

Tanker matters

*A focus on some of the issues surrounding
tanker fleets in the P&I world*



Bulk oil cargoes – shortage and contamination claims

Over recent years there has been a marked increase in the incidence of claims arising from the carriage of oil cargoes. The claims are often substantial and may allege either shortage or contamination or both. In the past it was believed that measurement inaccuracies and all the problems related to the carriage of oil in bulk were understood. Recent research and advances in technology and analytical techniques have uncovered information which is of considerable significance. The purpose of this article is to provide guidance on how tanker operators can minimise the risk of cargo loss or damage and defend themselves should claims arise.

Oil shortages

In general, oil shortage claims are based upon a discrepancy between the quantity of cargo as stated in the bill of lading and the outturn quantity as calculated in the discharge port. Both these figures are frequently derived from shore-tank calibration data. The most common arguments are that:

- The ship is bound by the figure stated in the bill of lading
- The shore tank calibrations are more accurate than the ship's tank calibrations
- The oil has become contaminated by water after loading
- Some oil remains onboard the ship.

The carrier's defence is commonly based upon the accuracy of the ship's cargo figures and seeks to demonstrate that they were comparable with the bill of lading figure, that there was no significant in transit loss, that any onboard quantity (OBQ) prior to loading has been taken into consideration and that all the cargo has been discharged with none remaining onboard (ROB).

In the following pages each phase of a typical tanker voyage is followed chronologically and likely causes of difficulty are considered.

Before arrival at the load port

The correct preparation of the cargo tanks in readiness for the grade of cargo to be carried is covered in the section dealing with contamination claims. Aside from ensuring the minimum safe quantity of clean ballast for arrival, the cargo officer should prepare a loading plan

taking into account stability, trim and stress. Where draft restrictions permit, it may be advisable to plan for leaving the loading port with a trim that avoids the need for internal transfers of cargo during the loaded passage. The inert gas system, if fitted, should be fully operational in readiness for the forthcoming cargo operation. The oxygen content of the cargo tanks should be as low as possible before arrival and a record of all tank readings should be maintained.

On arrival at the berth

Once the ship is securely moored it is important to arrange liaison with representatives from the shore loading facility and to ensure continued good communications throughout the loading. All relevant information must be exchanged between ship and shore including details of the ship's loading plan, maximum loading rates, shutdown procedures, safety regulations and cargo data.

Before loading

After all ballast has been discharged other than any permanent ballast which may be discharged simultaneously with the loading of the cargo, the ship's cargo valves and pipelines should be correctly set for the reception of cargo and the relevant tank valves opened. Any residual ballast water should be pumped or drained from the pipeline system either overboard in the case of clean ballast or into a suitable slop tank but always in compliance with the local oil pollution regulations. Before loading, it is customary for a joint inspection of the cargo tanks to be made by shore representatives and ship's officers to confirm that the tanks are properly drained of water and in a suitable condition to load the designated cargo. In general, the completion of such an inspection does not relieve the owner of his responsibility to ensure the correct condition of the cargo tanks. In large tankers and where tanks are inerted, such inspections are difficult and it may be necessary to rely on the ship's gauging equipment rather than any visual inspection. Preparations for the loading of multigrade cargoes are dealt with under the section covering cargo contamination claims. The measurement of any OBQ should be carefully undertaken preferably jointly with the shore representatives. The depth of any residues should be measured at as many locations as possible and at least at the forward and after ends of the tanks. Tank cleaning hatches should be utilized as appropriate.

During loading

The loading sequence of tanks should be planned in advance with the ship's stability and stress conditions in mind. It is customary to begin loading at a slow rate but



once it is established that cargo is entering the correct tanks and that there are no leaks from hose connections or any other difficulties, the rate is increased to the maximum. It is recommended that at an early stage the cargo officer should satisfy himself that the correct grade of cargo is being loaded, either by checking the specific gravity of a sample or at least by visual means. In modern tankers the ship's instrumentation may facilitate remote monitoring of temperatures during loading but in any event it is essential to measure accurately and to record the temperature in each tank during loading. It is wise not to use an average of the tank temperatures since this leads to inaccurate cargo figures.

The loading rate should be monitored and it is recommended that ullages and the corresponding tank volumes be recorded in the deck log at least at hourly intervals. Any changes in the loading rate or any stoppages must also be recorded. During the final stages of loading the rate should be reduced to a minimum in order to permit measurement of the quantity of cargo so far loaded and to calculate the correct finishing ullage in the last cargo tank.

On completion of loading

Before the cargo hoses are disconnected, the ship's figures must be calculated in order to check that the correct quantity of cargo has been loaded. Whilst it is in the ship's interests to measure the cargo onboard ship, it is customary for various witnesses to attend this operation and in some cases to make independent calculations. These witnesses may include representatives from the loading terminal, the shippers and the charterers. It is of prime importance that the

measurements of ullage, temperature and where appropriate, water dips are agreed by all concerned, although it must be accepted that the methods of calculation employed thereafter may not always be consistent. It is generally accepted that the latest edition of the API/IP Petroleum Measurement Tables are more accurate than the old tables, but it should be borne in mind that all tables are based on the average characteristics of a range of oils. Where a surveyor is attending on the ship's behalf he should collaborate with the ship's officers in order to ensure that no inconsistencies arise in the calculations.

Ship's tanks may be calibrated using imperial or metric units of volume and the quantity of cargo may be expressed in various units including long tons, tonnes or barrels. Whichever units are applied, it is essential to compare like with like. The use of standard volume may be considered preferable as it is less susceptible to misinterpretation by observers or laboratories. The appendix to this article shows the various terms used in the measurement of liquid cargoes and the abbreviations in common use.

At this point it may be worth considering in some detail the degree of accuracy which may be expected when ullaging tanks, measuring temperatures, taking samples or quantifying free water.

Ullaging

This is the measurement of the distance from the datum point at the top of a tank to the surface of the liquid cargo. This is usually done by means of a steel tape fitted with a weighted brass bob. Many tankers have fixed gauging equipment in each tank and electronic

measuring devices are also available. Ullaging is best carried out when the ship is on an even keel and with no list: otherwise inaccuracies may creep in despite the application of trim corrections. A ship whether afloat, alongside a jetty, at anchor or at sea, is a moving platform. Whilst it is not implied that ships necessarily roll heavily when berthed, nonetheless slight movement will affect the accuracy of measurement. In any single tank, a difference of one inch in the ullage may involve a volume of several hundred barrels.

Some factors may affect the calculation of onboard quantities particularly residues on tank floors and structures, which will vary with the age of the vessel and previous cargoes carried. It is not unusual for ullages to be recorded for the purpose of determining ROB and OBQ when the trim of the vessel, at the time of survey, is such that the ullaging tape or sounding rod is not perpendicular to the ship's tank bottom on contact. In such cases it follows that the depth of ullage obtained must also be inaccurate. Clingage is a further area for consideration because whilst crude oil washing (COW) reduces clingage with most crude, there are a few types of crude where the reverse is true.

Water dips

Free water beneath a crude oil cargo is normally measured with a sounding rod. Using water-sensitive paste, the presence of water can be detected by a change in the colour of the paste. Interface tapes may also be used for the detection of free water. Unfortunately, neither of these can be used to distinguish accurately between an emulsion and free water. Each method involves the risk of inaccuracies which can only be determined by proper sampling and analysis techniques.

Temperature

The temperature of liquid in a vessel's tank is generally obtained by the use of a cup case thermometer, although some vessels are now equipped with electronic temperature sensing devices. Cup cased thermometers are unreliable and errors of ± 2 to 3°C are not unknown. When taking temperatures, great care should be exercised to ensure that the thermometer is not affected by the environmental temperature after it has been removed from the oil.

The vertical positioning of the thermometer in a vessel's tank particularly at the discharge port is critical because significant temperature variations can develop within the cargo tanks during the voyage. Furthermore, as temperatures vary from tank to tank, calculations of quantity must be calculated using individual temperature corrections for each tank. The use of an

arithmetical average for the whole ship is, as previously mentioned, inaccurate and contributes to 'paper losses'. An error of 1°C in temperature produces an inaccuracy in the volume at standard temperature of approximately 0.1%.

Sampling

The ship when calculating cargo quantities, has to rely upon certain data supplied from the shore, in particular the density of the cargo which is calculated after the analysis of samples. Shoreline samples may however contain inaccuracies and cannot always be accepted as being representative of the cargo loaded. It is recommended that with crude oils, the standard sampling 'thieves' should not be used but that clean sample bottles be used for individual samples from each level, (i.e. top, middle and bottom of each of the ship's tanks) and clearly labeled. Regrettably, sampling is often undertaken using a one litre 'thief', each sample being decanted into a larger sample can.

During such an operation volatile fractions may be lost to the atmosphere and the density established from the final mix does not represent the true density of the cargo in each tank. This, in turn, may later have a significant effect upon the calculation of weight and bottom sediment and water. The importance of sampling as a measure to counter contamination claims is dealt with later in the article.

Measurement errors

Studies by a major oil company revealed that a measurement error of $\pm 0.21\%$ may occur when calculating the measurement of volumes and an error of $\pm 0.25\%$ when calculating weights. Thus, measurement errors may easily account for what has previously been termed a 'measurement error loss' or 'measurement tolerance'.

Completion of documentation

Once the calculation of the ship's figures has been completed, the shore installation will provide a shore figure. It is generally this figure which is used on the bill of lading. For the reasons given in the section dealing with cargo measurement, it is most unlikely that the two figures will precisely coincide. In practice, and in the vast majority of cases, the discrepancy is small and of no great significance and the master of the ship will have no difficulty in reconciling the figures nor in signing the bills of lading. In each case, the gross figures should be compared and the ship's experience factor should also be taken into consideration.

On those occasions when there is an exceptional difference between the bill of lading figure and the

ship's figure, the master should decline to sign the bills of lading. He should insist on a thorough check of all measurements and calculations, including those ashore, in order to ascertain the cause of the discrepancy. When checking the shore figures difficulties may arise because the measurements taken in the shore tanks before loading cannot be verified once the cargo has been transferred. The checking of the shore figures may, therefore, depend upon the accuracy of the records kept in the shore terminal. In the majority of cases this investigation is likely to be successful and the figures will be corrected and easily reconciled. The reasons for gross inaccuracies may include:

- Ullages wrongly measured
- Tanks filled but not taken into account
- The contents of pipelines not allowed for
- Wrong temperatures or densities
- Cargo mistakenly loaded on top of ballast
- Cargo lost in the shore installation
- Incorrect meter proving.

On occasions, despite such exhaustive checks it may be that the two calculations cannot be reconciled and the master then finds himself in a dilemma. On the one hand, he will doubtless be mindful of the Hague Rules which provide:

"No Carrier, Master or Agent of the Carrier shall be bound to state or show in the bill of lading any marks, number, quantity or weight which he has reasonable ground for suspecting not accurately to represent the goods actually received for which he has had no reasonable means of checking."

On the other hand, he will be conscious of the commercial pressures which dictate that the berth must be vacated and that the voyage must not be delayed. There is no inflexible rule to be followed which will apply in every case.

The master should note protest. He should certainly notify the ship's agents and instruct them to urgently inform the owners of the problem as well as the charterers, the shippers and any consignee, or notify party named on the bill of lading. The master should give full details of the available figures and ask the parties notified to inform any potential purchaser of the bill of lading of the discrepancy. It may be difficult for the master to contact all the parties named but the owner should do this at the earliest possible opportunity. Ideally, the master should be able to clause the bills of

lading but in practice this creates many difficulties. He should, therefore, decline to sign the bills of lading or withhold authority for anyone else to sign until the dispute has been resolved. In any event the master or owner should immediately contact the Association or the Association's correspondents.

