Bulk matters
A focus on some of the issues surrounding the carriage of bulk cargo in the P&I world
Hold cleaning – preparing a ship for grain

Surveyors inspection/requirements

Prior to loading grain, all ships are usually subject to a survey by an approved independent surveyor. The surveyor will require the vessel’s particulars and details of at least the last three cargoes carried. He will then inspect the holds for cleanliness and infestation, or the presence of any material which could lead to infestation.

When the surveyor is satisfied with the condition of the hold, he will issue the ship with a certificate stating which holds are fit to load grain.

Purpose:

To ensure cargo holds are prepared to receive the next cargo.

Large claims have arisen when cargo holds have not been cleaned sufficiently to prevent cargo contamination.

The requirements for cleaning the holds are dependent upon the previous cargo carried, the next cargo to be carried, charterers’ requirements, the requirements of shippers and/or the authorities at the port of loading and the receivers.

It is becoming common practice for receivers to have an inspector at the load port.

General

Regardless of the previous cargo, all holds should be thoroughly cleaned by sweeping, scraping and high-pressure sea water washing to remove all previous cargo residues and any loose scale or paint, paying particular attention to any that may be trapped behind beams, ledges, pipe guards, or other fittings in the holds.

If the ship has been carrying DRI (direct reduced iron), the dust created by this particular cargo during loading or discharging, will be carried to all areas of the ship’s structure and the reaction between iron, oxygen and salt will create an aggressive effect wherever the dust may settle. This is particularly noticeable on painted superstructures. (The IMO Bulk Cargo Code contains guidelines).

Whenever salt water washing is used to clean hatches, the relevant holds should always be rinsed with fresh water to minimise the effects of corrosion and to prevent salt contamination of future cargoes. In this respect, arrangements should be made in good time to ensure sufficient fresh water is available for this operation.

Before undertaking a fresh water rinse, the supply line (normally the deck fire main or similar) will need to be flushed through to remove any residual salt water. Accordingly, it is suggested that fresh water rinsing of the holds is left until the end of hold cleaning operations to minimise the amount of fresh water required.

Grain preparation and safe carriage

One of the most difficult hold cleaning tasks is to prepare a ship for a grain cargo after discharging a dirty or dusty cargo such as coal or iron ore, particularly if the last cargo has left ‘oily’ stains on the paintwork or other deposits stubbornly adhering to the steel surfaces. Greasy deposits which remain on the bulkheads will require a ‘degreasing chemical wash’ and a fresh water rinse in order to pass a grain inspection. The degreasing chemical used should be environmentally acceptable for marine use, and safe to apply by ship’s staff, who have had no special training and do not require any specialised protective equipment. Product safety data sheets of the chemical should be read, understood and followed by all persons involved with the environmentally friendly degreasing chemical.

To avoid taint problems, fresh paint should not to be used in the holds or under the hatch lids at anytime during the hold preparation, unless there is sufficient time for the paint to cure and be free of odour as per the
manufacturer’s instructions. Most marine coatings require at least seven days for the paint to be fully cured and odour free. All paint used in the holds and underside of the hatchcovers should be certified grain compatible and a certificate confirming this should be available onboard. Freshly painted hatches or hatchcovers will normally result in instant failure during the grain inspection, unless the paint has had time to cure.

Processed grains or grain cargoes that are highly susceptible to discoloration and taint should only be stowed in holds that have the paint covering intact. It is important that there is no bare steel, rust, scale, or any rust staining in the hold.

Dependent upon the quality of the grain to be carried, the charterer may require the holds to be fumigated. This may be accomplished on passage with fumigant tablets introduced into the cargo on completion of loading. Fumigation can also be undertaken at the port of loading (or occasionally discharge). The ship will normally be advised how the fumigation is to be carried out and of any special precautions that will have to be taken.

In all cases, the preparations (i.e. inspecting the holds and hatchcovers for gas-tight integrity) and fumigation must be carried out in accordance with the IMO document Recommendation on the Safe Use of Pesticides on Ships. Gas-detectors and proper personal protective equipment should be available and relevant ship’s officers should receive appropriate training in their use. After introduction of the fumigant, an appropriate period should be allowed (normally 12 hours) for the gas to build up sufficient pressure so that any leaks can be detected: the vessel must not depart from port before this period has expired. The entire process should be certified by a qualified fumigator. The holds must not be ventilated until the minimum fumigation period has expired, and care must be taken to ensure that subsequent ventilation does not endanger the crew.

**Alongside the discharge port**

On non-working hatches, remove all cargo remnants, loose scale and flaking paint from the underside of the hatch lids and from all steelwork within the hold, provided safe access can be obtained. Then commence washing the underside of the hatchcovers using liquid soap (such as teepol), followed by a fresh water rinse with a high-pressure water gun.

The hatch rubber seals should also be washed to remove cargo grime. However, caution is required to ensure that the hatch rubber seals are not damaged by the high pressure from the fresh water gun.

After washing, depending on weather conditions, cargo dust may lightly contaminate the underside of the hatch lids; however, the dust particles can easily be removed at a later date using a high-pressure portable fresh water gun.

**Ballast hold**

If the ship has a ballast hold, this should be discharged as soon as possible during the discharge sequence. This will allow ships staff the time to remove all cargo debris and prepare the hold for ballasting.

**Example of portable high-pressure fresh water guns from Stromme**
A good working relationship with the stevedores will probably assist the removal of cargo remains from all of the holds using the shore crane or other cargo-handling facilities, which will avoid lengthy difficulties for ships staff during the ballast voyage.

The bilges and strums of the ballast hold should be thoroughly cleaned and all traces of previous cargo removed. The bilge suctions should be tested and confirmed as clear prior to any washing out of the cargo holds and the bilge spaces pumped out and secured with the bilge blanks.

