may remain unused in tanks for many months, but it is important that the quantity of the tank contents is regularly monitored. Rising tank levels could be an indication of a leaking heating coil filling the tank with steam condensate, as can oil traces in the steam condensate returning to the hotwell.

Microbial attack

In the right conditions, bacteria can thrive in fuel tanks. Distillate fuels such as MDO and MGO are more vulnerable to microbial attack than residual fuels. They are particularly susceptible if the fuel has remained unused in the tank for long periods, dependant on temperature.

The presence of water in the tank triggers and accelerates the process of microbial growth. The consequences of microbial contamination include corrosion of the tank steelwork and slime build-up, which can lead to system blockages. If caught early, the affected fuel can be treated with biocides. Left too late, the full system may need to be drained and thoroughly cleaned.

Testing kits are available that allow the crew to monitor for bacteria in the fuel. Regular tests should be carried out if the tank contents are unused for a significant period of time or if any water ingress is suspected.

Settling tanks

The fuel oil is transferred as required from the storage tanks to the settling tank(s) via the transfer pumps.

The settling tank is heated to approximately 50°C, but always 10°C less than the fuel's flashpoint. The primary purpose of heating the fuel oil is to accelerate the separation of any water in the fuel oil. Particles with a greater density than the fuel oil, such as sand, scale, cat fines, rust and free water, will also migrate and settle to the bottom of the settling tank.

The separated water and heavier particles can then be drained from the settling tank. As a minimum, these drains should be operated every watch or at least twice daily on vessels operating with unmanned machinery spaces. If excessive water is suspected, then this might require more frequent draining. The gradual build-up of heavier particles that cannot be removed through the drain cocks is best removed by periodical cleaning of the tank, usually in drydock.

Although the design of shipboard fuel oil systems is beyond the scope of this guide, the bottom of a settling tank will be designed so it is inclined towards the drain cock, which should be a spring-loaded, fail-safe non-return valve. Spring-loaded drain cocks must never be wired open or permanently held open and should only ever be manually operated. Water and sludge drained from the settling tanks should always be visually monitored and lead into the fuel oil drains or sludge tanks via a secure and permanent pipe system. Plastic pipes, funnels, hoses and buckets should be avoided at all times.

FUEL TREATMENT SYSTEMS

This section concerns the system from settling tank to the engine inlet manifold.

Typical fuel treatment and supply system

The fuel is treated through centrifugal separators, drawing from the settling tank and discharging to the service tank. From there, the fuel passes through a fuel treatment module comprising pumps, a heater, mixing tank and automatic blowdown filters. The fuel then passes through a fine filter before entering the engine fuel manifold. Spill returns from the engine are directed back to either the service tank or the mixing tank.

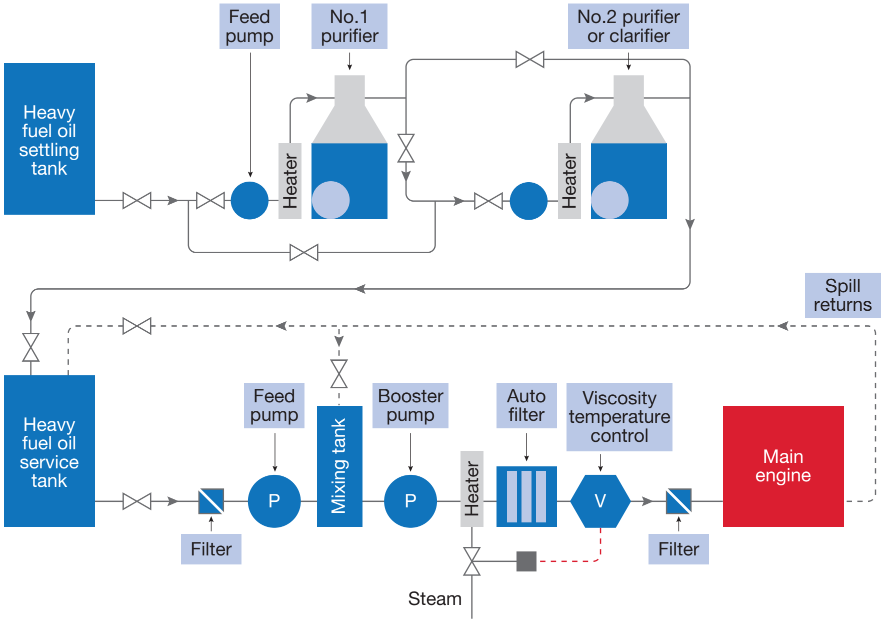

Fig. 25. Example of a fuel treatment and supply system

The condition of delivered bunkers determines exactly what shipboard treatment is required, although this is often only confirmed after laboratory analysis of a representative sample.

Centrifugal separation

Fuel drawn from the settling tanks is heated and passed through self-cleaning centrifugal separators before reaching the service tanks. Centrifugal separators operate on the same basic principle as settling tanks, but using centripetal force instead of gravity.

Fig. 26. Centrifugal separators on board a vessel

The primary purpose of the centrifugal separators is to remove any unwanted and damaging content from the fuel – namely, water, solids and cat fines. Fuel containing 60 mg/kg of cat fines may be acceptable for bunkering but it is highly unlikely that such levels will be tolerated at the engine. Perhaps the most effective method of lowering the concentration of cat fines in the fuel is through the proper set-up and use of the vessel's centrifugal separators.

Different vessels have different equipment and configurations. Some may use centrifugal separators set up as purifiers in parallel or in a purifier–clarifier train, whereas some will have standalone 'Alcap' units. In all cases it is essential that they are fully operational, set to the optimum temperature and set to an appropriate flow rate.

A failure to operate and maintain the vessel's fuel treatment equipment and systems properly can lead to bunkers that were supplied 'on-specification' causing significant damage to engine components. If the fuel was provided by the charterer and it was found to comply with ISO 8217, it would be very difficult for an owner to hold the charterer liable for the damage.

Principles of operation

A typical separator consists of a bowl spinning between 6,000 and 9,000 rpm that contains a set of discs stacked one on top of the other. Fuel enters the bottom of the spinning bowl through the centre of the disc stack and then flows up through the holes in each of the discs. The centripetal forces generated enable fast and efficient separation of fuel oil and any present water and heavier solids.

Separators set up as conventional purifiers allow for the removal of both water and solids from the fuel oil. A gravity disc controls the position of the oil–water interface. The correct selection of this gravity disc is essential to ensure any excess water is properly directed out of the bowl and does not carry over into the 'clean' fuel outlet. Separators set up as clarifiers remove only solids, not water. As such, they are not fitted with a gravity disc.

It is common for separators to be able to run as either purifiers or clarifiers and the system is designed so they can be run in parallel or in series. This allows the system to be configured appropriate to the treatment needed for the fuel. For example, a fuel with high water contamination may require two purifiers in parallel, whereas fuel with high levels of solids or cat fines should be treated with a purifier set up in series with a clarifier.

Separation is most effective when the fuel is heated to an optimum temperature. This is the temperature where the difference in the densities of the oil and water is at its greatest but without the risk of the water 'flashing off' into steam. For residual fuel oils, this is usually 98°C.

High density fuels

Before the development of secondary refining processes, such as vacuum distillation and catalytic cracking, marine fuel oils always had a density of less than 1,000 kg/m^3. Nowadays, fuel oils with a density of greater than 1,000 kg/m^3 are readily available.

For a conventional purifier to remove water effectively, the density of the fuel must be lower than that of water as it works on the principle of heavier water migrating to the outer region of the spinning bowl. This means a conventional purifier cannot handle fuel with density greater than 1,000 kg/m^3. There is insufficient difference between the densities of the fuel and the water to maintain an oil–water interface that would allow efficient separation.

Many modern separators, such as Alfa Laval's Alcap units, are designed to combat this problem associated with high density fuels. They effectively operate as a clarifier, therefore not relying on an oil–water interface, and use sensors to monitor the water content of the 'clean' outlet. If high water content is detected, the discharge to the service tank stops and the bowl is discharged to the sludge tank.

Service tank

The service tank (sometimes referred to as the day tank) should be kept full and, if containing residual fuel, maintained above 90°C. Running at all times, the centrifugal separators continuously transfer oil into the service tank. This will then overflow back into the settling tank and provides the necessary recirculation and continuous treatment of the fuel.

As with the settling tank, the service tank drains should be checked regularly for water. The drains should never be held open permanently.

Filtration

Fuel that has passed to the service tank from the settling tanks via the centrifugal separators is almost ready for use in the main and auxiliary engines. However, further filtration prior to being fed into the engine is vital.

The filters in a vessel's fuel oil system vary from simple coarse wire mesh grids, used to protect transfer pumps from the numerous foreign bodies which are found in bunkers, to fine filters with a typical mesh size of 10 μm that protect the precision-engineered components of the engine fuel injection system.

Many vessels are fitted with automatic self-cleaning backflush filters. This type of filter arrangement typically consists of several chambers each containing filter elements ('candles'), with one chamber in line at any one time. When the pressure differential in the chamber increases or a set time period elapses, the unit automatically changes to the next filter chamber in sequence and the dirty chamber is isolated and blown down, discharging the dirty contents.