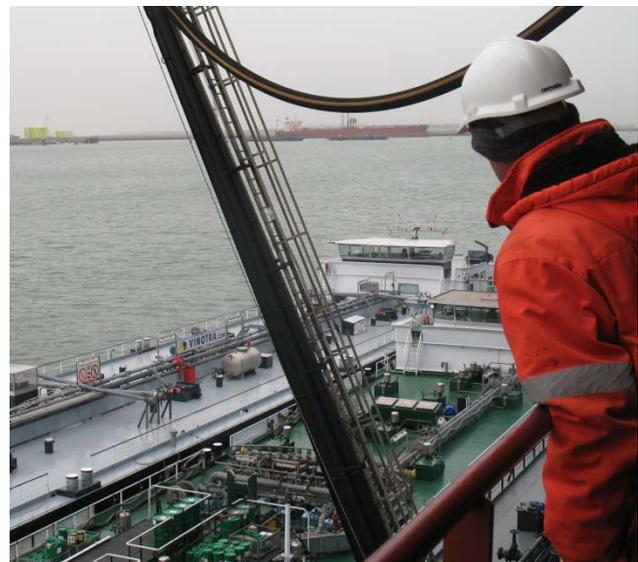
Early departure procedures

In certain busy oil ports, it is the practice, in the interests of expediting the turnaround of tankers, to offer the master the opportunity to utilise the 'early departure procedure'. This system was devised in the light of many years experience of tanker operations and shore figures after loading. On arrival at the loading berth the master agrees that on completion of loading, the loading hoses will be immediately disconnected and the ship will sail. As soon as the bill of lading figures are prepared, they are cabled to the master who then, provided he is satisfied, authorises the agent to sign the bills of lading and other related documents on his behalf. On no account should the master sign the bills himself before sailing without the correct figures being inserted.

Shipboard records

It is essential for the defence of possible cargo claims that the ship maintains certain documentary records of cargo operations. Time charterers, particularly the oil majors, are likely to place onboard their own documentation which they will require to be returned promptly at the end of each voyage. Typical returns would include:

- A voyage abstract (deck and engine)
- Notice of readiness
- A port log





- Pumping/loading records
- Stowage plan
- Loading and discharge port calculations
- Details of any cargo transfers.

They may also include records of all oil transfer, whether loading, discharging or internal and including bunkering operations. It should be noted that such records will assist not only with the defence of shortage and contamination claims but with handling of other possible disputes including performance claims and demurrage and dispatch disputes. The need to keep full records of bunker quantities and to properly maintain the oil record book cannot be over emphasised.

During the voyage

Provided the ship's fittings are properly maintained, the cargo will require little attention during the voyage unless heating is required. In such cases, it is important to follow the charterer's instructions particularly bearing in mind the specifications of the cargo carried. In some cases failure to heat the cargo properly may lead to severe difficulties. When crudes requiring heating are carried, particularly those with high wax content, it is important that the charterers provide clear instructions for heating both on the voyage and throughout discharge. Often, heating instructions are not sufficiently precise with the charterers relying on the experience of the master. Usually, it is wise to heat early

in the voyage in order to maintain the temperature rather than to be obliged to raise the temperature of the cargo significantly at the end of the voyage. If there is doubt about the heating instructions, the master should check with the charterers. The tank temperatures should be recorded twice daily.

Attention should be paid to the condition and operation of the pressure-vacuum valves on the tank venting system in order to ensure that they are functioning correctly. Failure to operate these valves properly may lead to a significant loss of product during the voyage.

Finally, as mentioned earlier, the loading has been carefully planned, there should be no necessity to transfer cargo between cargo tanks during the voyage. Indeed this should be avoided unless absolutely necessary as differences between ullages and soundings taken before and after the voyage invariably lead to disputes when defending shortage claims. Ideally, the two sets of readings should not differ to any degree. Owners should discourage the practice and insist that any transfers which the master considers urgent and essential be reported and properly recorded in the oil record book. Many charter parties do in fact require the master to notify the charterers of any cargo transfers.

Before arrival at the discharge port

A proper discharging plan should be prepared, taking into account any restrictions or requirements. It must include a careful check on not only the trim condition during discharge but on the stress conditions. Care should be taken to ensure that the parameters laid down by the shipbuilders are adhered to. It is also important to take into account the required discharging temperature and the need to maintain this temperature throughout the discharge. When discharging in ports where low sea temperatures prevail, this may require considerable vigilance. In those tankers fitted with inert gas and COW it is wise to ensure in advance that the systems are fully operational in readiness for the forthcoming discharge.

On arrival at the discharge port

On completion of the arrival formalities, the need to communicate with representatives of the discharging facility is no less important than at the loading port. Full liaison should include the exchange of all relevant information about the cargo, including the maximum discharge rates, the discharge plan, safety procedures, shutdown procedures scheduled shore stops and any local regulations. If the ship is fitted with COW it must be clear whether COW is to be carried out, particularly bearing in mind any Marpol requirements.

Before discharge

As in the loading port, the measurement of the cargo is undertaken in the presence of the cargo receivers and possibly other interested parties or their surveyors and including customs authorities. The remarks in the section on cargo measurement apply equally in this instance. The utmost care should be taken in checking and doublechecking the measurements. The measurement of temperature merits particular care especially where heated cargoes are concerned. Again it is stressed that apparently small discrepancies in temperature can lead to significant differences in the final calculations and the temptation to 'round off' temperatures or to use convenient averages should be discouraged. It is essential to note the ship's trim and list at the time of ullaging – the ideal trim is with the ship on an even keel and with no list. When sampling cargo before discharge and particularly in the case of heated cargoes, samples should be taken from the top, middle and bottom of the cargo tank.

On completion of cargo measurement, a comparison should immediately be made with the loading ullages tank by tank, in order to see whether there have been any appreciable changes since leaving the loading port. Should any differences be noted, then the reasons should be immediately investigated and fully recorded. The ship's responsibility should begin and end at the fixed manifold and the owners have no liability for measurements taken once the cargo has entered the complex of piping which forms the average receiving terminal. Claims are frequently presented on the basis

of shore figures which are inaccurate and the most effective and economical way of repudiating liability may be to recalculate these figures correctly. It would be beneficial for a surveyor representing the shipowner to check the shore reception facility, where he may be able to witness the taking of shore measurements. He may also be able to check the pipeline system, to verify its size and length and the method by which its contents are ascertained before and after discharge as well as noting any valves which lead off those pipelines which are in use. Some shore facilities are reluctant to allow ship's representatives to make full checks in their terminals. It should be recorded if an inspection of the terminal or its operations is refused.

Where shortage claims arise, they are usually based on the shore figures and the owner must defend himself not only on the basis of the accuracy of the ship's figures, but also by challenging the accuracy of those shore figures. It will greatly assist if the owners' surveyor has made a thorough inspection of the terminal at the time of the discharge.

During discharge

Once the necessary preparations have been completed aboard the ship and the shore installation has confirmed that the discharge can commence, the cargo pumps are started in sequence. Where one or more grades of cargo are carried, it may be possible to discharge each grade simultaneously subject to stress and trim considerations and any other restricting factors



including the design of the ship's pipeline system. Once it has been established that the cargo is flowing correctly, the discharge rate should be increased to the agreed maximum. The rate may be restricted either by back pressure or by the capacity of the ship's pumps. The rate of discharge should be carefully monitored throughout and recorded at intervals of no more than one hour. These records should show not only the amount of cargo discharged by volume but also the shore back pressure, the pressure at the ship's manifold, the speed of the cargo pumps and steam pressure or, in the case of electrical pumps, the amperage. If COW is being carried out, this operation must be closely monitored. Careful recording of the discharge in the ship's logs is essential if claims are to be successfully defended.

The effective stripping of the tanks is important since claims will undoubtedly be made against the owner for quantities of cargo remaining onboard. Provided the ship has a good stern trim, the tanks have been well cleaned and prepared prior to loading and provided also that the ship's pumps and pipelines are in sound condition, it should be possible to ensure that a negligible quantity is left onboard. In the case of light or clean products there should be no problem although where heavier or heated cargoes are concerned, there will inevitably be some clingage and perhaps some sediment remaining. COW will help to reduce these quantities and care should be exercised when stripping heated cargoes to ensure that the tanks are drained quickly, since once the level of the cargo falls below the heating coils, heat will be lost quickly and difficulties may be encountered.

Whatever type of oil is carried, it will be necessary to be able to demonstrate that ship's valves, lines and pumps were in good condition at the time of discharge, because this has an impact on the question of 'pumpability'. It might be assumed that oil is pumpable or unpumpable in the sense that it is liquid or not liquid. From the point of view of cargo claims however, it must also be considered whether, even if the cargo was liquid, it could be pumped by the vessel's equipment. It is possible that small quantities of oil, particularly where high gas cargoes are concerned, cannot be picked up by the pumps without the pumps gassing up. It could be that due to sediments from the cargo or shore restrictions on trim, the oil is liquid but cannot run to the suction. The master should call in a local UK Club surveyor if he experiences difficulty in obtaining a suitable dry tank certificate. If pressure is applied to the ship to sail before the surveyor can attend, the master should protest to the receivers and to the receivers' surveyor. If the surveyors are not prepared to certify cargo remaining onboard as unpumpable, they should

be invited to inspect the ship's pumps. The receivers should be informed that if they consider the cargo to be pumpable, the ship is prepared to continue to attempt to pump it until the UK Club surveyor arrives. Owners should ensure that the maintenance records for the cargo pumps are carefully preserved and that they are available when such disputes arise. Surveyors who certify cargo as pumpable should be required to prove that they have tested the nature of the cargo and have ascertained that it can and does reach the suction in the cargo tank.

ROB claims may therefore arise in three different ways:

- By loss of heating or inadequate heating onboard ships, sometimes coupled with low ambient temperatures at the time of discharge.
- The physical properties of the oil and the ability of the pumps to pump it. The possibility of pumps gassing up and loss of suction must be taken into consideration.
- Cargo sediments or trim restrictions which prevent the free flow of oil to the tank suction.

In the case of crude which does not require heating or which has a high vapour pressure, good crude oil washing and a good stern trim will overcome most problems.

Frequently the charterparty will call for COW 'in accordance with Marpol' and will allow additional time for discharge when COW is performed. Naturally, if the receiving installation will not allow satisfactory stern trim or if they refuse COW either in whole or in part then the master should protest to the terminal and to the charterers, stating that the vessel cannot be held responsible for any resulting cargo losses.

On completion of discharge

When the cargo has been completely discharged with all tanks and pipelines well drained, the cargo system should be shut down and all tank valves closed. A final tank inspection is then carried out and inevitably particular attention will be paid by the shore representatives to any cargo remaining onboard. All void spaces, including ballast tanks and cofferdams should be checked to ensure that no leakage of cargo has occurred. This is particularly relevant on OBO vessels.

Dry tank certificate

After discharge, a dry tank certificate will ideally be issued, signed by an appropriate shore representative describing any remaining cargo as 'unpumpable' and

carrying an endorsement that the ship's equipment was in good working condition. In many places, shore cargo inspectors are reluctant to describe oil as 'unpumpable' and may prefer to use the terms 'liquid/non-liquid'. This is not satisfactory and should be avoided if at all possible because it leaves cargo owners in a position to claim pumpability and to attempt to activate a charterparty retention clause, albeit unlawfully, if the clause requires the cargo to be pumpable.

It is strongly recommended that masters contact their UK Club representative and the ship's operators for advice if a dry tank certificate showing oil remaining onboard as being unpumpable cannot be obtained.

Ballasting

Where permanent ballast tanks are fitted, it is normal practice for these to be filled during the discharge in order to expedite the ship's departure. It is, however, recommended that other ballast tanks not be worked simultaneously with cargo operations as this will certainly entail the risk of contaminating the cargo. Should ballast, in addition to the permanent arrangements, be required then such ballasting is best completed after the discharge and after the inspection of the cargo tanks.

In-transit losses and their potential causes

In the past the standard defence put forward by a shipowner to a cargo shortage claim was that the loss was below or equal to 0.5% of the total cargo. This figure, which originally stemmed from the cargo insurance deductible, has been used by shipowners and cargo insurers as a yardstick for transit losses for many years. However, a number of courts, particularly in the United States, have rejected the concept of an automatic 'loss allowance'.