To prevent ballast water ingress into the bilge area, it is essential that the rubber joint/gasket is in good condition and all the bilge-blank securing bolts are fitted tightly. The un-seamanlike practice of securing the bilge blank with four bolts is unacceptable and may result in pressurising the bilge line. This must be avoided.

### Hatchcovers

Prior to closing the hatchcovers, all the hatch trackways should be swept clean, then carefully hosed down. If a compressed air gun is used, it should be used with caution and suitable safety equipment should be worn to ensure both face and body protection.

All hatch corner drains, including the non return valves, should be proven clean and clear. The blanking caps on the hatch corner drains, used to ensure hold airtightness should be attached by a chain to the drain. These blanking caps or plugs are provided if the drains do not have an approved automatic means of preventing water ingress into the hold.

If time permits, when the cargo has been discharged from respective hatches, all inner hatch coamings should be teepol washed and fresh water rinsed with the fresh water high-pressure gun because it is more convenient to wash this area in port rather than at sea. If permitted by the port authority, all hatch tops should be dock water washed, ensuring that cargo remains are retained onboard and not washed into the dock. The fitting of plugs to all deck scuppers should help prevent any pollution claims alongside.

Illustrated, from top: Discharging soya meal; tapioca cargo sticking and; cargo hold after discharging minerals
It is essential that permission is given by the port authority for this washing operation.

Under normal circumstances, when it rains during cargo operations, discoloured water from the decks will flow into the dock and this is normally accepted by the port authority. The washing of cargo debris into the dock is not acceptable.

In some loading ports, where helicopter operations are used for embarking and disembarking the pilot, it is a normal requirement of the port to wash down the helicopter area and at least one hatch length either side of the helicopter area, always ensuring that cargo debris is not washed into the dock.

**Preparation at sea**

To prevent cargo debris from the main deck being walked into the accommodation and tramped into freshly washed cargo holds, wash down the main decks and accommodation block as soon as possible after clearing the port of discharge, mindful of pollution from the cargo remains.

Prior to the commencement of the hold-cleaning, a quick safety pre-brief meeting should take place, which should include all the personnel who will be involved in the hold cleaning. During the pre-brief the hold-cleaning schedule should be discussed and the equipment and chemicals to be used must be fully explained and the safety data sheets understood by all involved. Basic safety routines should be established and the wearing of suitable attire throughout the hold cleaning must be of paramount importance.

**Hold cleaning**

Prior to high pressure hold washing, excess cargo residue on the tank top should be removed by hand sweeping and lifted out of the holds via the use of a portable mucking winch. As explained earlier, a good working relationship with the stevedores at the discharge port may help to expedite this operation.
After all excessive cargo residue has been removed, the holds can be washed with salt water using a high-pressure hold cleaning gun, supplemented by the deck air line to provide increased pressure. This is the most commonly used method of hold cleaning, however the hold cleaning gun normally requires two seamen to safely control the increased water pressure. Some ships are fitted with fixed hold cleaning equipment, normally fitted under the hatchcovers. This method of hold cleaning is less labour intensive. A flexible high-pressure hose is connected between a flange on the hatchcover and the deck high-pressure hold washing line.

Other ships have permanent high-pressure hold cleaning equipment that can be lowered through a flange on the main deck, turned ninety degrees and bolted to the high-pressure deck wash service line. All cargo residues washed down must be removed via the hold eductors or mucking winch. Special attention should be given to cargo residues wedged behind pipe brackets, hold ladders, and on the under-deck girders and transversals. Special attention should be paid to ventilators to ensure that remnants of previous cargo have been removed and the area is grain clean. Binoculars are quite useful for spotting cargo remains in high places. Hold bilges and recessed hatboxes should be cleaned out and all cargo remains removed.

Bilge suctions must be tested both before and after washing and the results entered in the cargo notebook and/or deck log book.

**Salt water chemical wash and hand scraping**

To remove any greasy deposits from the hold steelwork, all the holds should be high-pressure chemical washed using the hold cleaning gun complete with air line booster. The degreasing chemical used, as previously advised, should be environmentally acceptable for marine use, and safe to apply by ships staff, who have had no special training and do not require any specialised protective equipment.

Numerous degreasing chemicals are available (eg. Sea Shield detergent) and work quite effectively, if they are directly injected into the firemain via the general service pump strainer cover. Manufacturer’s instructions must always be followed, but in general the recommended chemical injection rate is approx. 5 litres/min.

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A typical 110,000 dwt bulker will require around 100 litres per hold, or 25 litres of degreasing chemical on each bulkhead.

To avoid long lengths of hose delivering chemical, the chemical station should be situated as close as possible to the injection point of the fire and GS pump. The easiest way to control the rate of chemical flow is by fitting a temporary small hand operated valve on top of the strainer cover. An alternative method is to use an eductor system to suck the chemical direct from the drum into the discharge nozzle. The quantity of chemical introduced is controlled by the operator or an assistant, lifting the nozzle clear of the drum. However, this method of educting the chemical from the drum into the discharge nozzle is time consuming and more awkward for the operator and restricts his movement around the hold. In addition it carries a greater risk of an accident or spillage of degreasing chemical because the chemical drums have to be lowered into each and every hold, whereas the first method allows all the degreasing chemical to be situated at one place i.e. by the GS pump.

One degreasing chemical injection station used successfully aboard a vessel consisted of: a transparent container of 120-litre capacity, graduated in 10 litre units; a 5 metre transparent length of reinforced hose with one end fitted with a 40cm long steel uptake branch pipe and the other end open. The branch pipe was inserted into the chemical container and the open end of the transparent reinforced pipe was connected to the hand valve on the pump strainer cover using two jubilee clips. The small hand valve on the strainer cover was used to control the flow of chemical into the fire pump.

Prior to starting the high-pressure sea water chemical wash, all fire hydrants and anchor wash hydrants on deck should be checked and confirmed as fully closed. The hydrant serving the hold cleaning gun should be opened and the fire and GS pump started.