The condition and correct operation of in-line filters is very important. Abrasive particles could inadvertently reach the engine fuel pumps and injectors, causing serious damage, through:

- incorrectly fitted filter elements
- torn or damaged mesh of the filter elements
- opening of any filter by-pass arrangements – intentional or otherwise.

Regular inspection and maintenance in accordance with the planned maintenance system and manufacturers' guidelines must be followed.

Temperature and viscosity control

Fuel must be at the correct viscosity prior to injection into the engines. This means the fuel must be at the correct corresponding temperature. Deviation from the design parameters can lead to poor engine performance, possible underperformance claims and possible engine damage.

Residual fuels, VLSFO/ULSFO blends and 'hybrid' fuels require heating to achieve the optimum injection temperature and viscosity. Distillate fuels such as marine gas oil or diesel oil do not usually require heating prior to injection unless in cold conditions.

The temperature to which the fuel oil is heated depends on the required injection viscosity. Engine manufacturers recommend a typical injection viscosity for their engines and this varies depending on the engine type. If burning residual fuels, it may involve heating to as high as 140–150°C.

Many vessels are fitted with viscometers which measure the injection viscosity and adjust the fuel temperature accordingly. In some other cases, the injection viscosity is controlled by monitoring the fuel temperature only.

The vessel's engineers should know, having received results from shipboard or laboratory analysis, the viscosity of the fuel oil at a known standard temperature, usually given in cSt at 50°C. Residual fuel oils consumed in marine diesel engines are typically 380 cSt or 180 cSt at 50°C.

Typical injection viscosities for marine diesel engines are between 10 and 15 cSt. The correct heating temperature for the fuel oil can be determined by various means. Simple examples of the different temperatures required for the different injection viscosities of fuel oils are given below.

Examples of different temperatures required for the different injection viscosities

Viscosity at 50°C: cSt	Injection temperature for 10 cSt: °C	Injection temperature for 15 cSt: °C
180	126.5	112.0
380	139.0	125.0
600	147.0	132.5

It is only after careful and extensive shipboard treatment that fuel oil is ready for combustion in the vessel's engines.

LNG AS A MARINE FUEL

The storage and management of LNG fuel on board a vessel is covered by the IMO International Code of Safety for Ships using Gases or other Low-flashpoint Fuels – known as the IGF Code. This has led to related amendments of other IMO conventions, namely SOLAS and STCW.

The IGF Code contains mandatory provisions for the arrangement, installation, control and monitoring of machinery, equipment and systems using low-flashpoint fuels, focusing initially on LNG.

Storage tank types

The types and sizes of on-board storage tanks will depend on the needs of the vessel and a detailed analysis of tank design is beyond the scope of this guide. However, some of the unique aspects to be aware of regarding the on-board storage and handling of LNG bunkers are discussed in this section.

LNG tanks can be classed as follows.

- Non-pressurised – this includes membrane tanks and types A and B independent tanks that can withstand only low pressures, a typical maximum being around 0.7 bar.
- Pressurised – namely type C independent tanks and are typically designed to handle working pressures up to 10 bar.

The choice of tank type will be determined by the needs of the shipowner as well as the trade and size of the vessel. The tank choice may also determine if any arrangements to capture boil-off gas need to be installed.

Boil-off gas

As LNG warms, vapour will be generated – known as 'boil-off gas' – and this can result in a pressure increase within the storage tank.

Type C tanks are designed to withstand this pressure and as such, there is usually no need for the boil-off to be managed. But non-pressurised tanks may only be able to contain boil-off gas for several days, depending on the rate of heat ingress.

When the engines are running and consuming fuel, the generation of boil-off gas can usually be managed. However, if the vessel remains idle for periods of time and the engines are not running, different means of dealing with the potential pressure increase are required.

The most common means of handling boil-off, other than consumption by the ship's engines, is to re-liquefy the vapour and return it to the storage tank. Re-liquefaction plants are not expected to be widely used on board LNG fuelled vessels due to their high energy consumption and space requirements. As things stand, these plants are more likely to be found on the bunkering vessel. Therefore the expected boil-off rate should be a factor to consider when deciding on tank type during vessel build or modification.

During bunkering of LNG, there may be an option to return any generated boil-off gas back to the supplier's vessel or installation through a vapour return line.

Rollover

If LNG products with different densities are stored within the same tank, which is most likely to occur when bunkering, the LNG with the higher density will settle below the LNG with the lower density. This is known as stratification.

If there is limited movement or minimal sloshing of the storage tank, the temperature of the lower layer will rise. But the hydrostatic pressure of the LNG on top will prevent the lower layer from boiling off. The density of the lower layer will decrease and approach that of the upper layer.

As the densities of the two layers approach equilibrium, the potential for what is known as 'rollover' increases. Rollover is where the layers change position – effectively rolling over and hence the term. It can lead to rapid boil-off and generate large amounts of vapour which, in extreme cases, is relieved through the pressure relief valves.

Rollover can be avoided by the following.

- Preventing stratification by:
  - top or bottom filling according LNG densities – top fill if the incoming LNG is heavier than the stored LNG and bottom fill for vice versa
  - recirculation / mixing of the contents.
- Avoid storing different compositions of LNG in the same tank.
- Monitor LNG density and temperature over height of tank.
- Monitor boil-off and heat balance to detect superheating.
- Manage consumption to ensure old LNG is not stored for excessively long periods.

Aging

LNG is volatile so it is usual for some of the fuel to vaporise into its gas phase. Over time this may result in a change to its composition which, in turn, could impact its quality. This phenomenon is known as aging or weathering.

The characteristics of LNG will change when left unused. As the temperature of the LNG increases, the lighter components will turn to vapour and leave behind the heavier liquid. This results in changes to the density, calorific value and consequently, the Wobbe Index of the LNG.

Chapter 9

ENVIRONMENTAL COMPLIANCE

The environmental legislation relating to marine fuels and vessel emissions has developed and expanded significantly in the last decade.

Vessels are subject to international regulations, namely MARPOL Annex VI (Prevention of Air Pollution from Ships) as well as numerous domestic and regional laws. Failure to comply with these regulations can lead to financial penalties, detentions and, in extreme cases, banning orders.

MARPOL ANNEX VI

MARPOL Annex VI entered into force in 2005 and has been amended regularly since. In addition to engine emissions, it addresses shipboard incineration and ozone-depleting substances such as fluorocarbon refrigerants. The important bunker-related regulations are those dealing with nitrogen oxides (regulation 13), sulphur oxides (regulation 14) and fuel oil quality (regulation 18).

Nitrogen oxides (NOx)

NOx compounds have an adverse effect on both the environment and human health. They can cause acidification and form tropospheric ozone, which at high levels is considered a pollutant.

Regulation 13 on nitrogen oxides applies to each diesel engine used on a vessel constructed or that underwent a major conversion on or after January 2000 with a power output of more than 130 kW. Note ‘major conversion’ is defined as:

- where the engine is either replaced with new
- the existing engine is modified in such a way as to affect NOx emissions, such as changing the camshaft or fuel injection system
- the maximum continuous rating (MCR) of the engine is increased by more than 10%.

The regulation puts in place limits on the amount of NOx emissions depending upon the speed of the engine. Different levels of emission control, termed tier I, II and III, apply and are based on the date of construction or modification. Vessels constructed on or after 1 January 2011 must comply with the more stringent tier II NOx limits.

The tier III limits apply to vessels constructed on or after 1 January 2016, but only when operating in North American and US Caribbean Sea MARPOL emission control areas (ECA). The NOx ECA for the North Sea and Baltic Sea is expected to come into force on 1 January 2021.

The testing, survey and certification requirements to show compliance with regulation 13 are given in the 2008 NOx Technical Code. Each NOx qualifying engine must be issued with an engine international air pollution prevention (EIAPP) certificate, accompanied by an approved NOx technical file.

Engines are generally surveyed using the 'parameter check' method detailed in the NOx Technical Code. The actual duty and rating of the engine and the settings and operating values of NOx critical components are checked against the given data in the NOx technical file.

Fuel oil quality only has a minor impact on NOx emissions, so regulation 13 does not set out any fuel specifications with explicit reference to these emissions.

While the limits on NOx emissions are linked only to the speed of the engine in the current regulations, there is also an allowance for engines fitted with technology designed to reduce NOx emissions. For example, selective catalytic reduction (SCR) systems which convert NOx into nitrogen and water have been used on some four-stroke medium-speed engines.

Sulphur oxides (SOx)

Ship-generated sulphur oxides contribute to acid rain which in turn affects the quality of soils and water.

Regulation 14 of MARPOL Annex VI on sulphur oxides (SOx) and particulate matter (PM) set an initial global cap of 4.5% m/m sulphur for marine fuels, which was reduced to 3.5% m/m in 2012. This global cap will reduce further to 0.5% m/m in 2020.

Emission control areas

MARPOL lists a number of geographical areas where further environmental restrictions apply. These special areas – known as emission control areas (ECA) – are (at 2018):

- Baltic Sea ECA (SOx only)
- North Sea ECA (SOx only)
- North American ECA (SOx, NOx and PM)
- US Caribbean Sea (SOx, NOx and PM).