Nonetheless, there is every indication that the same Courts would allow a $\pm 0.5\%$ 'measurement tolerance'. In transit losses and their causes can be considered under four headings:

- The true in-transit losses during the voyage where the ship's gross volume at standard temperature on loading is compared with the vessel's gross volume at standard temperature prior to discharge
- Theoretical in-transit losses when the comparison of net volume onboard at standard temperature on completion of loading is compared with the net volume onboard prior to the commencement of discharge
- Emptying and filling losses. This is particularly pertinent where a part discharge may take place into a lightering vessel or barge
- Additional losses which may occur as a result of crude oil washing.

The third and the fourth items become apparent when accounting for volumetric losses on outturn.

Various factors including permutations of tanker design, cargo density, Reid vapour pressure, cargo temperature, ambient temperature and general weather conditions, may combine to cause a release of gasses and an increase in pressure within the cargo tanks which, combined with the inert gas pressure, may cause venting through the pressure vent valves and consequent loss of product.

Losses during discharge

The largest volumetric losses are likely to occur when there is transfer from one container to another. This means that quite large losses can occur when pumping the cargo from the ship to the shore. Where lightering is



involved there will, inevitably, be a greater risk of volumetric losses between the ocean carrying ship and the shore tanks. Where COW is performed, the potential for volumetric losses is greater since the cargo is being formed into a high pressure spray and partially atomised.

The shore installation

When assessing a claim for short delivery of an oil cargo, the ship's calculation and figures are scrutinised. It is equally important to examine the shore calculations at both the loading and discharge ports. As mentioned earlier, the carriers liability does not extend beyond the ship's manifold, and claims for apparent oil losses can sometimes be resolved by recalculation of the shore figures. The cargo interests should be asked to provide full details of the shore installation including a plan showing all the storage tanks and the inter connecting pipelines as well as the position of isolating valves. They should be able to verify the maintenance of all their equipment and demonstrate that, for instance, all the isolating valves were tight and properly operating at the time of discharge. They should also be asked to demonstrate that the storage tanks were properly calibrated and show that the calibration was accurate. In some oil installations the accuracy of the tank calibrations may be doubtful particularly if they are of older construction or built on unstable sites. A small measurement inaccuracy may correspond to a substantial change in volume. Temperature measurements should also be closely considered: temperature gradients may exist when oil is stored in a large tank and in certain climatic conditions there may be significant variations in the temperature within the tank. In a cold wind, there may be a horizontal temperature gradient as well as a vertical gradient. In many countries the measurements taken at the time of custody transfer are witnessed by customs officials and if appropriate, the official customs documents should be produced.

Oil contamination claims

Many oil shortage claims arise from the presence of excessive quantities of water found in crude oil cargoes at the discharge port after settling out during the voyage. Oil contamination may occur in petroleum products but a cross contamination between two grades of crude oil would, in most cases, not lead to a cargo claim. Crude oil cargoes are regularly blended before refining and generally for a cargo contamination to arise, a large cross contamination would need to take place. This is not true of all grades of crude as there are a few which have particular properties and which must not be contaminated in any way.



Many modern refineries, designed for the reception of cargoes carried by sea have desalination facilities in order to protect the distillation columns and refinery equipment from excessive corrosion. Such facilities, however do not always exist. The presence of water in certain crude oil cargoes may also

cause emulsions to form with the hydrocarbons. This in turn may cause ROB volumes to be excessive and possible sludging of land tanks if efficient water draining is not carried out.

It is quite possible that any alleged contamination could have taken place ashore before loading. A prudent owner is therefore recommended to protect his interest by ensuring that a ship's staff take cargo samples from each tank after loading and at the ships manifold during loading, as a matter of routine, so that hard evidence is at hand to refute claims of this kind. Contamination claims are more likely to occur in the white oil trades where it is common for a number of grades to be carried simultaneously. As many as eight or ten grades are commonly carried simultaneously and on a modern purpose-built product carrier, fitted with deep well pumps and dedicated loading line, it may be possible to carry a different grade in each tank with complete segregation.

Aside from leakage which may occur between cargo pipelines or cargo tanks and which may result in contamination, the most likely cause of a product being off specification is failure to properly prepare the tank or associated pipelines after a previous incompatible grade.

Precautions before loading

Every care should be exercised to ensure that proper tank cleaning procedures are rigorously carried out and that tank coatings are in a suitable condition for the intended cargo. Particular care should be taken to ensure that all traces of the previous cargo are removed in the cleaning process.

When carrying multigrade cargoes, effective segregation is a prime importance. When preparing the loading plan, allowances must also be made for trim and draft restrictions, it is not uncommon for multigrade

cargoes to be loaded in more than one port and for several discharge ports to be involved. In some cases, additional cargo may be loaded during the voyage after the discharge of other products. Careful planning is advisable taking into consideration the quantity of cargo to be loaded and discharged, draft, trim and stress considerations as well as the consumption of water and fuel.

Before loading, all those concerned should have a clear knowledge of the intended loading plan and the pipelines and valves must all be carefully set and double-checked. Because product cargoes generally have a low specific gravity, it is likely that the ship may not be loaded down to her marks even with all cargo tanks filled to the maximum permissible. When loading for a voyage which entails passing through areas where higher sea temperatures are expected to be encountered, it is advisable to take into account the expansion of the cargo which will occur as a result of those higher temperatures.

During the loading of sensitive products it is common for 'foot samples' to be loaded and for samples to be taken and analysed before the rest of the product is taken onboard. When carrying multigrades it is an excellent practice to have as many samples of the cargo as possible taken at various stages of the loading and discharge, including samples taken from the shorelines. If claims for contamination arise, the analysis of such samples will often identify the source of the problem and may assist the shipowner in rejecting liability.

A more detailed article on the sampling of liquid cargoes is included later in this section, and a careful study of that article is recommended.

Conclusion

If the following points are borne in mind by owners and masters there will be a much greater chance of success when defending oil cargo claims.

- Careful attention should be paid to all onboard surveys when loading and discharging with a view to avoiding 'paper losses'
- After discharge try to ensure that a dry tank certificate is issued showing all cargo remaining onboard to be unpumpable and endorsed to confirm that the ships equipment was working correctly
- Employ properly qualified surveyors and protest if it can be demonstrated that a surveyor employed by cargo interest is not qualified or lacks experience.

Appendix: definitions of terms used

API = API GRAVITY

Petroleum industry expression for density of petroleum liquid expressed in API units. API gravity is obtained by means of simultaneous hydrometer/temperature readings, equated to, and generally expressed at 60°F. The relative density to API gravity relation is:

$$\frac{141.5}{\text{Relative density } 60^{\circ}\text{F}} - 131.5$$

AUTOMATIC SAMPLER

A device installed for indicating the level of product from a location remote to the manual gauge site.

BARREL

Petroleum industry measurement unit equal to 42 US gallons.

CLINGAGE

That oil remaining adhered to the inner surface and structure of a tank after having been emptied.

CRUDE OIL WASHING (COW)

The technique of washing cargo tanks of oil tankers during the discharge of crude oil cargoes.

DENSITY

The density is the mass per unit volume at a specified temperature used to determine weight for a volume at a standard temperature.

DIP

Is depth of liquid = to American expression: gauge.

FREE WATER

The quantity of water resulting from measurements with paste or interface detector, i.e. not entrained water present in oil.

GAUGE REFERENCE HEIGHT

The distance from the tank's strike point to the bench mark or reference point.

GROSS OBSERVED VOLUME (GOV)

The total volume of all petroleum liquids, excluding S&W, excluding free water, at observed temperature and pressure.

GROSS STANDARD VOLUME (GSV)

The total volume of all petroleum liquids and S&W, corrected by the appropriate temperature correction factor (Ct1) for the observed temperature and API gravity, relative density, or density to a standard temperature such as 60°F or 15°C also corrected by the applicable pressure correction factor.

LOAD ON TOP (LOT)

The concept of allowing hydrocarbon material recovered during tank washing to be commingled with the next cargo.

NET OBQ

OBQ less free water in cargo, slop tanks and lines, and water in suspension in slop tanks.

NET OBSERVED VOLUME (NOV)

The total volume of all petroleum liquids, excluding S&W, and free water at observed temperature and pressure.

ONBOARD QUANTITY (OBQ)

Cargo tank quantities of any material onboard a ship after de-ballasting immediately prior to loading. Can include oil, oil/water emulsions, water, non-liquid hydrocarbons and slops.

REMAINING ONBOARD (ROB)

Cargo or residues remaining onboard ship after discharge.

SEDIMENT AND WATER (S&W)

Non-hydrocarbon materials which are entrained in oil. Material may include sand, clay, rust, unidentified particulates and immiscible water.

SHIP'S COMPOSITE SAMPLE

A sample comprised of proportional portions from running samples drawn from each tank on the ship.

SHIP FIGURES

Stated volume extracted from ship's calibration tables based on measurements taken from cargo tanks.

SLOP TANK

A tank into which the tank washings (slops) are collected for the separation of the hydrocarbon material and water; the recovery most often becoming LOT (load on top).

TOTAL CALCULATED VOLUME (TCV)

The total volume of the petroleum liquids and

S&W, corrected by the appropriate temperature correction factor (Ct1) for the observed temperature and API gravity, relative density, or density to a standard temperature such as 60°F or 15°C and also corrected by the applicable pressure factor and all free water measured at observed temperature and pressure. (Gross Standard Volume plus free water).

TOTAL DELIVERED VOLUME (SHIP)

It is defined as the Total Calculated Volume less ROB.

TOTAL OBSERVED VOLUME (TOV)

The total measured volume of all petroleum liquids, S&W, and free water at observed temperature and pressure.

TOTAL RECEIVED VOLUME (SHIP)

It is defined as the Total Calculated Volume less OBQ.

ULLAGE (OUTAGE GAUGE)

A measurement taken from the gauge reference point to the liquid level.

VOLUME CORRECTION FACTOR (VCF)

The coefficient of expansion for petroleum liquids at a given temperature and density. The product of the petroleum liquid volume and the volume correction factor, equals the liquid volume at a standard temperature of either 60°F or 15°C.

WATER (DIP) GAUGE

- a) The depth of water found above the strike point, or
- b) To gauge for water.

WATER FINDING PASTE

A paste, which when applied to a bob or rule, is capable of indicating the water product interface by a change in colour at the cut.

WEDGE CORRECTION

An adjustment made to the measurement of a wedged shaped volume of oil, so as to allow for the vessel's trim.

WEIGHT CONVERSION FACTOR (WCF)

A variable factor related to density for use to convert volume at standard temperature to weight.

Samples and sampling in the carriage of liquid bulk cargoes

The period of the carriers' responsibility for liquid bulk cargoes is essentially the same as that for bulk or general cargo. Under the Hague and Hague Visby Rules, the period extends from the time when the goods are loaded until the time they are discharged and includes the loading and discharging operations. Under the Hamburg Rules, which came into effect 1992, the carrier, his servants and agents will be responsible from the time the goods are received by them at the port of loading until the time the goods have been delivered at the port of discharge.

Having received the goods, the carrier, the master or agent is required to issue to the shipper a bill of lading showing, among other things, the apparent order and condition of the goods as received onboard. With the exception of cargoes carried in the deep tanks of liner vessels, which may be loaded by the shipper and discharged by the consignee, most loading and discharging operations with bulk liquid cargoes are performed by the actual carrier. There may be different practices in the loading and discharging ports and these together with the nature of the cargo are important factors. Most bills of lading include the words "shipped in apparent good order and condition". Can order and condition be ascertained by ship's officers when loading takes place via a closed pipeline system?

The answer lies in an effective sampling system!

By reason of the wide variety of liquid cargoes that are carried and the vastly different types of ships involved, it will be appreciated that the subject of sampling is a very wide one. This article is confined to the general principles of how to ascertain the apparent order and condition of goods when they are shipped and, just as importantly, how to preserve the evidence.