To avoid unnecessary chemical waste, predetermined times of injecting the chemical into the fire main should be agreed between the hold cleaning party and the person controlling the rate of chemical injection. On a 110,000 dwt bulker it takes approx. 20 minutes to complete a chemical wash in each hatch, after which the chemical should be washed off using high-pressure salt water. Concurrent with the chemical wash the hold should be hand scraped with sharp long handled steel scrapers. All loose scale and flaking paint must be removed.

Fresh water rinse and hold preparation
The final stage of hold washing is the fresh water rinse. A ship preparing for a grain cargo would be advised to carry additional fresh water in a convenient tank. This is often the after peak, which can be pumped into the fire main via a GS pump. A typical 110,000 dwt bulk carrier will require around 30 tonnes of fresh water per hatch. Prior to commencing the fresh water rinse, the fire line is flushed through with the after peak fresh water to remove all traces of salt water. If a GS pump is used, the flushing through takes a few minutes and only uses a few tonnes of fresh water. Once the fire main is clear of salt, all deck fire hydrants and anchor washers should be sighted and confirmed that they are closed.

If a GS pump is to be used for the hold rinse, to prevent possible pump damage, a return line into the after peak should be set up using a hose connected from the fire main into the after peak vent.

On completion of the hold fresh water rinse, all hatch entrances, hatch trunkings and hand ladders should be hand washed and fresh water rinsed using the fresh water high-pressure gun. It is not advisable to rinse and clean the access ladders and hatches before washing the main hold, because splashings from the hold bulkheads will often contaminate the freshly washed ladders. Bulkheads either side of all the hand ladders
should be hand cleaned and jet washed as far as one can safely reach, using long handled turks heads. Safety body harnesses and (if required) a bosun’s chair should be used when undertaking this task.

When it is safe to open the hatches, all the hatch coamings should be hand washed using long handled turks heads and jet washed with fresh water using the high-pressure fresh water gun. With the hatch lids open, binoculars should be used to sight the holds for any cargo remains.

To prevent possible condensation in the hold, all the recessed hold eductors (if fitted) must be drained of any water residue, be clean dry and odourless. There is usually a small stainless steel drain plug on the underside of the eductor which can be temporarily removed to allow the eductor water to drain into the bilge area. When the eductor is empty the drain plug must be replaced and secured. The eductor hold plate must be secured with all the securing bolts and duct tape should be used to cover both the securing bolts and recessed lid handles.

Hold bilges should be completely dried out, odourless and in a fully operating condition. The surveyor will usually require to sight one bilge in each hold to ensure that they have been cleaned out correctly.

The tank top must be completely dry and any indentations on the tank top must be wiped dry. The hold should be made completely odourless, by maximising hold ventilation. Two layers of clean hessian cloth should be fitted to the bilge strainer plate to further restrict cargo particles entering the bilge area. Duct tape is used to cover the small gap between the bilge strainer and tank top. The hold hydrant area, if fitted, should be cleaned and dried out. The steel cover refitted and secured in place with all its bolts/screws.

**Hatch undersides**

When it is safe to open the hatches all the hatchcover undersides should be hand washed and fresh water jet washed using the high-pressure fresh water gun. If all the hatchcover undersides were hand cleaned at the discharge port, this operation will be completed very quickly and a high-pressure jet wash may suffice.

All loose scale and any flaking paint from the hatchcover undersides must be removed. All ledges on the hatch undersides must be checked to see that they are clean. All hatch rubbers and centre line drain channels should be clean and clear of any cargo remains or other debris.

**Hatch watertight integrity**

To prevent cargo claims due to water ingress, all hatch seals (both longitudinal and transverse), hold access lids and seals around the hatch sides should be chalk marked and water tested using deck wash hoses.

A more accurate method of testing a hatch for leakage is to use ultrasonic equipment. However this is usually completed by shore personnel who are trained in the use of this equipment.

Faulty or suspect sections of hatch rubber should be replaced in their entirety; localised replacement or
'building up' of hatch rubbers using sealing tape is discouraged.

**Grain inspection**

Prior to the grain inspection all hatches and access lids must be open and safely secured with all locking pins/bars.

All hatches should be checked for loose scale or flaking paint. Invariably there will be a little scale on the tank top, which can quickly be removed. If weather conditions permit during the day, the holds should be opened to allow fresh air to assist the hold drying process. All small pools of water should be mopped dry. All hatch rubbers and centre line seals should be wiped over with a clean dry rag to confirm their cleanliness.

Prior to the inspection, ships staff should lower into the first hold an aluminium ladder together with a small number of clean brooms, scrapers, dustpan and brush, a clean bucket and a few clean white rags. If possible the second hold to be inspected should also be equipped with similar items.

The first team to enter the open hold should comprise the grain inspector, a deck officer and a seaman. Under no circumstances should grain inspectors be allowed to inspect the hatches unescorted by a deck officer. A second team consisting of a deck officer and some crewmembers should be standing by at the top of the hatch being inspected. The second team should have available additional clean brooms, clean mops, scrapers, buckets, clean heaving lines and clean white rags.

The engineers should be on standby to test the bilges (dry sucking only).

Radio contact is essential between all three teams to prevent lengthy delays.

Any personnel entering the holds should have clean safety shoes or clean safety sea boots. It is essential that any debris on the main deck is not walked into the clean holds. Some ships issue overshoes to personnel entering the hold.

If the inspector finds a fault with a hold, if at all possible, the fault should be identified and recorded, and remedial action agreed with the inspector. If possible the fault should be rectified immediately and preferably before the inspector leaves the ship. If this is not possible a time should be agreed for his re-inspection.

**Ballast hold**

The ballast hold is usually de-ballasted and prepared alongside during the loading period. If the hold and bilges were cleaned at the discharging berth, the ballast hold preparation will be quickly completed.