When a vessel operates within an ECA, the sulphur content of the fuel must not exceed 0.1% m/m.

Regulation 4 recognises that there are alternative methods by which equivalent levels of SOx can be achieved. These include exhaust gas cleaning systems (often referred to as 'scrubbers') and are addressed in more detail in the alternative technologies section.

Fuel changeovers

Most vessels that operate both outside and inside ECAs will burn different fuel oils – compliant low-sulphur fuels when inside an ECA, and the less expensive higher sulphur fuel when outside. Currently, this generally involves changing to and from low-sulphur fuels – such as distillates, blended or hybrid fuels – and higher sulphur residual fuels. However, this may differ after 2020 and the global sulphur cap comes into force.

Before the ECA sulphur limit was reduced to 0.1% m/m from 1.0% m/m in 2015, fuel changeovers were rarely problematic. Other than the sulphur content, the two fuels were residual grade and had similar characteristics with almost the same pre-heating and treatment requirements.

However, there are significant differences when changing from high-sulphur heavy fuel to a low-sulphur distillate fuel while on passage and vice versa. If the changeover is not carried out correctly, there is a high risk of losing propulsion or experiencing an electrical power blackout. The potential consequences of getting it wrong can be much greater if the fuel changeover occurs in busy traffic areas or relatively close to shore.

When considering how to best manage the changeover process and ensure safe prolonged running on distillates, it is important to bear in mind the characteristics of the two fuels and how these will impact the operation of the main engine, diesel generators and oil-fired auxiliary boilers.

Key considerations include the following.

- Allow sufficient time for the fuel oil service system to be fully flushed of non-compliant fuel oil prior to entry into an ECA.
- Generally, distillates do not require heating before injection whereas heavy fuel is heated to temperatures in excess of 140°C. If, during changeover, the fuel heater is shut down too soon any heavy fuel remaining in the line will not easily burn. If the fuel heater is shut down too late then the distillate fuel could ‘gas up’ and disrupt flow of fuel to the engine (vapour locking).
- Lubricating oils with lower base numbers (reserve alkalinity) may be needed.
- Low-sulphur distillates have a lower lubricity which could lead to engine fuel pump plunger or barrel seizures. The engine manufacturer should be consulted on the minimum sulphur content to maintain the necessary level of lubricity, but generally a minimum 0.05% m/m is recommended.
- Lower kinematic viscosity that may be less than the engine manufacturer’s instruction.
- Fuel leaks become apparent or significantly worsen as distillates pass through hardened seals where heavy fuels previously could not.
- The flushing and cleaning characteristics of distillates can effectively remove sludge and residues from within the fuel system and this can lead to increased clogging of in-line filters.
- Engine timing adjustment may be required for prolonged running at high loads and boiler burners may require tip or nozzle adjustment.

Because of the risks, MARPOL Annex VI requires the vessel to have a written procedure showing how the fuel oil changeover is to be done. The procedures should provide guidance on when to carry out a changeover to ensure compliance on entry to the ECA, which often requires the use of dedicated fuel calculator software.

Changeover procedures must be workable and practical, making sure the changeover is managed safely. They should also address the following.

- Controlling of the rate of temperature change when changing between fuels.
- Eliminating the risk of contaminating the low-sulphur fuel with high-sulphur fuel, such as:
  - identifying potential for contamination through system cross-connections
  - ensuring spill returns from engines and other equipment are properly routed.
- Potential for compatibility issues which can lead to the formation of sludge and block the pipework.

Fuel sulphur record book

Prior to entry into and after exiting an ECA, certain data must be recorded in a log book approved by flag state. This data includes the volume of low-sulphur fuel oils in each tank as well as the date, time and position of the vessel when any changeover operation is completed.

2020 global sulphur cap

From 1 January 2020, the global sulphur cap of 0.5% m/m will come into force.

In addition to the well-documented concerns on whether refinery capacity will be adequate to meet the expected increased demands for compliant distillate fuels, the industry has voiced concerns on the potential for an illegal market to emerge supplying non-compliant fuels.

Leading environmental organisations and key representatives from the global shipping industry are calling (in 2018) for an explicit prohibition on the carriage of non-compliant bunkers when the global sulphur cap takes effect. This would essentially mean it would be illegal for a vessel to have non-compliant fuel on board, regardless of any intention to consume it. The subject was discussed at the 72nd session of the IMO Marine Environment Protection Committee (MEPC 72) in April 2018 and amendments were proposed. These are expected to be adopted at MEPC 73 in October 2018 and become part of MARPOL Annex VI. An obvious exemption to the proposed ban, however, would be vessels fitted with exhaust gas cleaning systems (EGCS), which would continue to legally burn fuels with a sulphur content of greater than 0.5%.

Irrespective of any future legislation coming into force that would explicitly prohibit carrying non-compliant fuels, it might be considered good practice not to carry such high-sulphur fuels if not fitted with an EGCS. This would help to avoid unnecessary scrutiny from port state control officials or other local authorities.

Fuel oil availability and quality

MARPOL Annex VI regulation 18 places an obligation on signatory states to promote the availability of compliant fuels in their ports.

The regulation also sets out requirements on fuel oil quality and requires local suppliers to provide a bunker delivery note and sample, certifying that the fuel oil delivered meets the requirements of regulations 14 and 18.

The bunker delivery note must be kept on board for inspection for a period of three years from delivery of the fuel oil. The bunker delivery note has taken over the role of the old bunker delivery receipt. Although the bunker delivery note performs the function of a receipt, it is also equally important to those policing the application of Annex VI, particularly in relation to the sulphur content of a particular fuel.

REGIONAL AND NATIONAL REGULATIONS

EU

EU Directive 2005/33/EC came into force in 2010 and requires vessels to change over to 0.1% m/m maximum sulphur fuel oil when ‘at berth’ in EU and European Economic Area (EEA) ports. This applies to all calling vessels, regardless of flag. The changeover does not affect main engine operation as it is undertaken as soon as possible after arrival and as late as possible prior to departure. This therefore effectively regulates the fuel used by auxiliary engines and boilers when either alongside or at anchor.

The current EU limits on the sulphur content of marine fuels can be briefly summarised as follows.

- Vessels at berth or at anchorage in EU ports must only use fuels containing a maximum sulphur content of 0.10% m/m.
- Passenger vessels that operate on a regular service to EU ports must only use fuels containing a maximum sulphur content of 1.5% m/m (reducing to 0.5% m/m from 1 January 2020).
- Vessels operating in the MARPOL Annex VI emission control areas (ECAs) – Baltic Sea, North Sea and English Channel – must only use fuel containing a maximum sulphur content of 0.1% m/m.

Although not a member of the EU, Turkey introduced legislation in 2012 that falls in line with the EU directive. As such, all vessels at berth in Turkish ports or operating in the inland waterways will be required to use fuel with a sulphur content of no more than 0.1% m/m.

China

Three new emission control areas have been established in China. They were created to reduce the levels of ship-generated air pollution, focusing on limiting the sulphur content of fuels.

These emission control areas arose as a matter of Chinese domestic law and are not MARPOL Annex VI designated emission control areas. The three areas are:

- Pearl River delta
- Yangtze River delta
- Bohai Bay.

The regulations apply to all vessels entering or operating within the emission control areas, with the exception of military, pleasure craft and fishing vessels. The limiting of the sulphur content of the fuels used within the emission control areas is a staged process. Also, there are provisions for vessels to take alternative measures to comply with the new rules, such as connecting to shore power – also known as 'cold ironing' – or using clean energy fuels. Another alternative is to use an exhaust gas cleaning system.

From 1 January 2018, vessels at berth in any port within a Chinese emission control area should use fuel with a maximum sulphur content of 0.5% – except one hour after arrival and one hour before departure. From 1 January 2019, vessels operating within an emission control area should use fuel with a maximum sulphur content of 0.5% m/m.

Taiwan

All vessels calling at Kaohsiung ports must use 0.5 % m/m sulphur fuel or other compliant fuel from 1 January 2019.

California

Prior to the introduction of the 0.1% m/m sulphur limit of the MARPOL Annex VI North American ECA, the State of California enforced this limit in 2008 under the California Ocean-Going Vessel (OGV) Fuel Regulation.

The OGV Fuel Regulation limits the sulphur content in both marine gas oil (DMA) and marine diesel oil (DMB) to a maximum of 0.1% m/m and is in force within the California OGV regulatory zone which extends 24 nautical miles from the Californian coast. This led to the need for vessels to changeover to distillate fuels before entering Californian waters.

It had been expected that the OGV Fuel Regulation would be superseded by the introduction of the MARPOL ECA requirements in January 2015 as they both imposed 0.1% m/m limits. However, California has kept its regulation in place and this is scheduled for review in 2018. Despite the common 0.1% m/m limit, there are two fundamental differences between the two sets of requirements.

- The MARPOL ECA regulation allows alternative emissions control technologies such as exhaust gas cleaning systems ('scrubbers') to be used, whereas the OGV Fuel Regulation does not have a similar provision. Therefore OGV Fuel Regulation compliance can only be achieved by using low-sulphur fuel.
- The MARPOL ECA regulation only requires that a fuel meets the specified percent sulphur requirements, while the OGV Fuel Regulation requires that the fuel must be a distillate grade.