Many parcel-tanker owners have issued instructions to their masters to sample each type of cargo at the ship's manifold on commencement of loading, after the first test-load (so called 'first run' sample) and from the ship's tank after completion of loading. Such samples are numbered and entered in a special sample log book. An additional advantage of this procedure is that the ship's officers who attended the sampling, or who actually drew the samples, are available for questioning at the port of discharge. It is so often the case that unilateral sampling by shippers at the loading port is not

witnessed by ship's officers and samples allegedly drawn from ship's tanks are handed to the ship's staff just prior to departure. These problems confirm absolutely the need for a joint sampling procedure between shippers and carriers and carriers and consignees.

Owners are strongly recommended to instruct their ship's officers that whenever they are in doubt as to the apparent good order and condition of a liquid bulk cargo, they should notify both the shipper and the Club's correspondents so that expert advice may be sought and samples analysed at the loading port. In case of serious doubt as to the condition of the cargo the results of the analyses should be awaited before any bills of lading are signed.

It should be emphasised that as with bulk or general cargo, the description on the bill of lading relates to the external and apparent condition of the goods. Claims on liquid bulk cargoes often involve the question of quality, which is not usually apparent and these claims may be based on a detailed analysis which the carrier has no means of checking. Furthermore, in the majority of instances, the ship's staff cannot question the condition of a product upon loading, except perhaps where the presence of free water, haziness or dull appearance, the presence of a strong foreign odour or an obvious deviation in the colour of the product is readily apparent.

It is therefore important that samples carefully taken at the time of loading and prior to discharge are truly representative of the condition of the cargo and are available in the event that any dispute arises. Where loading port samples have been drawn and retained onboard, any uncertainty about the quality of the cargo at the time of loading can be clarified at relatively low expense.

The shipper however, is in quite a different position because apart from the sampling and analysis which takes place prior to loading he may consider it necessary to take 'first run' samples from the ship's tanks at the commencement of loading operations and suspend loading until analysis is attained. The ship's staff may not be involved or even informed about the results of this analysis. Bona fide shippers will usually provide this information, however, and will require the ship to discharge the 'first run' of cargo if this analysis shows it to be 'off specification'.

When loading operations are resumed it should not be assumed that the 'first run' of cargo will be in good order and condition. This may not necessarily be the case as the shipper may have found the product to be

only slightly off specification and have decided to 'blend' the cargo during subsequent loading operations. Furthermore, water may be introduced into the product via the installation's pipeline system without the ship's staff being aware of it.

The importance of carefully cleaned tanks, compatible tank coatings, well maintained pipe lines, heating coils, valve systems, hoses and pumps cannot be too strongly stressed and some brief comments on the subject of hoses and pumps may be helpful.

When cargo is loaded by shippers and discharged by consignees, it is their responsibility to ensure that the hoses and pumps supplied are suitable for the product concerned. The importance of sampling firstly, after the 'first run' of cargo has been loaded, secondly, after completion of loading and thirdly, prior to discharge, is paramount in order to establish by analysis whether or not any alleged damage or contamination could have been caused as a result of the use of unsuitable equipment supplied by the shipper or consignee, or by defects in the ship's loading system.

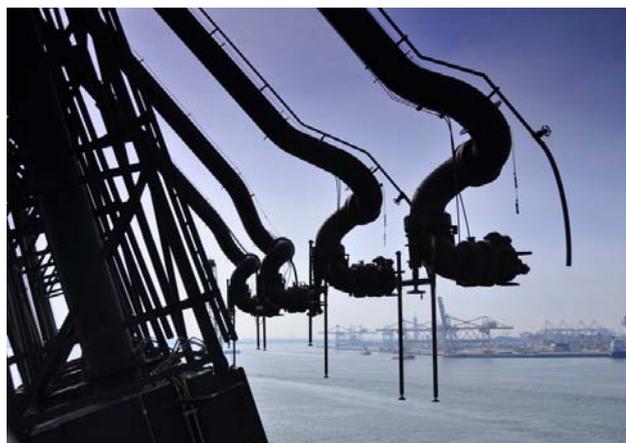
It must also be emphasised that there is duty on the ship's crew to assist shippers and/or consignee with the proper connection of hoses and to ensure that, in the case of loading over the top, hoses are placed in the proper tanks. The crew should also ensure that where the ship's integral piping system is involved, the cargo is directed to the correct tank during loading, and that the lines used during loading and discharging are properly isolated to avoid contamination with other products onboard.

Sale contracts

The condition of liquid bulk cargoes when shipped should be in accordance with either the specification in the contract of sale, or the usual grade specifications used in the trade. The carrier is not a party to the contract of sale and cannot be expected to have knowledge of the specification that in most cases relate only to quality.

Certain limited quality descriptions such as 'clear', 'colourless' etc. may be apparent upon visual inspection of samples and the presence of water can usually be detected by an experienced ship's officer. However, the wide variety of products, frequently referred to only by trade names or codes, makes it difficult, if not impossible, for ship's officers to detect other than the most obvious deviations in the condition of the cargo.

Sale contracts, while regulating the relationship between seller and buyer, also have some bearing on



the carrier's position. They usually require certain sampling procedures to be carried out and the appointment of an independent surveyor to certify the fitness and cleanliness of the ship's tank and pipelines. Many standard vegetable oil contracts require discharging samples to be drawn in the presence of both seller and buyer's representatives and analysed by an independent chemist. Almost all oils and fats are sold subject to such sampling and analysis but the contracts rarely provide for the carrier to be given such samples.

Evidence of the condition of a liquid bulk cargo on loading is therefore of paramount importance. Claims lodged at the port of discharge have frequently been defeated as a result of analysis of loading samples.

Most sale contracts provide for the change of ownership of the cargo to take effect at the time of loading onboard ship and for a bill of lading to be obtained from the carrier. It is therefore important for both seller and carrier to have evidence of the condition of the cargo at that time. The carrier's responsibility may however commence at an earlier time depending on the moment of taking charge of the cargo.

The sampling activities of shipper and buyer often lead ship's officers to believe that nothing is required of them, as the carrier's position has been sufficiently protected. This however is not always the case.

The carrier must take an active part in the sampling procedures especially at the loading port and must see that his interests are properly protected.

Sampling

There are several other important reasons why samples should be taken during loading of bulk liquid cargoes, i.e:

- To enable protest to be made to the shipper if the product loaded is not in apparent good order.

- To enable the loading operation to be followed in all its stages.
- To provide evidence should the ship's tank coatings be found damaged upon discharge.
- To enable the carrier to provide evidence should local authorities lodge pollution claims against the ship.
- To enable the specific gravity and temperature of the cargo to be established.
- To investigate subsequent claims against the carrier for admixture or contamination.

Sampling prior to loading

Shippers of liquid bulk cargoes will not in most cases allow the carrier to take samples from shore tanks, road tankers, barges or tank wagons, particularly when the shippers are responsible for the loading of the cargo.

It should also be particularly noted that there are many areas of the world where large consignments of vegetable oils are delivered alongside by a wide variety of road tankers, barges or rail tank wagons. With road tankers and rail tank wagons the product is usually drained into the shore containers before being pumped onboard. Invariably these tankers are used for a variety of commodities including both vegetable and mineral oils and their cleanliness should not always be assumed. Indeed, shippers do not always check the suitability of such wagons until they arrive alongside in loaded condition where they are sampled by the shippers' inspectors. It is also common practice in this trade for shippers to 'borrow' from each other to make up the total quantity loaded into a particular ship, so the cargo may consequently be of variable quality and condition. In the case of loading from tank barges, sampling takes place prior to loading into the ship. Even if the ship's officers are provided with such samples they have no control over how they were drawn and there is no certainty about when or from where they were taken.

Sampling during loading

The first requirement is that on commencement of loading samples are taken from the ships manifold or 'first run', samples from the ship's tanks, even though the loading operation may have to be suspended while this is done. It is essential that shipper's inspectors take part in this sampling procedure and that the samples should be split between the parties. Whenever loading operations are interrupted and hoses, pumps or line system are changed, sampling of the relevant ship's tanks before and after the changeover will be

necessary, unless it is certain that hoses, lines and pumps have been previously used for the same product.

On completion of loading, a representative sample from each tank should be taken. In the case of a parcel tanker, each consignment should be similarly treated. Shipper's inspectors frequently take 'first run' samples on their own initiative and will usually make up composite samples of all tanks after completion of loading.

Loading port samples other than those taken by the carrier

Samples are sometimes handed to the ship's staff to be delivered to the consignees in accordance with the sellers contractual obligations. In such cases ship's staff are unaware how or where such samples were obtained and it is rare for the ship to be provided with a duplicate set for its own use. The origin of such samples is uncertain and their labels often bear vague descriptions such as 'average shore tanks' 'average tank trucks' 'average head line' etc. These samples whether relating to vegetable oils, mineral oils, or petrochemicals, may be samples drawn before and/or during and/or after loading, single or duplicate, sealed or unsealed and either against a receipt or not. The carrier has no control over the drawing of such samples and in many cases analyses of them are in conformity with the required specification whereas the cargo on arrival is not. At the port of discharge such shipper's loading samples are collected by inspectors appointed by the shipper or consignees who may also measure and sample the ships tanks. Samples drawn at the loading port jointly by ship's staff and shippers representatives may then serve to prove that the samples handed to the ship's staff for delivery to consignees may not represent the true condition or quality of the cargo.

Sampling before discharge

On arrival at the discharge port and immediately tank ullages and temperatures have been carefully checked, samples should be taken of all cargo onboard. This sampling is usually carried out by the consignee's surveyor and the procedure should be attended by ship's officers. It is usual to take top, middle, lower, and bottom samples, depending upon the product. In the case of cargo that remains homogeneous during the voyage, such samples may be mixed into a composite sample with the largest proportion coming from the middle depth of the tank. It is also desirable to use a water finding instrument to establish if water is present.

In the case of edible oils and animal oils/fats, bottom samples should always be drawn to check for sediment. These bottom samples must be kept in separate jars, sealed and properly labelled for identification. It must be



emphasised that sediments, if any, should always be regarded as belonging to the particular consignment involved.

With many products it is the practice to defer commencement of discharge until analysis of the samples has been completed. If the receivers indicate that the cargo does not conform to the required specification, the master should immediately request the local UK Club correspondent to arrange for the attendance of an independent surveyor and for the analysis of loading samples.

Sampling procedures

Because of the wide variety of liquid cargoes carried and the different methods of loading only general advice on sampling can be given.

Cargo sampling is a difficult process and one that requires most careful attention. It should be emphasised that each sample must be representative of the product concerned. Continuous sampling at the ship's manifold in order to obtain a so-called 'ship's rail composite' sample, though a time consuming procedure, may be of value in the case of homogeneous cargoes where tank samples taken prior to commencement of discharge have shown the product to be satisfactory at the time the ship arrived. A sample of the first cargo arriving at the ship's manifold, a 'first run' sample from the ship's tank and a sample or set of samples drawn from the tank on completion of loading are the most important. In the chemical (parcel) trade, running samples during the first

five minutes of loading are sometimes also drawn. The object of all these sampling operations is to obtain a manageable quantity of cargo, the condition and properties of which correspond as closely as possible to the average condition and properties of the parcel being sampled.

Most liquid samples can be stored in glass jars with screw type caps or cork plugs. In most cases samples do not each have to be larger than half a litre (500cc).

The importance of cleanliness cannot be too strongly stressed. All sampling work should be done with clean hands and where protective clothing is necessary, as in the case of toxic products, clean gloves of a suitable material should be used. The apparatus used should be of a suitable material, e.g. stainless steel, which does not react chemically with the cargo being sampled. Various types of sampling bottle can be used, particularly in large tanks but should glass bottles be employed, great care should be taken to avoid breakage.