**Loading grain**

Hatches not being loaded should be kept closed. All hatches after passing the grain inspection and prior to loading, must be inspected on a daily basis to ensure that they are still completely dry. Hatches containing grain cargo must not be entered due to a possible lack of oxygen. During the load, it is important to keep the grain cargo dry. If the grain is allowed to become wet, high cargo claims will result.

Regular visual checks by ships staff throughout the load should ensure that the grain being loaded is not in a wet condition. These inspections should be recorded in the deck log book.

During the loading of grain, dust clouds often develop. These are a health hazard and additional safety requirements, such as the wearing of eye protection...
goggles and dust masks should be observed by all personnel in the vicinity of the dust cloud.

If the master is in any doubt about the condition of the grain during the load, he must issue a note of protest and seek advice from his operators and/or the UK P&I Club.

Completion of a hatch
All holds to be filled must be absolutely full. It is essential that the loading spout, or other mechanism, is directed to all corners, to avoid any void spaces. Time should be allowed for the grain to settle then refill any spaces (such as hatch corners).

When the loading of a hatch has been completed, the trackways, hatch drains, and channel bars must be swept clean and the hatch closed. Water must not be used to wash down hatch trackways. DRY compressed air is very useful, but crew safe working practices must be observed when using compressed air. Ventilators should be tightly secured.

If the voyage instructions require hatch sealing tape to be used, as an additional precaution to prevent water ingress, then the hatch surfaces must be scrupulously clean before the sealing tape is applied. In cold climates, some brands of tape will adhere better if warmed in the engine room before they are applied. Foam compound should not be used to ensure hatch watertight integrity.

To prevent unauthorised access to the oxygen depleted grain holds, and where fumigation in transit is to be undertaken, all the hold access lids should either be padlocked or have steel security seals fitted.

Loaded voyage
Regular checks of all hatch sealing tape (if fitted) should be completed and damaged or lifting tape immediately replaced. During the voyage, entry into any cargo space
must be strictly prohibited. Ventilation during the voyage will depend on weather conditions and a comparison between the dew point of the air inside the hold and outside the hold. Under no circumstances should hold ventilation be permitted during adverse weather conditions or before fumigation in transit has been completed.

In good weather, basic cargo ventilation rules should be observed. Guidance can be obtained from Bulk Carrier Practice: A Practical Guide (ISBN 928 0114 581). If the vessel has any oil tanks adjacent to or under the cargo holds, any steam heating to these tanks should be minimised, but in any case carefully monitored and full records maintained to prevent cargo heating and possible cargo damage. This is a point that is often overlooked by ships’ staff.

**Typical examples of hold failures**

The following images from a vessel which failed a grain survey, would suggest that:

- Ship’s crew completed a very quick salt water wash.
- No chemical wash was undertaken.
- No hard scraping of the bulkheads was completed.
- Previous hold cleaning had not been supervised (history of the ship’s cargoes on the stiffeners).

Showing:

- Staining from the previous cargo (coal).
- Cargo dust residues.
- Deposits of previous cargoes in hard to reach places.
- Flaking paint and scale.

A full version of this article including a ‘Grain cleaning checklist’ is available in the Loss Prevention – Carefully to Carry section of the Club website, www.ukpandi.com, under Dry bulk cargo – Hold cleaning
Moisture migration and surface ventilation

This article explains how and why moisture migration takes place and discusses to what extent surface ventilation can reduce or eliminate the damage to which moisture migration gives rise. The answer depends on the commodity; with grain in bulk, surface ventilation can do little or nothing; with rice or cocoa in bags, surface ventilation can do much more, but it cannot guarantee a sound outturn in all circumstances.

Movement of moisture

Moisture migration is the name given to the movement of moisture within a cargo. Thus a situation may arise where the total amount of water held in a cargo in a given space may be the same at the end of a voyage as it was in the beginning, but as a result of moisture migration, the moisture contents of various parts of this cargo have changed considerably (gains or losses being found). It is more usual, however, for part of the moisture that migrates to be lost to the external atmosphere as a result of ventilation, or to be drained off into the bilges.

Physical considerations

Vapour pressure (VP) and relative humidity (RH)

Vapour pressure

The atmosphere comprises a mixture of nitrogen and oxygen in the proportion of 78% nitrogen to 20% oxygen; approximately 2% represents other gases and this includes water in the form of vapour. Pressure exerted by the atmosphere will partly be dependent upon the pressure exerted by the water in vapour form, and this proportion of the total atmospheric pressure is known as the ‘water vapour pressure’ of the air at that time.

Saturation vapour pressure

Vapour pressure is measured in the same way as other gaseous pressures, i.e. in mm of mercury. It will be recalled that the normal atmospheric pressure at sea level is 760mm Hg.

As the quantity of water in the atmosphere increases, so the vapour pressure will increase proportionately. At a given temperature, the air can only hold a specific amount of water vapour, and the pressure exerted in the atmosphere when this limiting point is reached is referred to as the ‘saturation vapour pressure’ of the air at the particular temperature.

Super saturation

Any attempt to increase the water vapour in the air at this point will produce ‘super saturation’ and then water will be deposited from the air in liquid form, either as droplets to form fog or cloud, or on suitable surfaces in the form of water drops, e.g. as sweat in a ship’s hold.

Relative humidity

Under most circumstances, the vapour pressure of water in the atmosphere is less than the saturation vapour pressure. The percentage value of the actual vapour pressure in relation to the saturation vapour pressure is defined as the ‘relative humidity’ of the atmosphere. Thus, if the air only holds half its potential maximum amount of water in the form of vapour, then the relative humidity will be 50%, and at saturation vapour pressure the relative humidity will be 100%. Warm air is capable of holding more water vapour than cool air, so the actual weight of water that is required for saturation increases with increasing temperature. Thus for a given volume of air containing a constant weight of water vapour, the relative humidity will vary as the saturation vapour pressure changes with the temperature. If the temperature rises, the saturation vapour pressure will increase, so that the relative humidity will fall.