FUEL OIL NON-AVAILABILITY

As emissions-related regulations change, vessels experience difficulties in sourcing compliant fuels. When emission control areas were introduced or when sulphur limits were reduced, vessels were regularly unable to bunker the required fuel without making a significant and unreasonable diversion.

It has been common practice to allow vessels a temporary exemption if using a non-compliant fuel in cases where there is poor availability (MARPOL Annex VI regulation 18.2). However, this requires the vessel to give prior notice to the destination port prior to entering an emission control area and prove it made best efforts to source compliant fuel.

Vessels that fail to give sufficient notice to the port or cannot provide the required level of proof that they tried their best to bunker compliant fuel may be subject to action by the port state.

Prior to the 2015 reduction in sulphur limits within MARPOL emission control areas, the USA set up a 'fuel oil non-availability disclosure portal'. Vessels were able to submit fuel non-availability reports online using this portal. Similarly, the International Chamber of Shipping (ICS) has created a non-availability report template at www.ics-shipping.org/free-resources/sulphur-eca-compliance.

ALTERNATIVE TECHNOLOGIES

MARPOL Annex VI allows vessels to comply with the sulphur oxides (SOx) requirements by means other than burning low-sulphur fuel. This equivalency gives shipowners the option of continuing to burn high-sulphur residual fuel on the proviso that it is treated post-combustion.

Exhaust gas cleaning systems (EGCS)

Often referred to as 'scrubbers', these systems effectively wash the exhaust emissions to remove the SOx content. Manufacturers of EGCS generally claim removal rates of 98–99% and 80% of particulate matter (PM).

Some shipowners have opted for EGCS technology as a means of complying with the 2020 global sulphur cap. This includes installing systems in new vessels and retrofitting systems in existing tonnage.

EGCS can be 'dry' or 'wet'. Dry systems direct the exhaust gases through an absorption unit, filled with a chemical such as calcium hydroxide. However, it is wet systems that have been more widely adopted for marine use.

A wet system consists of:

- a wash tower located in the uptakes, where the exhaust streams from engines and boilers are mixed with either seawater or freshwater
- a treatment plant to filter and neutralise the wash water after scrubbing
- a residue or sludge storage and handling unit.

Wet systems are further categorised as open-loop, closed-loop or hybrid systems, where either open- or closed-loop mode can be employed.

Open-loop systems

Water is taken from the sea and pumped into the scrubber wash tower. The natural alkalinity in seawater means it does not need chemicals to be added prior to scrubbing. This method can be used in most seas around the world where alkalinity levels are high. The effluent is then treated and discharged back to sea.

Closed-loop systems

Seawater or freshwater is treated with an alkaline chemical such as caustic soda before entering the wash tower to scrub the exhaust gases. Wash water is re-circulated and any losses made up with additional water. A small amount of the wash water is bled-off to a treatment plant before discharge to sea, or the system can be run in 'zero discharge' mode where the effluent is held in a tank.

Hybrid systems

Hybrid systems can operate in either open- or closed-loop mode. Depending on design, they may operate with either freshwater or seawater when in closed-loop mode.

Potential areas of SOx non-compliance

Compliance with SOx regulations on an equivalent basis relies on the EGCS operating as designed. If the system is defective or is operated incorrectly, there is a significant risk of the vessel being in breach of MARPOL or any domestic regulations that may apply.

In its Marine Guidance Note MGN 510 (M+F), the UK Maritime & Coastguard Agency (MCA) identified three potential areas for non-compliance.

- Transitory non-compliance – for example, the EGCS temporarily does not perform as required due to an engine load fluctuation.
- Non-compliance with the SOx emission limits during the running up and shut down of the EGCS.
- Unintentional failure of the EGCS or any of its critical components.

Vessels using EGCS to comply with sulphur regulations should assess these risks and introduce contingency plans to ensure non-compliances are reported in good time and alternative methods of compliance are in place.

Condition of effluent

IMO have published guidance on EGCS wastewater criteria in the *2015 Guidelines for Exhaust Gas Cleaning Systems* (MEPC.259(68)). It requires the following wash water parameters to be continuously monitored and logged against time and ship position.

- pH – a low pH can impact marine organisms, and IMO has set a minimum limit of 6.5 or a maximum of two pH units difference between the seawater intake and effluent discharge.
- Polycyclic aromatic hydrocarbons (PAH) – PAHs occur naturally in petroleum and are also by-products of fuel combustion. Some PAH compounds have been found to be carcinogenic, mutagenic to mammals and have high toxicity levels that adversely impact aquatic organisms.
- Turbidity – this is a measure of suspended particulate matter. When combined with PAH, turbidity measurement is an effective means of monitoring the performance of wash water treatment.

The IMO guidelines require this data to be retained for a period of not less than 18 months from the date of recording.

EGCS waste water is also addressed by the US Environmental Protection Agency (EPA). Under its 2013 Vessel General Permit (VGP) programme, the effluent criteria is similar to that of the IMO guidelines, with the main exception that the minimum pH limit for the effluent at the overboard discharge is 6.0.

OTHER EMISSION-RELATED POLLUTANTS

Greenhouse gases (GHG)

The combustion of fossil fuels in a diesel engine or boiler is essentially carbon molecules undergoing an oxidation process. This results in the generation of carbon dioxide (CO_2) and water.

Carbon dioxide emissions are of concern as they are a 'greenhouse gas' (GHG) that can contribute to global warming. In 2018, IMO announced a target to reduce the total annual GHG emissions from international shipping by at least 50% by 2050, compared to 2008.

Programmes are either in place or in development (in 2018) to address carbon dioxide emissions from shipping – namely, the EU MRV and the IMO DCS. The focus of these programmes is capturing data and it is not yet understood what the next step, if any, will be. The future may see the adoption of further legislation to limit carbon dioxide emissions from vessels or, as is common in other industries, the introduction of market-based measures and carbon dioxide emissions trading to encourage 'carbon-neutral' operation.

EU MRV

Applicable to vessels 5,000 GT and greater, the EU Measuring, Recording and Verification (MRV) Regulation requires shipowners and operators to monitor, report and verify carbon dioxide emissions from their vessels calling at EU and EEA ports.

The deadline for submitting a monitoring plan for verification to comply with the EU MRV passed in August 2017, and emissions monitoring and recording commenced on 1 January 2018.

IMO DCS

The IMO Data Collection System (DCS) for fuel oil consumption is similar to the EU MRV, both applying to vessels 5,000 GT and greater. However, unlike the EU MRV, the monitoring plan will not be a separate entity and instead will be integrated as part of the ship energy efficiency management plan (SEEMP) under MARPOL Annex VI.

Vessels are required to monitor and record the required data from January 2019.

Particulate matter

Particulate matter (PM) comprises solid and liquid particles suspended in air, many of which are hazardous. The combustion of petroleum products can produce a mixture of sulphates, partially combusted hydrocarbons, black carbon and ash.

Black carbon is of particular concern as it is harmful to human health and can lead to respiratory and heart problems. Furthermore, it is recognised as being a contributor to global warming as it darkens surfaces in the polar regions (reducing reflectivity and absorbing heat energy) and, when airborne, it can absorb heat from sunlight.

Currently, PM is not subject to quantified emission limits, despite being referenced in regulation 14 of MARPOL Annex VI. It is expected that at some time in the future vessels will be required to reduce the amount of PM released into the atmosphere from engine exhaust systems.

PM is reduced when vessels burn distillate rather than high-sulphur fuel. PM can also be effectively reduced by using exhaust gas cleaning systems (EGCS), which are primarily focused on reducing SOx emissions.

LNG AS A MARINE FUEL

One of the main drivers for shipowners to turn to LNG as a marine fuel is that it emits zero SOx and virtually zero PM. This satisfies regulation 14 of MARPOL Annex VI, but LNG and dual-fuel engines do generate NOx emissions and must comply with regulation 13.

Nitrogen oxides (NOx)

Current solutions offered by gas and dual-fuel engine manufacturers to comply with NOx tier III include the installation of exhaust gas recirculation systems (EGR). Exhaust gas is cooled and cleaned before being fed back into the engine air intake. This reduces oxygen levels and increases carbon dioxide levels in the charge air, which slows down combustion and leads to lower temperatures, therefore reducing NOx emissions.

Methane slip

Methane is also a GHG and contributes to global warming. The greenhouse effect (global warming potential) of methane is estimated to be between 21 and 25 times that of carbon dioxide for the same quantity.

The potential sources of methane release into the atmosphere from a gas or dual-fuel engine include:

- 'methane slip' during combustion
- purging of gas when stopping the engine or changing to diesel
- release from storage tanks or the engine supply system.

Methane slip is the term used to describe the loss of methane from the engine when running. Very basically, it is methane that has leaked through the engine unburnt and has escaped into the atmosphere.

It is a recognised problem in both dual-fuel and spark-ignited four-stroke engines that operate on the Otto cycle. A common feature of these engines is that the fuel gas is pre-mixed outside the cylinders and then injected at low pressure. These low-pressure gas engines have low NOx emissions but are prone to methane slip.