With edible oils, where smell and flavour is important in quality assessment, scrupulous cleanliness is essential and the sampling devices should be thoroughly washed with hot water and soap and rinsed with hot water before use. All sampling equipment should be protected from the weather, rain, dust, rust, grease, etc., and before the sample is divided into suitable glass jars, the outside of the sampling apparatus should be wiped clean.

When sampling from the manifold or pipeline, great care should be taken to ensure that the sampling cock through which the product is drawn is absolutely clean. This method of sampling is most difficult and must be carefully supervised to ensure that both shipper and carrier obtain a part of the same representative sample. It is important that when samples are being taken by this method, a constant rate of flow of the product is involved. If there is a variation in the flow rate, the sampling cock must be carefully regulated to ensure that the full sample is taken at a constant rate.

Certain products, such as those reacting dangerously with water and/or air and corrosive liquids or liquefied gases, cannot be sampled by normal means. It may also be dangerous to keep samples of some products for too long as they become unstable.

Labelling of samples

All samples jointly taken should be properly labelled and sealed and identical sets should be kept by all parties. Should shippers refuse to seal the samples jointly, then an appropriate entry should be made in the log book. They should be unilaterally labelled and sealed by the ship's staff and/or the independent surveyor representing the carrier. The samples themselves must, of course, be identical to those taken together with the shippers and the latter must be notified in writing immediately, to confirm the joint sampling and record their refusal to seal these identical samples jointly with the carrier.

The attention of owners is also drawn to the undesirable practice in many ports of the chief officer being asked to sign paper labels which bear the names of the ship, the shippers, the product, the ship's tank, the date and place of sampling, a seal number (such as the one to appear later on the wax seal) and the signature of shippers' inspectors before the loading operations have been completed or sometimes even before they have started. These labels are later attached to the sample containers after they have been filled and closed.

It cannot be too strongly emphasised that the only way to be certain that the proper label is put on the proper sample container is for the ship's staff to participate in the whole procedure of sampling and sealing and to insist that the sealing and the labelling should take place onboard the ship. All labels should be properly dated and should indicate the local time when they were drawn, name of the product and its destination, the name of the shippers and whether the sample was drawn conjointly with them. The label should also record the quantity, tank number, the tank ullage and

temperature, the bill of lading and voyage number and whether it is a manifold, pipe line, 'first run' or 'average' ship's tank sample after completion of loading. Care must be taken that all these necessary details will remain legible by the use of permanent washable ink. Having signed the labels, the ship is entitled to retain a set of the samples.

Storage of samples

Samples should be stored in a dark, well-ventilated place where daylight cannot enter and away from sources of heat, from living quarters and foodstuff storerooms. Edible oils and chemicals should be stored separately. Samples should be contained in clean, dry and airtight containers, preferably of glass, tinned steel or a plastic material which will not become affected by the contents. They should be closed with corks or suitable plastic stoppers.

A sample log book should be maintained recording the sample number, the sampling date, place, ship's tank, quantity and kind of product, name of shipper and place of shipment, name of consignee and place of discharge, where stored onboard, and notes on disposal. It is suggested that samples be retained for a period of three months after the ship has discharged.

The carriage of liquid bulk cargoes requires careful sampling as an essential part of the operation. If this is performed in accordance with the procedures set out in this article it will be of considerable assistance in repudiating unjustified claims brought against the ship.

Sampling instruments

Various types of instruments designed to facilitate sampling are obtainable in most major ports. They may be made of glass, stainless steel, aluminium, etc., so that a choice of material is available to ensure that the instrument is compatible with the cargo carried. It is generally advisable to avoid instruments made of copper or copper based alloys.

Sampling instruments should be simple, robust and easy to clean. On the following pages a number of instruments are shown in diagram form together with their descriptions. The Association is grateful to the British Standards Institution for allowing material from B.S.627 to be reproduced.

Sampling instruments for bulk oil shipments and some other liquid bulk cargoes

Fig1. Sampling bottle or can

The sampling bottle is suitable for sampling large ships and tanks of liquid oil. It consists of a bottle or metal container, which may be weighted, attached to a handle long enough to reach the lowest part to be sampled. It has a removable stopper or top to which is attached a suitable chain, pole or cord. This device is lowered to the various desired depths, where the stopper or top is removed and the container allowed to fill

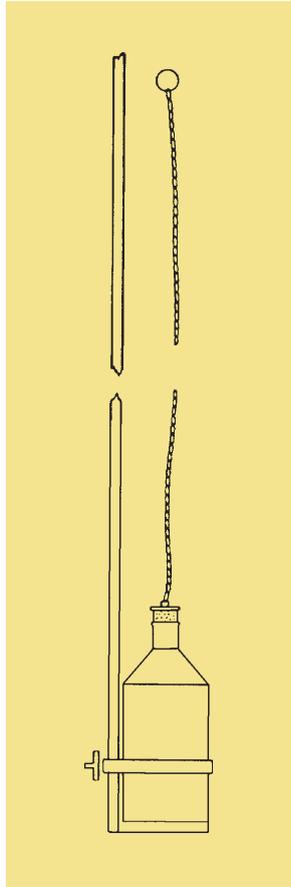


Fig 3. Go devil' sampling bottle

The 'Go devil' sampling bottle consists of a bottle, heavily weighted at the bottom, approximately 12" (300 mm) long, 3" (75 mm) body diameter and approximately 1" (25 mm) body diameter and approximately 1" (25 mm) neck diameter, with a chain attached. On being placed in oil in a tank it drops so quickly that it does not begin to fill with oil until it reaches a fixed position

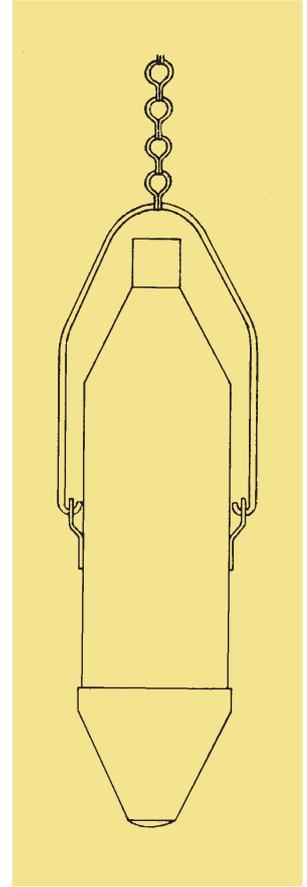


Fig2. Sampling tipping dipper

The tipping dipper consists of a cylinder approx. 6" (150 mm) long and 2" (50 mm) in diameter, carrying an extension with a hole at its closed end and a stout wire handle at the open end; the handle carries a small metal catch and a rope. The cylinder is inverted in the position shown on the left, and maintained in that position by the insertion of the catch into the hole, and then sunk into the oil in the tank; at the required depth the rope is twitched to release the catch, where upon the cylinder rights itself and becomes full of oil

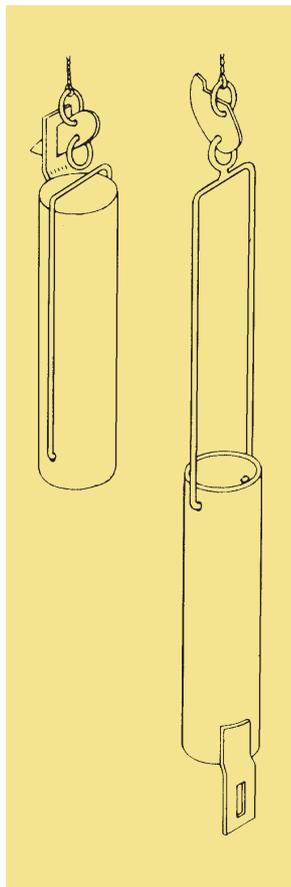
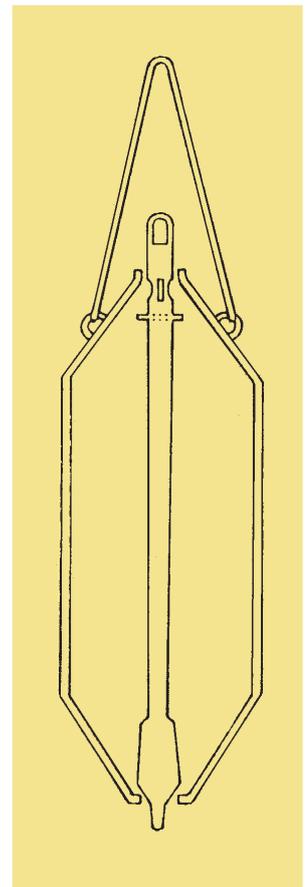


Fig 4. Bottom sampler or zone sampler

The bottom sampler or zone sampler is suitable for withdrawing bottom samples or zone samples at any level from tanks of liquid oil. To withdraw a bottom sample the apparatus is attached to a cord or chain and lowered empty to the bottom of the tank, when the central spindle valve automatically opens and the container fills from the bottom. On withdrawal of the sampler the valve automatically closes again. To withdraw samples at any level the apparatus is lowered empty to the required level and then, by means of an additional cord attached to the top of the central valve spindle, the valve may be opened and the container filled. When the sampler has filled, the valve is allowed to close and the container is withdrawn



Biofuels: Marine transport, handling and storage issues



The production and use of biofuels as transport fuels has increased dramatically in recent years. A number of legislative reforms are mandating the integration of fuels derived from renewable sources into the current fuel infrastructure. However, the introduction of biofuels has not been without problems and indeed there is a large amount of research still ongoing into the properties of biofuels and how they behave when blended with conventional fossil fuels. This article will discuss some of the issues surrounding the introduction of biofuels into the present fuel system with particular focus upon the potential implications for those involved in the transportation and storage of these products.

Legislative targets

Biofuels were originally seen by many as an answer to the problems of increasing greenhouse gas emissions and global warming. Unlike transport fuels derived from crude oil, such as diesel and gasoline, biofuels are produced from renewable sources; that is, sources that can be replenished at a rate comparable to or faster than the rate at which they are consumed by humans. Fuels produced from agricultural crops such as corn, wheat, rapeseed and soybean, which could be quickly and easily replenished and, in theory, should have a negative overall impact in terms of carbon dioxide emissions, seemed an ideal solution for governments facing increasingly difficult decisions with regard to the links between pollution and climate change, and legislative targets were quickly put in place mandating the integration of biofuels into the current transport fuel infrastructure.

However, it was not long before serious questions were raised with regard to the environmental credentials and

overall sustainability of the commercially available biofuels. Issues included the use of crops which would normally be used for food being put into biofuel production, the questionable carbon dioxide emissions savings when considering the overall production process ('wells to wheels'), deforestation to make way for biofuel crop plantations and the use of environmentally harmful fertilisers and pesticides employed in growing the crop feedstock. Indeed it was suggested by some parties that biofuels could in reality be causing more harm than good to the environment.

Amid these growing concerns, the UK Government has recently decided to amend the targets set out in the Renewable Transport Fuel Obligation (RTFO), a directive aimed at reducing greenhouse gas emissions from road transport. The RTFO requires that by 2013/14, 5% by volume of all fuel sold in UK forecourts is to come from renewable sources, with intermediate targets of approximately 3.5%, 4% and 4.5% for the periods 2010/11, 2011/12 and 2012/13 respectively.

These targets represent a slowdown in the required biofuels targets, but they are likely to be reviewed in



2013/14 in order to assess the progress of the UK RTFO in complying with the wider EU initiative to reduce carbon emissions, the Renewable Energy Directive. This directive was recently reviewed and agreed in December 2008, and mandates that by 2020, 10 per cent of all automotive fuel consumption by energy content should be sourced from renewable energy sources.

Amid all the uncertainty, it appears likely that the worldwide push for increasing biofuel use as a means of reducing overall carbon dioxide emissions will continue, and one can reasonably expect the biofuels market to continue to grow. Much of the biofuel is shipped internationally by sea. For example, first half figures for the 2008/2009 period indicate that 670 million litres of biofuels were supplied to the UK transport market. Only 8% of the biofuel supplied was produced from within the UK, such that 92% (approximately 616 million litres) of biofuel was imported. A recent report by Pike Research estimated that the global biodiesel and ethanol markets are likely to reach US\$ 247 billion in sales by 2020, up from US\$ 76 billion in sales predicted for 2010.