Temperature rises – relative humidity falls

This phenomenon may be illustrated with an example. Let it be assumed that a given quantity of air at 20°C has a vapour pressure of 9mm Hg. The saturation vapour pressure of air at 20°C is 17.5mm Hg. Therefore the relative humidity is 9/17.5=51.5%. If the air is heated to 30°C, the quantity of water in the air remaining the same, then the vapour pressure of the air will still be 9mm Hg. However the saturation vapour pressure of air at 30°C is 31.8mm Hg. Therefore the relative humidity is 9/31.8 or 28.3%, i.e. by increasing the temperature 10°C, a fall in relative humidity of 23.2% has occurred. The reverse effect occurs if air containing a given quantity of water is cooled.

Relationship at different temperatures

The graph shows the relationship between the vapour pressure and relative humidity at different temperatures, e.g. 100% relative humidity at 10°C represents a water vapour pressure of 9.2mm Hg; at 20°C of 17.5mm Hg.

1 Vapour pressure can also be measured in terms of other units – either in atmospheres or kilopascals. 1 atmosphere (1 atm) = 760mm mercury (mm Hg) = 101.325 kilopascals (kPa).

2 Actually, there will be a very slight rise in vapour pressure, but this may be ignored for the purposes of the example.
and at 30°C of 32mm Hg – i.e. an increase of 20°C has resulted in a more than three-fold increase in the water-holding capacity of the atmosphere.

Condensation
If air is cooled to the point where saturation (100% relative humidity) is reached, then moisture will begin to be deposited in the form of droplets or mist i.e. condensation will occur.

Ship’s sweat
If the air in a ship’s hold is warm and it comes in contact with the deckhead which has become cooled by the outside atmosphere, so that the temperature of the air close to the surface of the deckhead may be reduced below that at which saturation vapour pressure for that particular water content is reached, i.e. 100% relative humidity, then condensation will normally form on the deckhead in the form of sweat.

Equilibrium relative humidity (water activity)

Equilibrium point
All biological materials normally contain a certain amount of water. The amount of moisture present at any given time is the moisture content. If the material is put in contact with dry air, then it will tend to lose a small proportion of its water to the air in the form of water vapour. This process will continue until an ‘equilibrium’ of the air in contact with the material of that particular moisture content and at that particular temperature. Equilibrium relative humidity is sometimes referred to as ‘water activity’. The latter is measured as a ratio rather than as a percentage thus equilibrium relative humidity of 50% is equivalent to a water activity of 0.5.

Usually, with a biological cargo, the condition of the atmosphere within the cargo (that is, of the air trapped between the various particles of the cargo) is controlled largely by the condition of the cargo. In cargoes such as bulk grain, where air movement within the bulk is very restricted, the moisture content of the atmosphere within the cargo (which is also termed the ‘interstitial’ or ‘inter particular’ air) is, under normal conditions, completely controlled by the temperature and moisture content of the cargo.

Experimental work with maize has made it possible to construct graphs that equate equilibrium relative humidity with moisture content at various temperatures. Such graphs are known as ‘desorption isotherms’, since all the experiments were constructed so that to achieve equilibrium relative humidity, moisture was given up by the maize to the surrounding air. If the air around the maize is wetter than the equilibrium relative humidity, then the maize will absorb moisture from the air. Such a process is known as ‘adsorption’ and a similar series of curves or isotherms can be constructed which are called ‘adsorption isotherms’. The relationship between adsorption and desorption isotherms is a complex one and it is not proposed to discuss it at length in this article. However, it may be stated that under conditions of desorption, the equilibrium relative humidity at any given moisture content is slightly lower than under conditions of adsorption. Normally in the grain trade, from harvesting through to the discharge of cargo, there is a tendency for the grain to lose moisture to the surrounding atmosphere, and thus behaviour patterns should be deduced by a study of desorption isotherms. If a situation occurs where the grain is absorbing moisture from the atmosphere, strictly speaking, the behaviour pattern should be deduced by a study of adsorption isotherms.

Moisture migration

The mechanism of moisture migration
It is necessary to understand the definition referred to above in order to appreciate the process of moisture migration. We will illustrate the mechanism by which moisture migration operates by considering a cargo of bulk maize. With this commodity migration is slow.

Change of temperature – change of ERH – change of vapour pressure
We have already stated that the interstitial air that occupies some 40% of the cargo space in the case of maize in bulk will contain water vapour, and the vapour pressure in this air will rapidly reach equilibrium with the moisture content of the maize. In maize with a moisture content of 14% and a temperature of 25°C, the relative humidity of the interstitial air will rapidly reach 68% and the water vapour pressure in the air at that time will be
16.3mm Hg. A change in the temperature of the maize will result in a change of the equilibrium relative humidity and in the vapour pressure. The table below shows equilibrium temperatures for maize at 14% moisture content. The temperatures at which saturation vapour pressure occurs (i.e. 100% relative humidity) are included in the table. These temperatures are known as the ‘dew points’.

Table 1. Temp / ERH / VP / DP – Relationship of maize at 14% moisture content

<table>
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<tr>
<th>Temp °C</th>
<th>Equilibrium RH</th>
<th>Vapour pressure mm Hg</th>
<th>Dew point °C</th>
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</tbody>
</table>

Thus, air at 25°C and 68% equilibrium relative humidity will have a vapour pressure of 16.3mm Hg, but if this air is reduced to a temperature of 18.7°C, then moisture will be deposited because the saturation vapour pressure will then be reached. If we assume that the ship carrying this maize of 14% moisture content and of temperature 25°C passes into a region of colder water, then the outside of the cargo will assume the temperature of the cold sides of the vessel, and if we assume this to be 15°C, it can be seen from the table that such maize will have an equilibrium relative humidity of 60% and a vapour pressure of 7.1mm Hg. The cooling process of the colder sea will not noticeably affect the maize in the centre of the bulk, since maize is a poor conductor of heat. Its thermal conductivity at normal moisture contents is less than five times as great as that of loose cork insulation and only one fifth the average value for concrete. Thus the maize in the centre of the stow will still have a temperature of 25°C and the interstitial air in this region will still have a vapour pressure of 16.3mm Hg.