Methane slip can be greatly reduced through engine design, such as minimising dead volume (crevices, voids, clearances etc.) in the combustion chamber and optimising swirl. Some of the lowest levels of methane slip appear to be achieved by two stroke dual-fuel engines operating on the diesel cycle, which operate with high injection pressures aided by diesel pilot ignition.

Chapter 10

CLAIMS MANAGEMENT AND COLLECTING EVIDENCE

Disputes and claims regularly arise amongst shipowners, charterers and bunker suppliers. These disputes generally concern either the quality or the quantity of fuel supplied or fuel remaining on board the vessel.

By way of a reminder, the 'golden rule' for successful resolution of bunker quality and quantity disputes is as follows.

Golden rule for bunker quality and quantity disputes
The success of any bunker quality or quantity dispute will depend upon the quality of evidence collected in support of the claim

The party with the strongest evidence to support their claim will generally be successful. This is fundamental to the claims management process.

This chapter looks at how quality and quantity claims and disputes are managed by a P&I club or a freight, demurrage and defence (FD&D) insurance provider, and the evidence needed to pursue or defend a claim successfully.

ACTION IN THE EVENT OF A QUALITY DISPUTE

When managing a claim and collecting evidence, it is useful to have in mind those losses that may form part of a claim against the opposing party, which may be a bunker supplier, time charterer or shipowner. Each of the components of a claim will have to be proved by establishing that a loss was incurred and it was in the amount being claimed.

For example, a bunker quality claim may include the following losses:

- cost of replacing any damaged machinery, including replacement parts, shipping and labour
- cost of pursuing the claim, including legal costs, surveyor/expert fees and laboratory analyses
- loss of time, hire or freight
- cost of de-bunkering the old substandard fuel and re-delivering the vessel with new bunkers
- cost of liabilities to third parties (such as cargo receivers) incurred solely as a result of the delays associated with the bunker dispute
- indemnity against the consequences of receiving fuel oil that does not comply with the sulphur requirements of MARPOL Annex VI
- crew overtime and superintendent attendance.

Evidence collection

The type of evidence required to pursue or defend a claim will depend on the nature of the incident. The simple process on managing evidence following an incident is as follows.

- *Collect.* Gather physical, documentary and electronic evidence and witness statements.
- *Preserve.* Ensure evidence remains protected, secure and a chain of custody exists.
- *Record.* Maintain a record of the items of evidence.

It is important to remember that the opportunities to collect information, evidence and any other material might be limited. This is particularly pertinent if trying to gain access to evidence belonging to another party.

Some examples of important evidence are listed in this section, but the lists are not exhaustive and may not be relevant to all scenarios. For claims management purposes, the P&I or FD&D claims handler might provide recommendations on what evidence should be gathered and this may also prove useful to the shipowner's own investigation. The master should also take guidance from any attending experts or the insurer's appointed surveyors.

Documentary evidence

After receiving what turns out to be substandard bunkers, documentary evidence should be collected as follows.

Documentary evidence of loading substandard bunkers
Details of which tanks received the alleged substandard bunkers and in what order they were loaded.
Details of the fuel oil that was already on board prior to bunkering the alleged substandard fuel: quantity, grade and location.
On-board testing record and laboratory analysis report of alleged substandard bunker stem.
On-board testing records and laboratory analysis reports of previous bunker stems.
Copies of any advisories issued by the testing laboratory on using the fuel.
Oil record book entries.
Relevant deck and engine room log book entries.
Engine room work books and fuel transfer record books.
Scrap or rough logbooks.
Bunker delivery notes of the affected and previously loaded fuel oil.
Copies of any letters of protest which may have been issued during this or previous bunkering operations.
Fuel oil tank plan.
System drawings of the fuel system pipeline and pre-heating arrangements.
Relevant extracts from engine manuals and any pertinent service bulletins.
Safety management system (SMS) extracts detailing the shipboard procedures relating to bunkering, storage and treatment of fuel oil.

Where it is disputed that damage to the vessel's engine has resulted from consuming off-specification or otherwise problematic fuel oil, additional evidence should be collected. The master and chief engineer should be instructed to make a detailed record describing the problems being experienced by the vessel when using the fuel oil, paying particular regard to the following.

Additional documentary evidence of machinery damage from substandard bunkers
When and where the alleged substandard fuel oil was bunkered and into which tanks.
Environmental conditions at time of incident.
Date and time the alleged substandard fuel oil was first and last burned in engines.
Description of the immediate symptoms of fuel oil problems.
Extracts from alarm recorder and events recorder.
Details of the actions taken to mitigate the problem and the results of such actions.
Report nature and extent of damage as observed and detail which parts of the engines were subsequently overhauled or renewed.
Details of any repair work done and the supervising officer or authority.
Describe the effects on engine performance once the vessel stopped burning the problem fuel.
Advise on the quantity and type of fuel oil additives used.
Provide details on the shipboard fuel oil treatment procedures adopted (e.g. how centrifugal separators and filters were set up and used).
Quantities of impurities recovered (e.g. water from tanks and centrifugal separators).
Technical repair or service reports issued by any attending technicians.

Witness statements

There are two types of evidence with regard to statements and it is important to differentiate between the interviewed crew's opinions and facts:

- factual evidence relates to what was seen or done at time of the incident
- opinion evidence concerns what people think happened.

Statements should be taken as soon as possible after the event. There are three main reasons for this.

- *Memories fade.* The ability to accurately recollect what happened fades with time.
- *Collaboration.* People's versions of events can change after they have had the opportunity to discuss it with either their superiors or fellow crew. There can be a tendency to amend their version to match others either subconsciously or through coercion
- *Legal value.* Contemporaneous evidence carries more weight in a court of law. For example, a court may hold a statement made at time of the incident in higher regard than a statement made a week later.

Physical evidence

Physical evidence should be collected as follows.

Physical evidence of substandard bunkers and machinery damage
Fuel samples taken during bunkering by the vessel (not the samples required under MARPOL Annex VI).
Fuel samples drawn by the bunker supplier and received by the vessel.
Fuel samples of the alleged substandard fuel drawn from (as applicable): • storage tank • settling tank • before and after centrifugal separators • service tank • engine fuel supply system. Samples should be taken direct from the bunker tanks in sets of three at different levels within the tank — top, middle and bottom (but only relevant if fuel oil is supplied into empty tanks). The date, time and location of sampling must be recorded on the bottle labels.
Sludge removed from centrifugal separators should be stored for subsequent analysis.
Any damaged machinery parts should be kept on board (without being cleaned), recorded with a seal number and placed in a secure location.
Photographs and videos should be taken of all damaged components whenever they are discovered.

Claims procedure

It is important that the shipowner or charterer acts quickly to notify its P&I club and/or FD&D provider (defence club). If the vessel's engines or boilers have been damaged, hull underwriters and/or the charterer's damage-to-hull (DTH) underwriter should be notified. Specialist bunker underwriters (if applicable) may also need to be notified.

One of the first steps a claims handler or lawyer will take is to review the contracts in play that directly relate to or reference bunkers. The warranties and conditions in these contracts should be scrutinised, and the claims procedure contained in the terms incorporated into the bunker delivery contract should be followed exactly.

The initial review of the file will determine whether or not an independent surveyor should be instructed to attend. If a surveyor is needed, the claims handler should be satisfied of their suitability to act on bunker related issues. Depending on the severity or complexity of the incident, it may be appropriate to secure the services of a bunker expert on a retainer.

Statements should be taken from the master, the chief engineer and any other personnel involved in either bunkering or an actual incident. Evidence and records concerning the bunker supply should be collected.

Guidance should be sought from the machinery manufacturer, fuel experts and fuel quality analysts. It may be necessary to arrange additional sampling and laboratory analysis. The laboratory testing authority may provide recommendations on how the fuel oil should be dealt with on board the vessel. For example, if the problem is related to the fuel oil viscosity, advice should be sought as to the temperature required to heat the fuel oil to obtain the correct injection viscosity.

A decision must be taken in principle as to whether or not the fuel oil is acceptable. If the fuel oil does not meet the specification ordered and is not fit for use by the vessel, then it should be rejected. It is always advisable to take legal advice on how to make a proper rejection of the fuel oil.

Immediately following rejection, the charterer (if the vessel is on time charter) or the bunker supplier (if the shipowner purchased the fuel oil direct) should be instructed to remove the fuel oil and arrange for a fresh supply of the correct grade. The time charterer and/or the bunker supplier should be notified that the shipowner holds it responsible for all losses caused by the supply of off-specification fuel oil. For example, any time lost in consequence and the cost of de-bunkering.

Decision to de-bunker

Shipowners and time charterers can only claim their reasonable losses. For example, where the fuel oil does not conform to the specification ordered, but may nonetheless be consumed with little or no risk to the vessel, it would be unreasonable to incur the cost and the associated loss of time involved in de-bunkering. The time charterer and/or bunker supplier would be able to argue that because the decision to de-bunker was unreasonable, it should not be liable for the costs of doing so.

Where it is unclear whether or not the vessel can use the fuel oil supplied, the shipowner should carefully assess the risks. The shipowner should consider the information to hand, and then decide if it is reasonable to go to the time and expense of de-bunkering or to attempt to use the fuel oil. Factors that should be considered include the following.