In order to meet the necessary targets, the quantity of biofuels shipped both into the UK and worldwide is likely to increase, and it is therefore important for those involved in the carriage of biofuels to understand the issues that need to be considered if these products are to be carried safely, without risking damage to either the ship or the cargo.

Current biofuels

There are presently two main classes of biofuels in widespread use; biodiesel (or more correctly, FAME) and bioethanol. The two are very different in their properties and therefore have different issues to consider if they are to be safely shipped, handled, stored and used. Each will be considered in turn.

FAME/Biodiesel

Biodiesel is a fuel derived from vegetable oils or animal fats, although the term 'biodiesel' is too vague a description and we therefore use the more correct terminology, Fatty Acid Methyl Esters (FAME), when discussing these fuels. FAME is the product of reacting a vegetable oil or animal fat with an alcohol (methanol, a petrochemical which is generally derived from natural gas or coal) in a process known as transesterification. When compared to conventional diesel derived from crude oil, vegetable oils and animal fats generally have higher viscosities (which means they are more difficult to pump and store without heating) and are more



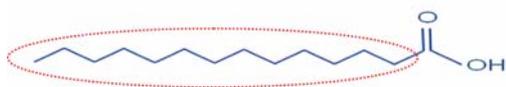
unstable (which means they are more likely to degrade during storage, handling and end-use). The transesterification process brings the properties of the raw materials closer to those of a conventional diesel, making the product more suitable for use as a road transport fuel. However, whilst the FAME produced can be used neat as a fuel, it is more commonly blended with conventional petroleum diesel for use in diesel engines.

The ASTM has described a system of nomenclature for naming FAME/diesel blends (see ASTM D6751). Pure FAME is denoted B100, standing for 100% 'biodiesel'. Other common blends include B5 (5% 'biodiesel' and 95% conventional diesel), B7 (the EN590 European diesel standard allows up to 7% by volume FAME in diesel) and B20 (20% 'biodiesel' and 80% conventional diesel). In the UK, a major supermarket chain has introduced B30 (30% 'biodiesel' and 70% conventional diesel) pumps onto a number of their forecourts (*Motor Consult Update* November 2008). However, this fuel is not currently governed by any standards and is not approved for use by many of the major automobile manufacturers.

Raw materials for FAME production

A wide number of raw materials can be used for the production of FAME, including palm oil, coconut oil, rapeseed oil, soybean oil, tallow and used cooking oils. A general FAME cargo might be the product of processing any one of these raw materials, or may indeed be a mixture of FAMEs produced from different raw materials. Each raw material would give FAME of a different chemical composition, with correspondingly different characteristics. For example, if we compare a FAME derived from palm oil (PME) with a FAME derived from rapeseed oil (RME), it is possible to notice an immediate visible difference between the two – namely that at normal UK winter temperatures the PME is likely to be solidified whereas the RME will be a liquid. It is the chemical composition of the raw materials and the FAMEs produced from them that explains many of the different characteristics displayed.

One of the most important chemical characteristics of FAME is the structure and composition of the fatty acid methyl ester groups, which will be determined by the fatty acid components of the raw material used in the production process. Pictorially, we can see a difference if we look at the structures of two different fatty acids below – one a *saturated* fatty acid and one an *unsaturated* fatty acid – the saturated fatty acid has a 'straight chain' of carbon atoms (circled in red) whereas the unsaturated fatty acid has, in this case, two 'double bonds' present in the hydrocarbon chain. These are circled in green and result in 'kinks' in the hydrocarbon chain:



Myristic Acid – A saturated fatty acid



Linoleic Acid – An unsaturated fatty acid

FAME species which are composed of a relatively high proportion of saturated fatty acid methyl esters, for example, palm oil derived FAME (denoted PME) will in general be relatively stable to unwanted degradation reactions, but will have poorer cold temperature performance. FAME species which are composed of a relatively high proportion of unsaturated fatty acid methyl esters, for example, soybean oil derived FAME (denoted SME), will display markedly different behaviour, typically having improved cold temperature properties in comparison to PME, but being less stable to degradation reactions. The reason for the improved cold-temperature behaviour displayed by the FAME species high in unsaturated fatty acid methyl esters is that for every double bond in the hydrocarbon chain and associated kink in the molecule, the individual molecules cannot pack as closely together thereby reducing intermolecular forces and correspondingly decreasing the melting point. However, it is the presence of the double bonds in the unsaturated FAME species that infers the greater degree of instability upon the molecules – the double bond sites render the molecule prone to oxidative degradation.

The presence and composition of other chemical constituents are also important. For example, FAMES with high levels of vitamin E are thought to be more stable to unwanted oxidative degradation reactions. Recent research reported in *Biodiesel* magazine has identified the formation of sediments in stored B5 and B20 blends. Analysis of the sediment components suggests that they originate from the oxidation of

unsaturated fatty acid methyl ester components of FAME. However, the addition of antioxidants to the neat FAME prior to blending was found to prevent sediment formation. Vitamin E is a natural antioxidant which would appear to prevent the occurrence of such unwanted oxidation reactions.



FAME problems

Water contamination: A major problem with regard to the carriage of FAME by sea is the issue of water contamination. FAME is a hygroscopic material, which means that it will absorb water from its surrounding environment, including the atmosphere. This renders FAME very sensitive to water contamination. The current maximum allowable water content in the European EN 14214 and American ASTM D6751 FAME standards is 500 mg/kg, although often selling specifications are lower (300 mg/kg being a typical maximum water content on a sales specification), reflecting the high potential for water pick-up in this material.

Unlike most conventional diesels, in which any undissolved water present will generally settle out over a period of time, FAME can hold water in suspension up to relatively high levels (above 1000 mg/kg). Apart from the fact this will render the cargo off-specification for water content, the presence of water can promote unwanted hydrolytic reactions, breaking down the FAME to form free fatty acids, which can again affect certain specification parameters for the material – such species are corrosive and may attack exposed metal surfaces. Additionally, once a certain threshold level of water content is reached, water can separate out from the FAME, forming a separate (and potentially corrosive) free water phase. The possibility of phase separation occurring is greater for blends of FAME and conventional diesel.

The presence of a FAME/water interface provides ideal conditions for the promotion of unwanted microbiological growth, which may in turn lead to filter blocking and corrosion problems. Certain publications have referenced the greater degree of biodegradability of FAME as a positive factor when dealing with environmental spillages. This is indeed correct, but by the same token this factor means that FAME is

considerably more prone to microbiological attack than a conventional fossil fuel, with the associated problems mentioned above. A number of studies have been performed in this area which highlight the need for further detailed analysis and research into the potential for serious microbiological contamination occurring at various stages in the biofuel supply chain.

Possible sources of water contamination aboard a vessel range from the obvious – sea water ingress or residues of tank washing operations – to the less obvious – moisture in an inert gas blanket produced from a faulty flue gas generating system, or atmospheric humidity in tanks’ ullage spaces that are not under a positive pressure of dry inert gas. Despite having relatively high flash points, FAME cargoes are generally carried under a (dry) nitrogen blanket in order to avoid the potential increase in water due to absorption of moisture from tank ullage spaces.

Stability problems: FAMEs are generally more prone to issues with regard to their stability than conventional petroleum diesel. We have mentioned previously that certain FAME/diesel blends can be oxidised to form unwanted degradation products and that the addition of antioxidants may prevent the formation of these sediments. FAME can degrade



under the influence of air, heat, light and water, and degradation may occur during transport, storage or even during end-use. FAME cargoes may display different levels of stability dependent upon their composition and the feedstock(s) used in their production. In general FAME with higher levels of unsaturated fatty acids, such as soybean and sunflower oil derived FAME, will be less stable than those composed of higher levels of saturated fatty acids, for example, palm oil or coconut oil derived FAMEs.

Potential shipping problems include the promotion of degradation reactions by trace metals (copper heating coils or zinc-containing tank coatings have the potential

to cause deterioration in quality) and thermal stability issues if the FAME cargoes are stored next to heated tanks, for example, bunker settling tanks. Issues with the promotion of instability by the presence of trace metals are worse for B100 than for lower biodiesel blends (e.g. B5, B20). Degradation reactions can form insoluble sediments and gums, which may increase the viscosity of the FAME, lead to filter blocking or potentially further decompose to other more corrosive species. The carriage of FAME under dry nitrogen blankets can also help to prevent unwanted degradation reactions caused by the material coming into contact with air.

Low temperature behaviour: The poor low temperature properties of FAME when compared to conventional diesel may give rise to issues where FAME cargoes are shipped through extremes of cold temperature. It is possible for certain FAMEs to form waxy precipitates at low temperatures which will then not re-dissolve when the product is reheated, although this would not appear to be a common problem. However, there is the potential for FAME cargoes shipped from a warm, humid climate to extremely cold conditions, if the correct measures for heating the cargo are not applied, to form unwanted waxy precipitates which may lead to specification failure or pumping problems.

As has been mentioned previously, it is generally recognised that FAMEs produced from vegetable oils with relatively high proportions of unsaturated fatty acids, for example, soybean oil, will have better cold-temperature properties than FAMEs produced from vegetable oils with high proportions of saturated fatty acids, such as palm oil. It is therefore vital that the correct heating instructions are issued and followed – an understanding of the nature of the FAME will impact upon the necessary heating instructions – this should be borne out by the appropriate research into the origin of the FAME and indicated by the results of any pre-shipment testing.

FOSFA International (The Federation of Oils, Seeds and Fats Associations Ltd) has now included FAME products in its published heating recommendations:

Oil Type	Temperature during voyage		Temperature at discharge	
	Min (°C)	Max (°C)	Min (°C)	Max (°C)
FAME from Maize/Rapeseed/Soya/Sunflower	Ambient		Ambient	
FAME from Coconut/Palm/Palm Kernel/Tallow	25	30	30	40

FAME contamination of jet fuel: FAME is a surface active material and can adsorb onto the walls of tanks or pipelines and de-adsorb into subsequently carried products. This can be an issue where multi-product pipelines or storage tanks are utilised, or where ships carry jet fuel cargoes after carrying FAME/diesel blends.

The latest DEFSTAN 91-91 jet fuel specification states that jet fuel containing less than 5 parts per million (ppm) FAME can be considered acceptable for use, that is, can be considered as being free from any FAME. Full inclusion of this specification limit into the DEFSTAN 91-91 standard is pending on the development of a suitable test method to accurately identify FAME in jet fuel at this level. A test program conducted by the Joint Inspection Group (JIG) tested jet fuel dosed with various FAMEs up to 400 ppm and found no significant affect on specification test results, and the inclusion of the 5 ppm maximum limit into the DEFSTAN 91-91 standard has been granted on the basis that the aviation industry is working towards a 100 ppm maximum FAME content (DEFSTAN 91-91 Issue 6).

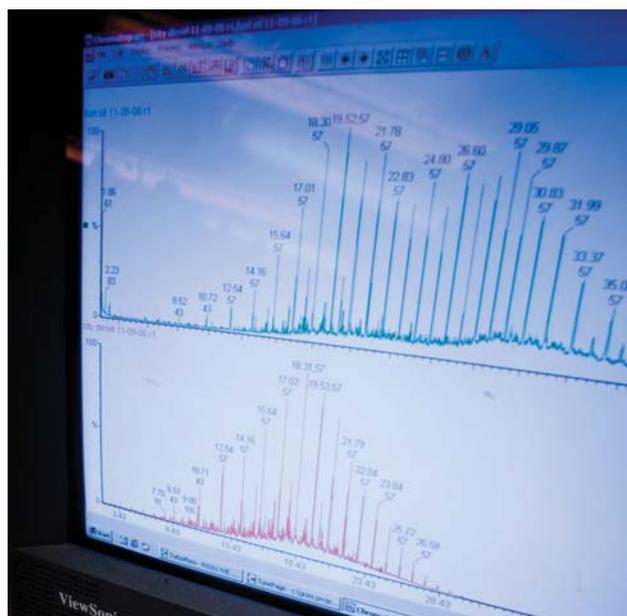
In May 2008 a number of jet fuel storage tanks at Kingsbury supply terminal and Birmingham Airport were quarantined after it was discovered that samples of the jet fuel in question contained up to 20 ppm of FAME. The cause of the contamination is thought to have been as a result of mixing of jet fuel with B5 diesel in the distillate manifold at Kingsbury terminal. As an indication of the very small quantities needed to cause such a contamination, the 5 ppm specification limit would be equivalent to just 1 litre of B5 diesel in 10,000 litres of jet fuel.