A vapour pressure difference is therefore created, between the interstitial air in the maize in the centre and the interstitial air in the maize on the periphery of the stow. Consequently, there will be a flow of moisture vapour from the high pressure region to the low pressure region in order to equalise the pressure difference, and water will thus move from the centre towards the periphery.

This movement of water from the inner portion of the cargo will have the immediate effect of causing a reduction in the vapour pressure of the air there, but equilibrium conditions will be restored as result of more water moving from the grain into the interstitial air, so that the original vapour pressure of 16.3mm Hg will be maintained. Consequently, there will be continuous flow of water vapour from the warmer part of the stow to the colder part.

**Cargo sweat at periphery**

In the example which we have given, the overall effect of this transfer of moisture vapour will be to cause deposition of physical water in the periphery of the stow in contact with the cold hull. This follows from the table, which shows that a vapour pressure of 16.3mm Hg at 25°C will have a dew point of 18.7°C. As this dew point is higher than the temperature of the cargo at the periphery, water will be deposited on the cargo. This illustrates the mechanism whereby ‘cargo sweat’ is produced.

The above example is an over-simplification of what happens in practice, since there is a tendency to set up a temperature gradient in the maize, along the route
from the inside of the stow to the outside, and there will be a gradual drop in the temperature of the air which moves and the grain in contact with it. Hence water vapour will be absorbed en route, lowering the dew point of the air moving towards the periphery of the stow. Thus it is not possible to make an exact prediction of what conditions are necessary for cargo sweat to occur.

**Heating up**

If there is a temperature differential between the outside of the stow and the inside, then moisture migration will result from the mechanism previously described. Such moisture migration will also occur when one part of the bulk becomes heated-up for any reason, e.g. insect infestation, microbiological activity or proximity to a hot bulkhead. In all these circumstances moisture will migrate from the warmer region to colder parts of the stow.

**Warmer to cooler**

We have illustrated, taking maize as an example, the reasons why moisture migration occurs. As with maize, the problem of moisture migration is most evident with exports of biological materials from warmer climates to cooler climates. Moisture migration can occur from many causes but, however the temperature differential comes about, the result will always be (where the moisture content is uniform) a movement of moisture from the warmer to the cooler parts of the cargo.

Moisture migration is observed in cargoes where ‘insect infestation’ occurs. Here, centres of heating arise from the respiratory heat from the insects and moisture migrates from these spots to form a wetter shell in the cooler cargo immediately surrounding the heated zone. As heating becomes progressive, the heating zone of course expands as the wetter shell moves outwards.

A second example is where ‘ship’s heat’ causes a localised rise in the temperature of the cargo in contact with the source of the heat – e.g. an uninsulated engine room bulkhead. Here moisture migrates from the warm cargo and forms a layer of increased moisture content in the cooler cargo adjacent to it.

Unfortunately, the straightforward pattern of moisture movement resulting from a vapour pressure differential is not the only phenomenon that results from temperature differential in a cargo. Where temperature differentials are present, convection currents are set up owing to the fact that warm air is less dense than cold air. Thus, if heating occurs within a cargo, there will be a tendency for moisture to migrate in all directions from the heating zone. But there will also be a tendency for hot air to rise from the heating zone, to be replaced by cooler air coming in from the sides and underneath. The warm air will carry moisture with it, so that the pattern of moisture movement will be distorted in a vertical direction. In fact, where a hot spot occurs in a cargo, moisture movement is greater in a vertical direction than either laterally or downwards, because convection currents reinforce the upward movement of moisture. Thus for grain loaded warm and subjected to peripheral cooling, the major amount of moisture movement will be in a vertical direction, i.e. more water will pass towards the top of the cargo than towards the sides. If it is not possible to remove the water migrating to the top region of the cargo by ventilation, a subject that is discussed later in this report, more damage may be anticipated in the top layers than at the sides.

**The rate of moisture migration**

Having established the causes and the pattern of moisture migration, we now consider the quantitative aspects of the phenomenon.

**Difference in vapour pressure**

The rate at which moisture moves from a warm to a cold region is dependent to a large extent on the difference in vapour pressure between the warmer and colder parts of the cargo. From Table 1 it will be seen that the vapour pressure of interstitial air of a cargo of maize at 14% moisture content does not increase directly with temperature. Thus an increase in temperature from 15°C to 25°C will give a vapour pressure increase of 9.2mm Hg, whereas a rise in temperature from 25°C to 35°C will give a vapour pressure increase of 15.2mm Hg. It therefore follows, that moisture migration will be greater, all other things being equal, when moisture is moving from cargo at 35°C to cargo at 25°C than when moisture is moving from cargo at 25°C to cargo at 15°C, although the temperature difference in both cases is the same. Thus, when considering rate of moisture movement within a cargo, not only is difference in temperature important, but also the ‘actual temperatures’. A further factor is of course the differential in temperature in relation to distance – thus moisture will move more rapidly from cargo at 25°C to cargo at 15°C if the distance through which it must travel is only 1m rather than 10m, because it will be obvious that the vapour pressure gradient is much greater in the former case. In this respect the ‘thermal conductivity’ of the cargo in question is of considerable importance; the lower the conductivity, the slower heat will move through a cargo, and hence the less the potential for moisture movement.