- The risk of damage to the vessel's machinery and the severity of the potential consequences.
- The risk of the vessel's performance being adversely impacted.
- Whether the risks can be mitigated to an acceptable level.

When considering the factors, it is worth bearing in mind the comments of the arbitrators in an unreported London arbitration award in 1996.

London arbitration award (1996) on de-bunkering

The charterparty described the vessel as capable of burning IFO with a viscosity of 180 cSt and the charterers agreed to supply bunkers of this specification. The vessel's engines normally consumed IFO 180 and the charterparty warranties were based on this.

'But as we have found, the owners did not get the fuel to which they were contractually entitled ... We find ourselves in agreement with the owners that it was difficult to see why they should be exposed to the risk of further loss in consequence of the charterers' breach such as damage to the main engine, breakdown or consequential claims under the next charterparty fixture.

'Although such problems were not inevitable, there was a risk of all or some of the possible consequences occurring. In contrast, any such problems were avoided by taking a simple, trouble-free and relatively cheap course of replacing defective bunkers. One would be hard put to say that they had acted unreasonably.

'We further mention that had the owners taken the alternative course contended for by the charterers to burn the bunkers despite the inherent risks and ended up with a much larger claim, then the charterers may well have successfully argued that the owners had not only failed to mitigate their loss (for example by de-bunkering or replenishing the bunkers in Singapore) but that the chain of causation between the charterers orders and loss sustained had been broken.'

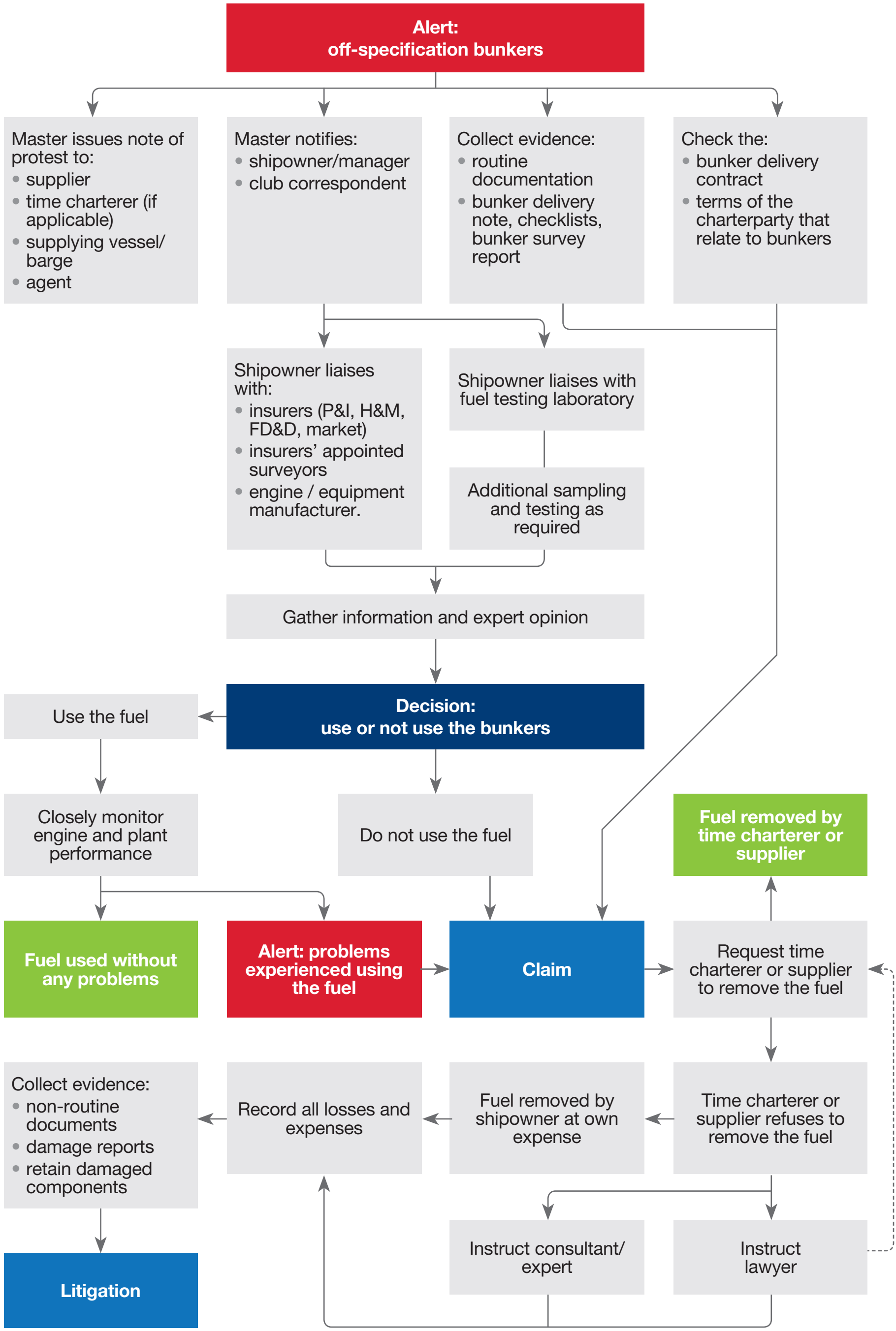

Fig. 27. Bunker quality claims management

Every case will be decided on its own facts. But where it has been established that the bunkers were not of the specification contracted for and that there are real risks to the vessel, its machinery, or its ability to perform to warranties in the current charter or any subsequent charter, arbitrators have consistently shown they will support a shipowner's decision to de-bunker.

ACTION IN THE EVENT OF A QUANTITY DISPUTE

Disputes concerning the quantity of fuel generally relate to a disagreement on the amount remaining on board after bunkering or at the time of redelivery of the vessel after a charter period.

The strength of a party's claim depends on the evidence proving the remains on board were measured and calculated properly and accurately.

Evidence collection

The evidence required to pursue or defend a quantity claim will largely be documentary. Typical records and documents that may be required include the following.

Documentary evidence of bunker shortage
Bunker calculations that provide details of the following for the vessel and – if related to a bunkering operation – the bunker supplying vessel: • manual sounding, ullage or gauge reading of every tank • observed quantity of water in each tank • volume of tank contents as determined by sounding (tank calibration) tables • temperature of tank contents • density of fuel in each tank • volume correction factors used • weight corrections factors used • draughts, trim and heel.
Bunker flowmeter readings.
Bunker loading plans.
Independent bunker survey reports.
Completed bunker checklists.
Notes of protests – both issued by the vessel and received by the vessel.
Relevant extracts from vessel's official sounding (tank calibration) tables.
Oil record book entries.
Relevant engine room log book entries.
Relevant deck log book entries.
Engine room work books.
Fuel transfer record books.
Scrap or rough logbooks.
Bunker delivery notes.
Shipboard bunker history — records of previous bunkering operations.
List of personnel involved in bunkering and those witnessing taking soundings/ullages.
Safety management system extracts detailing the shipboard procedures relating to bunkering.

Claims procedure

As with bunker quality disputes, the shipowner or charterer should promptly notify its P&I club and/or FD&D provider (defence club). Again, the claims handler or lawyer will review the contracts in play that directly relate to or reference bunkers, scrutinising the warranties and conditions.

It may be appropriate to instruct a surveyor to carry out a bunker survey to provide an independent calculation of the remains on board.

Fig. 28. Accurate measurements are vital for determining quantity (VPS)

IMPACT ON INSURANCE

Substandard fuel oil can cause major operational problems on board a vessel. It can cause severe damage to machinery and consequently lead to significant delays. There are a number of different types of insurance that may be relevant to bunker quality disputes, but the relationship between them is not always clear.

The insurance provisions that may be relevant to the shipowner and/or charterer when a bunker quality problem arises are as follows.

Hull and machinery (H&M) insurance

Most shipowners will have in place a policy which insures them against damage to their vessel's hull and machinery (H&M). Off-specification fuel oil can cause significant damage to the vessel's engine and plant. The associated repair and replacement costs may be recoverable from an H&M underwriter depending on the terms of the policy.

Charterer's damage to hull (DTH) insurance

Time charterers may seek insurance for the liabilities they may face towards shipowners in respect of damage to the chartered vessel's hull and machinery. This insurance is commonly known as 'damage-to-hull' (DTH) insurance.

DTH cover can be sought directly from market or through a P&I club. DTH policies commonly include cover against the liabilities a charterer may face in respect of damage to the vessel's engines (and any subsequent loss of time) caused by fuel oil that is owned by the charterer.

Freight, demurrage and defence (FD&D) insurance

Freight, demurrage and defence (FD&D) is a separate class of insurance and is often referred to as 'defence' cover. This is offered as an additional class of cover from a P&I club or can be sought from an independent defence club.

In the event of a bunker quality or quantity dispute, the FD&D insurer will, where merited, provide a shipowner with cover for the costs involved in pursing or defending a claim against another party. It does not provide shipowners with cover for the actual substantive liabilities themselves, such as the payment of any awarded damages.

Typical costs covered in an FD&D claim are the fees for lawyers, correspondents, arbitrators, surveyors and other experts. This may also include the costs incurred collecting evidence (such as surveys and taking statements) and the legal costs of prosecuting the claim against the bunker supplier or time charterer purchaser.