When vessels may potentially carry jet fuel cargoes following on from FAME or FAME/diesel blends, the JIG recommends that care must be taken with tank cleaning and flushing and draining common lines including sea or jetty loading lines. From experience, they suggest that switching from a B5 to jet fuel requires at least a hot water tank wash (but preferably also an intermediate FAME-free cargo) to remove FAME residue. Switching from neat FAME to jet fuel requires particular care and some advocate at least three intermediate (FAME free) cargoes plus the hot water wash before loading jet fuel (source: *JIG Bulletin* No. 21).

As 5 ppm is such a low level of contamination, there is the potential for erroneous results to be produced from inaccuracies in the test methods or incorrect sample handling. The DEFSTAN 91-91 standard suggests that the currently specified method of flushing sample

containers three times for jet fuel samples may not be sufficient to remove traces of FAME, which may even be transferred from contaminated gloves. This could potentially lead to false positive detection of FAME in actually on-specification material, resulting in erroneous claims being made. It is therefore recommended that new sample containers and new gloves are used when sampling jet fuel cargoes.

For products tankers carrying multiple products, the danger of inadvertently contaminating a cargo of jet fuel with traces of FAME is a very real risk, even if it does not initially appear that there is any potential for cross contamination to occur. For example, ultra-low sulphur diesel meeting the EN590 specification may appear in the shipping documents as ULSD, which would not immediately indicate that the product contained any FAME. However, the EN590 diesel specification allows up to 7% by volume FAME content. If the ship's tanks and lines are not completely stripped of all the ULSD prior to loading a cargo of jet fuel, the quantity of ULSD containing 7% FAME needed to render the jet fuel cargo off-specification would be very small.



Solvent behaviour: An interesting property of FAME is its ability to act as a solvent, taking up any organic residue, dirt or scale that may have accumulated on surfaces of tanks or pipelines. This can have the effect of cleaning out the dirty storage or pumping systems but contaminating the FAME itself, and may lead to subsequent fouling of filters or pump blockages.

As an indication of its solvent strength, researchers from Iowa State University are investigating how the solvent properties of FAME can benefit military applications, by looking into whether or not certain varieties of waste generated *in-situ* in battlefield

locations will dissolve into biodiesel, and also if stationary engines can be run on the biodiesel containing certain levels of dissolved plastics. FAME is known to attack and quicken the ageing process of certain materials, including elastomers (which may be used as seals, valves, gaskets etc.) – materials should be checked for compatibility with FAME and FAME/ diesel blends by consultation with the equipment manufacturer.

Biodiesel in bunkers: On 15 June 2010 the fourth edition of the marine fuels standard, ISO 8217:2010, was issued. The previous edition of the marine fuels standard, ISO 8217:2005, required under point 5.1 of Section 5 – General Requirements that the fuels to be classified in accordance with the standard should be “*homogeneous blends of hydrocarbons derived from petroleum refining.*” This was interpreted as precluding the fuel from containing any bio-derived components. During the preparation of the fourth edition of the standard, the working group committee responsible for the production of the standard considered the topic of biodiesel and the potential for the material to find its way into the marine fuel supply chain. It concluded that it was almost inevitable that as a result of blending FAME into automotive diesel that some marine distillates and possibly even marine residual fuels may contain a proportion of FAME as a result of cross contamination within the distribution system (Source: *Bunkerworld Forum* 03/09/2009).

As such, the ISO 8217:2010 International Standard now additionally requires under point 5.4 of Section 5 – General Requirements that “*The fuel shall be free from bio-derived materials other than ‘de minimis’ levels of FAME (FAME shall be in accordance with the requirements of EN 14214 or ASTM D6751). In the context of this International Standard, ‘de minimis’ means an amount that does not render the fuel unacceptable for use in marine applications. The blending of FAME shall not be allowed.*”



Annex A of the ISO 8217:2010 International Standard considers the issue of bio-derived products and FAMEs finding their way into marine fuels in more detail. Annex A states that notwithstanding the fact that FAME has “*good ignition, lubricity properties and perceived environmental benefits*”, there are “*potentially specific*

complications with respect to storage and handling in a marine environment”, including:

- A tendency to oxidation and long term storage issues
- Affinity to water and risk of microbial growth
- Degraded low-temperature flow properties
- FAME material deposition on exposed surfaces, including filter elements.

It is recognised that there are a number of different sourced FAME products each with their own particular characteristics which may impact upon storage, handling, treatment, engine operations and emissions. The standard states that in “*...those instances where the use of fuels containing FAME is being contemplated, it should be ensured that the ship’s storage, handling, treatment, service and machinery systems, together with any other machinery components (such as oily-water separator systems) are compatible with such a product.*”

The meaning of a ‘*de minimis*’ level is expanded upon in Annex A of the ISO 8217:2010 international standard. It is noted that determining a ‘*de minimis*’ level is not straightforward for a number of reasons, including the fact that there is no standardised analytical technique for detecting FAME materials in fuel oils and that, in most cases, sufficient data is not yet available with respect to the effects of FAME products on marine fuel systems. For the purposes of the International Standard, for the four grades of distillate fuel (DMX, DMA, DMZ & DMB when clear and bright) it is recommended that ‘*de minimis*’ be taken as “*not exceeding approximately 0.1 volume %*” when determined in accordance with test method EN 14078. For DMB when not clear and bright and for all categories of residual fuels, the standard notes that “*... ‘de minimis’ cannot be expressed in numerical terms since no test method with formal precision statement is currently available. Thus, it should be treated as contamination from the supply chain system.*”

Bioethanol

Bioethanol refers to ethanol produced by the fermentation of renewable sources of sugar or starch crops. Unlike FAME, bioethanol is a single chemical compound, the properties of which are well documented and understood. It is a volatile, colourless liquid which is miscible with water and also hygroscopic. Ethanol is the alcohol found in alcoholic beverages and is also commonly used as a solvent in perfumes, medicines and paints. However, the most



common use for ethanol is as a fuel or fuel-additive. Ethanol for use as a fuel is generally dosed with a 'denaturant' to render it unsuitable for human consumption.

As we have mentioned previously, there has been significant experience worldwide in the use of ethanol as a fuel or fuel-additive. In the USA there has been over ten years successful use of gasoline containing up to 10% ethanol (E10), and in Brazil blends containing up to 85% to 100% ethanol (E85 and E100) are commonly used in flexible-fuel vehicles. The current European gasoline specification, EN228, allows up to 5% ethanol by volume (E5).

Whilst bioethanol can be produced from a number of raw materials, including sugar cane, corn and wheat, the raw materials do not impart the same variation in properties of the end product fuel as is the case with FAME. However, there are still a number of potential hazards for consideration.

Bioethanol problems

Water contamination: Issues with regard to the carriage of bioethanol and bioethanol-gasoline blends include the potential for damaging water contamination. We mentioned previously that ethanol is hygroscopic

and highly soluble in water. Small quantities of water can be dissolved in gasoline/bioethanol blends, but, dependent upon temperature and the gasoline/ bioethanol blend ratio, there is a critical threshold level of water that can be dissolved. Once this threshold level has been exceeded, irreversible phase separation will occur whereby the water causes the ethanol to separate from the gasoline, forming an alcohol rich water/ethanol aqueous phase and an alcohol poor gasoline phase. The alcohol rich aqueous phase will collect at the bottom of the ship's tank or storage tank. This phase is likely to be highly corrosive and will not be able to be used as fuel. In addition, if such phase separation does occur it is possible that the gasoline phase will be classed as Pollution Category Z, which means that it is considered to present a "*minor hazard to either marine resources or human health*" if discharged into the sea from tank cleaning or deballasting operations and therefore "*justifies less stringent restrictions on the quality and quantity of the discharge into the marine environment*". Whilst the regulations do not require ethanol to be carried on a chemical tanker, ethanol is generally shipped on chemical tankers to maintain the integrity of the product.

It should be noted at this juncture that the terms biodiesel and bioethanol do not appear in the IBC Code. As it is a requirement that the proper shipping name be used in the shipping document for describing any product to be carried which appears in the IBC Code, these terms cannot be used to describe the products being carried.

The situation becomes somewhat more confusing when we consider how blends of conventional fossil fuels and biofuels are shipped, and which Annex of MARPOL they fall under. MARPOL Annex I covers the prevention of pollution by oil and MARPOL Annex II covers the control of pollution by noxious liquid substances carried in bulk. Blends of biofuels and



conventional fuels are essentially mixtures of mineral oil based hydrocarbons and noxious liquid substances. At present, the International Maritime Organization (IMO) Bulk Liquids and Gases sub-committee are addressing the issue of how to classify the blends. In the interim, provisional measures are in place which state that blends of conventional fossil fuels and biofuels in which the proportion of biofuel component is less than 15% should be carried under the provisions of MARPOL Annex I. Blends with a proportion of biofuel component greater than 15% would have required the shipper in question to contact an administrator for a decision on how the product should be carried. These measures were to remain in place until July 2009 but have recently been extended until July 2011 and have been developed to take the form of a 3-band system as follows:

Band 1: 85% or more petroleum oil (15% or less FAME) – Product is carried as an Annex I cargo. Oil discharge monitoring equipment (ODME) should be approved/certified for the mixture carried *or* tank residues and all tank washings should be pumped ashore.

Band 2: More than 1% but less than 85% petroleum oil (15% to 99% FAME) – Product carried as an Annex II cargo. Blend is treated as tripartite mixture in line with MEPC.1/Circ.512 *but* ship type cannot be lower specification than any component in the blend;
or
Cargo treated as pollution category X, ship type 2 with worst case minimum carriage requirements assigned (based on analogous products in the IBC Code such as pyrolysis gasoline, butyl benzene or the generic entry for n.o.s. (4) products)

Band 3: 1% or less petroleum oil (Greater than 99% FAME) – Product carried as Annex II cargo and cargo treated as the Annex II product contained in the blend. Issues of concern include the potential effect that FAME and ethanol cargoes might have on ODME equipment – it is understood that further testing is needed to clarify this issue. The varying blend levels also impact upon how the cargo is measured – work is currently being undertaken on samples of FAME from various origins and at different blend levels to establish suitable volume correction factors (VCFs) to be used in cargo measurement.

Future developments

Up to this point, discussion has been limited to FAME and bioethanol, the so called 'first-generation' biofuels. The Renewable Energy Directive was updated in December 2008 to include sustainability criteria for

biofuels, amid worries that the biofuels currently in production were not being produced in a sustainable manner. In order to meet the various legislative targets, not only will the volumes of biofuels used need to increase, but technology will need to be developed and made commercially viable to bring new, sustainable biofuels onto the market. Examples of such biofuels include; biodiesel produced from algal oil, biodiesel produced from the crop jatropha (which does not compete with food crops for land), bio-butanol (which is a slightly longer chain alcohol than ethanol) produced from renewable sources of biomass, and 'renewable diesel', a synthetic diesel which would meet the EN590 diesel standard, produced by the catalytic hydrogenation of vegetable oils.