**Initial moisture content**

The initial moisture content is also important. If we consider a cargo of maize at 14% moisture content
loaded at 35°C with its periphery cooled down to 25°C, the equilibrium vapour pressures will be 31.5mm Hg and 16.3mm Hg respectively, giving a differential of 15.2mm Hg. Under the same temperature conditions, but with maize at moisture content of 11%, the equilibrium vapour pressures will be 22.4mm Hg and 11.6mm Hg, giving a differential of 10.8mm Hg. Thus the differential at lower moisture contents – therefore moisture movement – is less. In addition, (and this is of considerable practical importance), a much greater quantity of water can be absorbed by the cooler grain before the moisture content is raised to a level at which spoilage will commence.

Compactness
Because of the importance of convection currents in moving moisture, the more readily air can move through a cargo, the more rapidly moisture can be carried through that cargo in the moving air, so that all other things be in equal, there will be more rapid moisture movement through a cargo that is less compact (e.g. pellets) than through a cargo which is for example powdered, where the movement of air will be very limited.

The cargo itself
Finally, when considering the rate at which moisture may move through a cargo, it is necessary to consider the nature of the cargo itself. Thus cargo such as grain, which consists of seeds grown in dry climate, has comparatively low moisture content and the seed itself has a protective outer skin, which is relatively impermeable to moisture. In fact, one of the main purposes of this skin is to prevent the seed from drying out, either during growth or subsequent to growth and prior to germination. Thus moisture is released rather slowly from seed products such as wheat and maize when compared with other products, particularly those grown under wet conditions in the tropics, where there is no natural necessity to conserve moisture. Similarly, whole grain will lose moisture much more slowly than grain that has been milled or pulverised in some way, where the natural protective coating is disrupted.

Quantitative data for the release of moisture from various products is scanty, and direct comparisons are particularly difficult. We have therefore not been able to give examples to illustrate the above.

When studying moisture movement there are two factors of interest. The first is the actual quantity of water moving from one place to another. The second is the rate at which the ‘zone of enhanced moisture’ moves forward. We have done some work on the latter factor with maize.

It was found that in 28 days, a zone of enhanced moisture had moved approximately 1m in a vertical direction (i.e. with convection currents reinforcing the moisture movement) from the hot spot. The temperature differential in this experiment was from 40°C to 21°C over a distance of approximately 1.25m. The actual quantities of water involved could not be accurately determined. There is no doubt whatsoever, that with other types of cargo both the rate of movement and the quantities of water moved would have been many times greater than was found with maize.

Therefore, when considering the significance of potential moisture migration in a cargo, it is necessary to consider the vapour pressure differential in relation to the distance between the hotter and colder zone, the temperature of the hotter material and the temperature of the colder material to which moisture is migrating, the initial moisture content, the nature of the cargo and the ease with which air may move through it.

Practical application
To take simple practical illustrations of this, it is not unusual to shift bulk grain round the world in tankers (where of course there is no possibility of ventilation) and to store bulk grain in unventilated silos for long periods of time where considerable differences in temperature can occur between summer and winter. This is only possible because under normal conditions, the rate of moisture migration in bulk grain is low. When cargoes of cocoa or rice are considered, the rate of moisture migration is many times greater. It would of course be courting disaster to attempt to carry cocoa from West Africa to Northern Europe in tankers. Thus the quantitative aspects of moisture migration are of primary importance when considering the best method of carrying a particular cargo on a particular voyage.

No general rules
In the following section, we discuss ventilation in general terms in order to illustrate how the use of ventilation can assist in minimising the deleterious effects of moisture migration. Because of the many factors involved however, it would be unwise to attempt to formulate general rules for the carriage of cargo to minimise the effects of moisture migration.

Grain in bulk
General
Vessels which carry grain in bulk vary in their capability for ventilating the cargo. Considerable quantities of grain are carried in tankers with no ventilation whatsoever. Sometimes grain is carried in vessels fitted with a sophisticated Cargocaire system of surface ventilation, which also has facilities for pre-conditioning
the ventilating air. Other vessels have fan-assisted surface ventilation and quite a large proportion have the normal type of surface ventilation through cowls, unassisted by any mechanical effort, the flow of air being dependent upon the movement of the ship. Some bulk carriers which successfully carry many thousands of tonnes of grain etc. have no means whatsoever of ventilating the surface of the cargo.

It should be pointed out, that vast quantities of grain are transported around the world, and in the great majority of instances, the cargoes outturn in a sound condition. This is true also of tankers, which indicates that surface ventilation is not a necessary pre-requisite to successful carriage.

On numerous occasions, claimants have been advised by their experts that spoilage of grain in transit has resulted from unsatisfactory ventilation. Alternatively, it has sometimes been suggested that lack of ventilation has exacerbated damage caused by other factors. We consider that a bulk cargo of grain, if stowed in accordance with SOLAS Regulations – see later – cannot be significantly affected by surface ventilation or from a lack of it.

Oxley states:

"...popular opinion greatly exaggerates the virtues of ventilation...gaseous diffusion and heat movement in grain are both exceedingly slow and in the absence of mechanical means of forcing air through the bulk, changes in the atmosphere at the surface have a negligible effect on the intergranular atmosphere and on the water content or temperature of the grain."

In order to reduce moisture movement and its effects within a grain cargo, it is necessary to reduce the moisture content throughout. This will not only cut down the rate of moisture movement but will also mean that greater variations in moisture can occur within the cargo without commercial loss caused by the development of microbiological activity. Alternatively, the temperature differential may be reduced by cooling the bulk of the grain; this again would cut down the amount of moisture movement. A reduction in moisture content and a reduction in temperature could both be achieved by passing significant quantities of air through the cargo. Through ventilation, although possible in some silos ashore, is not possible onboard ship. In practice, onboard ship, only surface ventilation is available to attempt to control the deleterious peripheral effects resulting from moisture migration in bulk grain.

**Cargo sweat**

In the case of tankers, all are agreed that nothing can be done about ship’s sweat should it occur, but it is suggested in the case of vessels fitted with natural or mechanical ventilation, that the moist air may be continuously removed from the headspace above the cargo and the quantity of condensation occurring on the deckhead accordingly reduced or eliminated.