Similarly, where merited, a charterer may receive the support of its FD&D insurer when defending a claim by a shipowner that the fuel oil was not fit, or when making a claim against the bunker supplier under the bunker delivery contract.

In cases of minor damage to the vessel's hull and machinery, FD&D insurance also provides cover for legal costs that would have formed part of a claim on the vessel's H&M policy except for the fact the claim was below the policy deductible. Recently, the level of such deductibles has increased and this aspect of a shipowner's FD&D cover has assumed greater importance.

A less obvious aspect of bunker quality claims for which FD&D insurance can provide cover is in assisting with disputes against underwriters. An H&M underwriter and bunker insurance underwriter may, for whatever reason, refuse to pay a claim made by a shipowner (or charterer). FD&D cover may extend to provide legal costs insurance in respect of such disputes.

Protecting and indemnity (P&I) insurance

It is unlikely that any P&I liabilities will arise directly from the supply of off-specification fuel. Furthermore, a shipowner and charterer may not recover from their P&I insurer any losses caused by the substandard fuel, such as the cost of de-bunkering and the purchase of replacement fuel oil.

However, there may be consequential liabilities arising from the supply of off-specification fuels which do give rise to a P&I claim. For example, a main engine breakdown may cause delay in the delivery of a sensitive cargo causing loss to a cargo receiver, which it attempts to recover from the carrier under the bill of lading. Alternatively, the charterer and receiver may seek to avoid paying contributions in general average declared as a result of the main engine breakdown because of an alleged breach of the contract of carriage.

A failure to comply with fuel sulphur limits can also result in fines being imposed, which may fall within the scope of P&I cover.

Market insurance

Specialist bunker insurance tailored to the liabilities that could arise from bunker quality problems is also available. Such policies provide cover for a shipowner or time charterer against losses and damage caused by off-specification fuel. These include:

- the cost of discharge, storage, refining and/or other incidental expenses incurred until the defective fuel oil is sold or returned to the original seller
- the cost of cleaning the vessel's tanks
- the loss of vessel use solely as a result of the time taken to discharge the defective bunkers, clean the tanks and load fresh fuel oil.

Bunker policies will normally exclude claims for damage that is already covered by other policies.

Loss-of-hire insurance

Shipowners may purchase loss-of-hire insurance to cover lost hire or freight when a vessel is out of service beyond a pre-set period of time.

Such policies are of only limited assistance in the context of bunker quality disputes, but they can provide the shipowner with the comfort of knowing that it will not be deprived of a vessel's earnings beyond the amount of the deductible under the policy.

Insurance for bunker quantity losses

There is no commonly available insurance to insure against bunker quantity disputes.

Appendix I

RECOMMENDED CLAUSES

BIMCO periodically updates clauses it publishes and readers should always check with BIMCO for the latest version.

BIMCO BUNKER QUALITY AND LIABILITY CLAUSE

(a) The Charterers shall supply fuels of the agreed specifications and grades. The fuels shall be of a stable and homogeneous nature and suitable for burning in the Vessel's engines or auxiliaries and, unless otherwise agreed in writing, shall comply with ISO standard 8217:2010 or any subsequent amendments thereof.

(b) The Charterers shall be liable for any loss or damage to the Owners or the Vessel caused by the supply of unsuitable fuels and/or fuels which do not comply with the specifications and/or grades set out in sub-clause (a) above, including the off-loading of unsuitable fuels and the supply of fresh fuels to the vessel. The Owners shall not be held liable for any reduction in the Vessel's speed performance and/or increased bunker consumption nor for any time lost and any other consequences arising as a result of such supply.

BIMCO BUNKER QUALITY CONTROL CLAUSE FOR TIME CHARTERING

(1) The Charterers shall supply bunkers of a quality suitable for burning in the Vessel's engines and auxiliaries and which conform to the specification(s) mutually agreed under this Charter.

(2) At the time of delivery of the Vessel the Owners shall place at the disposal of the Charterers, the bunker delivery note(s) and any samples relating to the fuels existing on board.

(3) During the currency of the Charter the Charterers shall ensure that bunker delivery notes are presented to the Vessel on the delivery of fuel(s) and that during bunkering representative samples of the fuel(s) supplied shall be taken at the Vessel's bunkering manifold and sealed in the presence of competent representatives of the Charterers and the Vessel.

(4) The fuel samples shall be retained by the Vessel for 90 (ninety) days after the date of delivery or for whatever period necessary in the case of a prior dispute and any dispute as to whether the bunker fuels conform to the agreed specification(s) shall be settled by analysis of the sample(s) by (...) or by another mutually agreed fuels analyst whose findings shall be conclusive evidence as to conformity or otherwise with the bunker fuels specification(s).

(5) The Owners reserve their right to make a claim against the Charterers for any damage to the main engines or the auxiliaries caused by the use of unsuitable fuels or fuels not complying with the agreed specification(s). Additionally, if bunker fuels supplied do not conform to the mutually agreed specification(s) or otherwise prove unsuitable for burning in the vessel's engines or auxiliaries the Owners shall not be held responsible for any reduction in the Vessel's speed performance and/or increased bunker consumption nor for any time lost and any other consequences.

BIMCO BUNKERING OPERATIONS AND SAMPLING CLAUSE

(a) The Chief Engineer shall co-operate with the Charterers' bunkering agents and fuel suppliers during bunkering. Such cooperation shall include connecting/disconnecting hoses to the Vessel's bunker manifold, attending sampling, reading gauges or meters or taking soundings, before, during and/or after delivery of fuels.

(b) During bunkering a primary sample of each grade of fuels shall be drawn in accordance with IMO Resolution MEPC.182(59) Guidelines for the Sampling of Fuel Oil for Determination of Compliance with the Revised MARPOL 73/78 Annex VI or any subsequent amendments thereof. Each primary sample shall be divided into no fewer than seven (7) samples; one sample of each grade of fuel shall be retained on board for MARPOL purposes and the remaining samples of each grade distributed between the Owners, the Charterers and the bunker suppliers.

(c) The Charterers warrant that any bunker suppliers used by them to bunker the Vessel shall comply with the provisions of Sub-clause (b) above.

(d) Bunkers of different grades, specifications and/or suppliers shall be segregated into separate tanks within the Vessel's natural segregation. The Owners shall not be held liable for any restriction in bunker capacity as a result of segregating bunkers as aforementioned.

BIMCO BUNKERING PRIOR TO DELIVERY/REDELIVERY CLAUSE

Provided that it can be accomplished at ports of call, without hindrance to the working or operation of or delay to the Vessel, and subject to prior consent, which shall not be unreasonably withheld, the Owners shall allow the Charterers to bunker for their account prior to delivery and the Charterers shall allow the Owners to bunker for their account prior to redelivery. If consent is given, the party ordering the bunkering shall indemnify the other party for any delays, losses, costs and expenses arising therefrom.

Appendix II

DRAFT LETTERS

NOTIFICATION BY MASTER TO CHARTERER'S PORT AGENT AND BUNKER SUPPLIER THAT FUEL SUPPLIED DOES NOT CONFORM TO SPECIFICATION REQUIRED BY THE VESSEL AND IS UNUSABLE

From:

Company:

To:

Date:

Time:

At:

Re: MV

Bunkers loaded at *(insert port)*

I hereby give you notice that a [*(insert name of the testing authority)*] [shipboard] analysis of a representative sample of the bunkers supplied by you to the vessel indicates that the fuel is wholly unsuitable for use in the vessel's machinery.

In the circumstances, I cannot jeopardise the safety of the vessel, crew, or cargo by accepting or using the bunkers and on behalf of owners hold [charterers/suppliers] wholly responsible for all damages and delays and other loss and expense arising as a direct or indirect consequence from your failure to supply suitable fuel.

Yours faithfully

Master

Make and model of sampling equipment:

Make and model of main engine:

NOTIFICATION BY MASTER TO CHARTERER'S PORT AGENT AND BUNKER SUPPLIER THAT SUPPLIED FUEL DOES NOT CONFORM WITH SPECIFICATIONS REQUIRED BY THE VESSEL

From:

Company:

To:

Date:

Time:

At:

Re: MV

Bunkers loaded at *(insert port)*

I hereby give you notice that an analysis carried out on this vessel of a representative sample of the bunkers supplied by you indicates the deficiencies listed below. The fuel is therefore outside the specification of fuel suitable to the vessel's engines and auxiliary machinery and has been submitted for further analysis.

Deficiencies were noted in:

1	Density	☐	5	Salt Water	☐
2	Viscosity	☐	6	Compatibility	☐
3	Pour point	☐	7	Catalytic fines	☐
4	Water content	☐	8	Sulphur content	☐

Owners await charterers' instructions and until these are received, the vessel cannot proceed. In the meantime, the vessel's engineering staff will use their best endeavours to protect the vessel's engines (including the slowing and stopping of the vessel's machinery when necessary).

Owners hold charterers fully responsible for any damage, delays, poor performance, over-consumption or any other loss or expense arising as a direct or indirect consequence of your failure to supply suitable fuel.