Conclusions

It is clear that the integration of biofuels and blends of biofuels with conventional fuels into our current fuel infrastructure has raised a number of issues, many of which were unforeseen and have only come to light after the introduction of the fuels. The majority of the problems concern FAME, both as a neat product and as a blend with petroleum diesel. The variety in the feedstock which can be used to produce FAME can impart very different properties on the FAME produced. In Europe there is currently only a single FAME standard, and the particular type of FAME, and therefore the properties the material may be expected to display, may not always be clear from the shipping documents.

The major issues for consideration for those involved in shipping FAME are the high potential for water contamination and associated problems with microbiological spoilage, and, whilst a 5 ppm limit remains in the DEFSTAN 91-91 jet fuel specification, the potential for contamination of jet fuel cargos by traces of FAME. Additionally, the relative instability and sensitivity of the material to low temperatures and trace metals require extra care in terms of how the product is handled. Bioethanol and gasoline blends are also sensitive to water contamination with the potential for irreversible phase separation to occur if the level of water passes a certain threshold level.

Of course, it is possible that as blend levels increase, new and unforeseen problems will arise that will require further research and new approaches to our way of dealing with these materials. It is likely that biofuels will continue to provide a very real challenge to all those involved in their production and distribution over the coming years, and a knowledge of the often quite unique properties that these products display will be very beneficial for those wanting to minimise the risk of facing unwanted claims.

Liquid natural oils, fats and fatty products

The products dealt with below include crude vegetable, animal and marine oils as well as fats. Some of the oils are edible and others are used in the production of soap, paint, lacquer, cosmetics and medicines.

Occasionally, refined vegetable oils are shipped. When these products are transported by sea, a variety of difficulties may be encountered, the cause of which generally fall into two categories.

- Handling (basically temperature control)
- Contamination.

Handling

Claims still frequently arise which involve allegations of unsatisfactory handling by ships. It is sometimes necessary to apply heat to these cargoes, since during a sea passage, the temperatures encountered are likely to be lower than those recommended by the shippers. Many products of this type are adversely affected by heating so that some deterioration is inevitable, with the extent of the damage depending on the nature of the product and length of the voyage. Unsatisfactory temperature control can cause additional deterioration, usually because the carrying temperature has been too high for all, or part of the voyage. It is possible for experts to estimate the level of unavoidable damage and hence the extent of any further damage caused by poor temperature control.

Damage may also result if the carrying temperature is allowed to fall below that recommended by the shippers. The normal procedure for heating this type of product is by heating coils at the tank bottoms and lower sides, with heat being transferred throughout the oil, mainly by convection current. The heat transfer becomes progressively less efficient as viscosity increases. The viscosity of liquid natural fatty products is greatly affected by temperature and a reduction in temperature of only a few degrees can have a serious effect. If the heating process is inadequate to the maintenance of sufficient fluidity within the bulk of cargo, then the liquid in the vicinity of the heating coils can become overheated.

During the discharge of cargo, if the environmental temperatures are very low, further problems may arise as a result of solidification, which most commonly occurs when a tank is almost empty and the liquid level has fallen below the level of the heating coils. Under such circumstances, the final residues may be removed by sweeping or by steam stripping, provided the

receivers are able to accept the fat and water mixture which is produced. Ship's officers responsible for discharging heated products in cold climates should ensure that the maximum pumping rate is maintained and that there are no interruptions during discharge, shore operations permitting.

Contamination

In the past, the most common contaminant, resulting in claims, was water, originating from shore or ship tanks, pumps or lines at the time of loading, or introduced by mistake, or due to leakage. Some products contain a significant quantity of water when shipped, but the presence of excess water in others may accelerate deterioration. Experts can frequently estimate the damage due to contamination with excess water.

More recently, traders and governmental authorities have taken a serious view of the contamination of edible products by traces of chemical substances. Often, but not invariably, these contaminants have come from residues of previous cargoes.

It is normal practice for samples to be drawn by independent surveyors during loading, or immediately after loading, and for at least one set of these samples to be given to the ship. It is important that the ship has a set of loading samples, since most claims are based upon differences in analytical parameters in samples drawn at loading and discharge. If the master is instructed to deliver a set of samples to the receivers on arrival at the discharge port, it is recommended that he requests that the shippers provide a second set of samples for the use of the shipowners. Any such samples handed to the ship should be properly stored during the voyage, preferably in a refrigerated store.

At the time of discharge, samples are always drawn by the receivers or their surveyors. Normal analyses conducted at both load ports and discharge ports are quite straightforward and the typical parameters determined are water, free fatty acid, unsaponifiable matter and odour. If there is evidence or suspicion that on delivery the cargo does not conform to either a specification or to the loading samples, more detailed chemical analysis may be performed. There are now reliable and effective procedures available for determining traces of chemical contaminants. Certain contaminants can be identified and determined at levels as low as 10 parts per billion (ppb).

Contamination at this level will result from admixture of 10 grams of contaminant, with 1000 tonnes of cargo. Most chemical contaminant can be identified and determined at levels of 100 ppb or 100 grams per 1000 tonnes of cargo.

When cargo is loaded or trans-shipped, it is essential to consider the nature of previous cargoes. In some cases, it is virtually impossible during tank cleaning to remove all traces of previous cargo to a level which is not detectable by modern laboratory equipment. For this reason, restrictions are laid down in the contracts of sale, regarding the immediate previous cargo carried in each of the ship's tanks. These restrictions are imposed within the industry by such bodies as FOSFA and NIOP. Their rules should always be consulted. They are constantly under review and may change in the future. Similar restrictions were imposed in the past concerning leaded petroleum or other leaded products. Shippers and charterers should be notified in good time of the nature of the three previous cargoes carried in each individual tank.

It is important that, before loading, every care and attention should be paid to the proper preparation of tanks, pumps and pipelines. It is very important that the tank coating is maintained to a high standard. The coating covering all sections of the tank must be sound. Where any breakdown of the coating takes place, particularly where epoxy and polyurethane coatings are concerned, there is a risk that the remains of previous cargoes may accumulate, creating a potential source of contamination. The breakdown of epoxy coating usually manifests itself in the form of blisters, open or closed, or in areas where the coating is detached, forming pockets which cannot be reached by cleaning water. In these areas, there is also a risk that rust may form, which is again likely to trap cargo residues and lead to contamination. It is not possible to properly clean tanks with damaged coatings. Cases have been recorded where traces of the third previous cargo have been found when samples of damaged coatings were tested.

Another possible source of contamination is the penetration and softening of epoxy and polyurethane coating by a previous cargo. This may find its way later into newly loaded products. Masters should always

consult the 'cargo resistance' list provided by the manufacturers of the tank coating. This will list those cargoes to which the tank coating is resistant. For cargoes not included in the list, or cargoes without resistance indicators, or when deviating from the maximum temperatures indicated on the list, the manufacturers should always be consulted.

Bearing in mind that even the most minute traces of previous cargoes may be discovered, (although this may not always lead to significant damage), it is evident that the washing of cargo tanks must be performed with the utmost care. The precise method of cleaning will depend on the previous cargo carried and the state of cleanliness required for the products to be loaded. The relevant tank cleaning guides should always be consulted. Generally, the most important part of the tank cleaning process is butterworth with hot or cold sea water at sufficient pressure and at the appropriate tank levels. This should be followed by fresh water washing in order to remove sea water residues. Tanks which may have contained monomer or drying oils should first be washed with sufficient quantities of cold water to avoid polymerisation of cargo residues. In some cases it is necessary to employ tank cleaning chemicals but their use is generally limited as it may be difficult to dispose of slops.

On completion, the tanks should be clean, dry and free from residual odours. It may also be desirable to take wallwash samples and have them analysed for traces of previous cargoes, but this requires skilled inspectors. The presence of an odour in a tank, which has been cleaned, indicates the presence of cargo residues and also indicates the need for further cleaning. It is advisable, when checking for residual odours, to make the test after the tank has been closed for a period.

Interior of tanks

Below left: A newly coated tank.

Below right: Coating starting to break down but clean.



Testing should, in any case, be carried out by personnel who have not been working in or near the tanks for at least one hour.

When cargo with a high melting point has been carried, tanks should be washed with hot water. If possible, steam should be used to ensure the residues are effectively melted and cleared, and the cleaning process must also include the tank lines, tank lids and vent lines, including pressure vacuum valves and risers. Examples of cargoes with high melting points include phenol and waxes.

Cargo pumps, usually of the hydraulic deep well type, should be dismantled and inspected, as recommended by the manufacturer. The pumps should be purged in order to test the seals which separate the cargo and the hydraulic oil from the void space in the pump. This procedure should always be followed after tank cleaning, before loading and discharging and after repairs. The results should always be properly recorded in the ship's log book or other formal records. Where defects to the seals are suspected, cargo should not be handled until corrective measures have been taken. Due consideration must be paid to the trim of the ship when cleaning pumps, in order to ensure that any contamination product is properly drained away. Portable pumps should be tested before being lowered into the cargo tank.

Before loading, if heating coils are not to be used, they should be thoroughly purged and blanked both at the supply and the return ends. Even though coils may have been in use for some time, they should be pressure tested before loading, in order to avoid the possibility of contamination through leaks which might have developed. Pumps not required for cargo handling should always be isolated.

Special attention should be paid to the cleanliness of vent lines, as they may contain residues of previous cargoes, both in a liquid and a solidified state. Vent lines, when not cleaned after discharge, may drain into a newly loaded tank when the vessel changes trim or when encountering heavy weather. Solidified cargo residues in a vent line may melt, due to the heat emitted from a heated cargo and the melted product may drain back into the tank, causing contamination. The practice of steaming ventlines after the carriage of heated cargoes is to be recommended as blocked lines may result in over-pressuring of cargo tanks.

Drain cocks which are fitted at the lowest parts of deck and manifold lines, as well as plugs at the bottom of cargo valves, should be opened and rinsed in order to remove any trapped cargo residues. These drain cocks

may contain sufficient liquid to result in serious contamination. When clearing deck and drop lines it is important to ensure that the dead ends of these lines and drop lines are not overlooked. They should be opened and thoroughly cleaned.

Mild steel tanks are still sometimes used for the carriage of natural oils and fats but their use is in decline as cargo charterers more frequently stipulate the use of stainless steel or coated tanks. When used, mild steel tanks should be free from rust and scale, since remnants of previous cargoes are likely to be trapped and transferred into subsequently loaded cargoes. Where sensitive cargoes have been carried in mild steel tanks, contamination has been known to occur from the residues of hydrocarbon (petroleum products) cargoes.

The importance of proper tank cleaning procedures and the correct preparation of tanks and all related equipment prior to loading cannot be over-emphasized. Masters may wish to consider appointing an independent surveyor to verify the condition of the tank coating, heating coils and hatch openings after the tank preparations are completed.

On completion of loading, an ullage survey by an independent surveyor may be appropriate, whereafter valves and hatches should be sealed. This process can be repeated at the discharge port. The practice of taking onboard samples at all stages of the loading and discharging operation which is referred to earlier, is also to be highly recommended.

Should contamination occur at some stage in the course of transit, it may be possible, by analysis of such samples, to identify the source of contamination. By ensuring that the cargo is carried to the highest standards, the product should be well protected.

Tanker Matters is a compilation of Carefully to Carry articles. *Bulk oil cargoes, Samples and sampling and Liquid natural oils* were first produced for the *Carefully to Carry* manual and were revised in September 2006. *Biofuels* was produced in July 2010 and written by Richard Minton of Minton Treharne & Davies. All articles are available on the UK Club website ukpandi.com

Tanker Matters video

Tanker cargo claims - how they are caused, and how to avoid them

The UK Club's *Cargo Matters* series of videos aims to increase awareness of the causes of P&I claims for cargo damage and loss. *Tanker Matters* focuses on some of the most frequent causes of tanker cargo claims and how to avoid them.

The DVD can be viewed continuously, or scene by scene:

- Introduction
- Ensuring the ship is suitable for the cargo
- The cargo plan
- Preparing cargo systems
- Before loading - the key meeting and lining up
- Loading
- The loaded voyage
- Discharging
- Summary