Yours faithfully

Master

Make and model of sampling equipment:

Make and model of main engine:

REQUEST FROM MASTER TO CHARTERER'S PORT AGENT AND BUNKER SUPPLIER TO ATTEND DURING REPRESENTATIVE SAMPLING

From:

Company:

To:

Date:

Time:

At:

Re: MV

Samples of bunkers

[In accordance with charterparty conditions] I hereby request you to ensure that representative samples of the bunkers to be supplied to the vessel will be taken and sealed in the presence of competent and authorised representatives of charterers and the vessel, such samples to be taken during bunkering at the vessel's manifold in accordance with MEPC.182(59) Guidelines for the Sampling of Fuel Oil for Determination of Compliance with the Revised MARPOL 73/78 Annex VI. In addition to the sample required under MARPOL Annex VI, regulation 18, the vessel will require a minimum of two samples for its own use.

It will be of assistance to you to know that the vessel has facility for drawing continuous samples at the manifold. If no joint samples are taken during bunkering by a satisfactory alternative system, only those samples drawn at the manifold by the vessel's representatives will be regarded as representative samples.

I shall be grateful if you will advise me as soon as possible what arrangements have been made by you or the bunker supplier in respect of bunkering and sampling.

Yours faithfully

Master

Make and model of sampling equipment:

Make and model of main engine:

PROTEST BY MASTER FOR FAILURE OF CHARTERER'S PORT AGENT OR BUNKER SUPPLIER TO ATTEND DURING REPRESENTATIVE SAMPLING

From:

Company:

To:

Date:

Time:

At:

Re: MV

Samples of bunkers

I hereby make a formal protest that you and the bunker supplier have failed to participate in the proper obtaining and sealing during bunkering time of representative samples of the bunkers supplied to the vessel.

In particular:

- ☐ No samples have been drawn by you and supplied.
- ☐ Ready sealed samples have been supplied.
- ☐ Samples were drawn in a method which is unsatisfactory and susceptible to gross error.

I hereby give you notice that the vessel has taken her own samples during the bunkering operation [which were sealed in the presence of charterers or bunker supplier's representative] [in the absence of a response to my invitation to attend joint sampling] and only these samples will be regarded as representative. Two sealed samples drawn by the vessel are available to you on request.

Yours faithfully

Master

Make and model of sampling equipment:

Make and model of main engine:

PROTEST BY MASTER FOR FAILURE OF CHARTERER'S PORT AGENT OR BUNKER SUPPLIER TO PROVIDE A BUNKER DELIVERY NOTE, A REPRESENTATIVE SAMPLE OR LOW-SULPHUR FUEL IN COMPLIANCE WITH MARPOL ANNEX VI

From:

Company:

To:

Date:

Time:

At:

Re: MV

BDN Reference Number:

Sample Reference Number:

I hereby make a formal protest to you and the bunker supplier regarding the following items which is regarded as being non-compliant with reference to MARPOL 73/78 Annex VI.

[The Bunker Delivery Note presented to the vessel is not in compliance with the relevant requirements of MARPOL Annex VI, regulation 18, due to the fact that *(insert reason)*.]

[The representative sample of the bunkers supplied to the vessel is not in compliance with the relevant requirements of MARPOL Annex VI, regulation 18, in accordance with IMO Resolution MEPC.96(47) Guidelines for the sampling of fuel oil for determination of compliance with Annex VI of MARPOL 73/78, due to the fact that *(insert reason)*.]

[The bunkers supplied to the vessel are not in compliance with the relevant requirements of MARPOL Annex VI, regulation 14, due to the fact that we have been informed by *(insert organisation)* through a Fuel Quality Report dated *(insert date)* that based on the sample and the Bunker Delivery Note, the measured sulphur level exceeds the limit stipulated in MARPOL Annex VI, regulation 14 (4), for fuel to be used within a designated emission control area (ECA).]

Yours faithfully

Master

Copied to: Port State Authority
Vessel's Flag Administration
Vessel's records
Company

Appendix III

NO LIEN PROVISIONS

INTERNATIONAL GROUP CIRCULAR CONCERNING THE 1971 AMENDMENT TO US VESSEL MORTGAGE ACT AFFECTING LIENS ON VESSELS UNDER TIME CHARTER

By Public Law 92-79 approved 10 August 1971, the United States Congress amended prior American legislation affecting the creation of liens on vessels under time charter so that owners are now exposed to significantly greater risks of vessels being held liable for services and supplies ordered by time charterers despite prohibition of liens clauses. The Federal Maritime Lien Act 33 US Code Section 971-75 provided that a person furnishing supplies by order of the owner or a person authorised by the owner had the right to arrest a vessel in rem. Persons authorised by an owner included agents appointed by a charterer. This Act contained a proviso, now deleted by Public Law 92-97 that no lien was to be conferred where the supplier knew or ought to have known that by the terms of the charterparty the person ordering the supplies was without authority to bind the vessel.

It is considered that Public Law 92-79 fails in its purpose since it simply deletes this proviso. New York Counsel consider that the effect of the amendment can be negative where the supplier is actually informed that a person ordering supplies does not have authority to bind the vessel or by putting the supplier on actual notice of the prohibition of creating liens.

It is recommended therefore that a registered letter in Form A be sent to the prospective supplier of goods advising him that under the terms of the time charter the charterer does not have authority to bind the vessel. Additionally, the master should not accept services for materials ordered by the charterers or their agents unless the supplier will sign a notice disclaiming any reliance on the credit of the vessel, see Form B, which should be stamped on the documents submitted by the supplier.

In negotiating time charters the normal clause denying the charterers' right to create liens on the vessel (clause 18 of the New York Produce Exchange Form) should be maintained by the addition of the following words on Form C.

Form A

To be signed by owners or their agents and posted by registered letter, return receipt requested, addressed to all of the charterers' known stevedores, suppliers of fuel and other necessaries or services at the prospective ports of call.

Dear Sirs

We have recently chartered our .... flag .... vessel named the '..............' to Messrs .... of .... as charterers.

It has come to our attention that in your capacity of .... at the port(s) of .... where our said vessel may be trading, you may be called upon by said charterers to furnish .... for their use in connection with the vessel.

We wish to advise for your guidance that under the terms of the charter between us, as owners of said vessel, and said charterers, neither the charterers nor the master nor any other person has power or authority to pledge either our or our said vessel's credit, or to create, or permit to be created, any liens on our said vessel, and that accordingly any such .... furnished by you to our said vessel will be so furnished solely upon the credit of Messrs .... as charterers, and not on the credit of the vessel or ourselves as her owners.

Very truly yours

Form B

To be endorsed as a prominent and legible rubber or typed stamped legend by the Master, Chief Officer, Chief Engineer and all other vessel's officers signing receipts or other papers submitted by suppliers for fuel, stevedoring and other necessaries or services which are not under the governing charter, ordered for the account of the owners.

IMPORTANT NOTICE

The goods and/or services being hereby acknowledged, receipted for, and/or ordered are being accepted and/or ordered solely for the account of charterers of the MV/SS/MS. .... and not for the account of said vessel or her owners. Accordingly, no lien or other claim against said vessel can arise therefore.

OWNERS OF THE .... VESSEL

Form C

Suggested form of the last two sentences of clause 18 of New York Produce Exchange form, or equivalent clause in other time charters, or time charter: the second sentence in italics is the proposed addition to the form.

'Charterers will not suffer, nor permit to be continued, any lien or encumbrance incurred by them or their agents, which might have priority over the title and interest of the owners in the vessel. In no event shall charterers procure, or permit to be procured, for the vessel, any supplies, necessaries or services without previously obtaining a statement signed by an authorised representative of the furnisher thereof, acknowledging that such supplies, necessaries or services are being furnished on the credit of charterers and not on the credit of the vessel or of her owners, and that the furnisher claims no maritime lien on the vessel therefore.'

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MARINE FUELS: PREVENTING CLAIMS AND DISPUTES

The North of England P&I Association

Quantity and quality issues regarding the supply of marine fuels can lead to potentially complex, costly and lengthy claims and legal disputes. This guide provides helpful advice on how these claims and disputes can be avoided. Just as importantly, it also provides guidance on how to have the best chance of success when pursuing or defending a claim.

This guide aims to assist seagoing officers, vessel operators, vessel managers and time charterers in understanding what can go wrong when purchasing, bunkering and using marine fuels and what steps can be taken to prevent them and mitigate their impact. It explores the subject of marine fuels, from the production and refining process all the way to burning in the vessel's engines. The nature and characteristics of marine fuels is discussed along with purchasing, contractual obligations, loading, handling, sampling and testing. The guide finishes by looking at claims management and the all-important collection of evidence.

Increasingly stringent environmental regulation has placed more demands on seafarers and operators. Compliance with the global sulphur cap in 2020 has driven the demand for new compliant fuels and new technology. This guide considers this change in the landscape, with a particular focus on the increasing use of LNG as a marine fuel.

The North of England P&I Association is a leading marine mutual liability insurer based in Newcastle upon Tyne, UK, with regional offices in China, Greece, Hong Kong, Japan and Singapore. The club has developed a worldwide reputation for the quality and diversity of its loss-prevention initiatives.

£30
ISBN: 978-0-9955653-3-3