It must, however, be remembered in these circumstances that the air used for ventilation is at the same temperature as, or below, the temperature of the deckhead and hatchcovers. If the ventilating air is cool, then the immediate effect will be to take up moisture vapour by diffusion from the interstitial air in the surface layers of the cargo, because the vapour pressure of the interstitial air will be higher than the vapour pressure of the ventilating air. At the same time, the surface of the cargo will be cooled, both directly by contact with the cooler ventilating air and as a result of evaporation of moisture. The temperature of the surface layer of the cargo may therefore be reduced below the dewpoint of the warm moist air rising from within the bulk. Water will then condense in the cooler surface layers of the cargo thus producing a wet cake just below the surface. Microbiological spoilage will eventually occur in this wet cake. Even if no condensation occurs in the surface layer, the moisture content of these layers may rise as a result of absorption of moisture, to a level where microbiological activity can commence – although this damage does not arise strictly from ‘cargo sweat’.

Thus, if the external ambient conditions are such that ship’s sweat would occur in the absence of ventilation, then cargo sweat will frequently occur just below the surface if ventilation is employed. This means in fact that, under these circumstances damage will result whether ventilation is used or not.

Surface ventilation is also claimed to be useful in removing heat from cargo that is heating, thus minimising the increase in temperature which might cause further deterioration of the cargo. It is, however, generally agreed that heat transfer through bulk grain is a very slow process. Work carried out using a vertical heat transfer system with a temperature differential of 20°C indicted that about 32 days continuous heating was required before there was a rise in temperature of 3°C in maize one metre from the heat source. This practical data is in line with calculations published by Leninger and the views of Oxley (ibid). Indeed, it is because of this very fact that microbiological spoilage does produce serious heating up. Hence surface

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4 Scientific Principles of Grain Storage, Liverpool, 1948, p23

5 Ayerst & Leniger: Report on Heat Damage to Argentinian Maize during shipment to Europe, December 1967
ventilation cannot significantly affect a heating process which is occurring more than about a metre below the surface. What can occur when the surface of a heating cargo is continuously cooled by ventilation, is that the vapour pressure differential between the interior of the cargo and the periphery is maintained and consequently the phenomenon of moisture migration is encouraged.

**Stowage regulations**

The irrelevance of surface ventilation to the carriage of grain is apparent from the stowage regulations in force in all major grain exporting countries, which insist that the vessel be stowed so that shifting of the cargo is impossible. Under these regulations, a ship’s grain carrying compartments are classified as either partly filled or full. Grain in partly filled compartments must be levelled and topped off with bagged grain or other suitable cargo, tightly stowed and extending to a height of 1-2m above the bulk. The bagged grain or other suitable cargo must itself be supported by a platform made either of close boarded wood, or strong separation cloths laid over the whole surface of the bulk cargo.

These regulations provide that in compartments totally filled with grain, the grain shall be trimmed so as to fill all the spaces between the beams, in the wings and ends. Further, to ensure that the compartment is maintained fully filled during the voyage, the compartment must be equipped with a feeder, from which grain can flow into the compartment if the cargo settles during the voyage. Alternatively the grain in the area of the hatch may be trimmed hard up to the deckhead beyond the hatchway to form a saucer. This saucer and the hatchway above is then filled with bagged grain or other suitable cargo extending to a height of at least two metres in the centre of the saucer. The bagged grain or other suitable cargo must itself be stowed tightly against the deckhead, and the longitudinal bulkheads, the hatch beams and hatch coamings.

The express purpose of the regulations, is to reduce to a minimum – and if possible to eliminate – the head space between the surface of the cargo and the overlying deck. With cargo stowed correctly in this way there is no possibility of effective surface ventilation.

**Other cargoes where moisture migration is substantially more rapid**

We took grain stowed in bulk as a first example because this probably represents a cargo in which moisture migration is the slowest compared with other cargoes which may be carried both in bulk and in bags.

The rate of moisture migration and the amount of moisture moving in other cargoes may be higher because, on the one hand, of differences in voyage and loading temperature, and, on the other, of the physical nature of the cargo stowed.

A typical cargo in which rapid moisture movement can occur is bagged rice. This cargo is usually loaded at a high temperature and at a moisture content just below the critical level which is about 14%. If the cargo is stowed in a block, stow temperature changes in the external atmosphere and sea water may set up serious temperature gradients between the centre and peripheral regions of the stow, with the result that massive moisture movement occurs leading to the formation of both cargo sweat and ship's sweat. This in turn results in part of the cargo becoming excessively wetted. Microbiological deterioration occurs in the wetted cargo.

In order to prevent or minimise this problem, bagged rice is normally stowed so that linked vertical and horizontal ventilation shafts are incorporated in the stow to facilitate moisture movement from the bulk to the external atmospheres.

Even with this form of stowage, when a rapid fall in external temperature occurs, as might be experienced with a vessel sailing to Northern Europe in the winter, serious sweat formation can result. This is well known to surveyors working in Northern European ports.

A similar phenomenon also occurs with bagged cocoa shipped from West Africa to Northern Europe. Here, the cargo is artificially dried so that ventilation in the early stages of a voyage, i.e. before about the latitude of Dakar, can result in the cargo picking up moisture from the atmosphere and is not normally recommended.

After this, ventilation may be used to minimise sweat formation; but it must be borne in mind that cooling the surface of the cargo encourages moisture migration by increasing the temperature gradient between the bulk and the surface of the cargo, and may also result in the formation of cargo sweat. Thus, shock cooling of the surfaces of the cargo should be avoided and ventilation during the hours of darkness or during cold weather is probably best avoided.

It can be shown by calculation that, in any event, when cold conditions are encountered, the rate of emission of moisture from a normal cargo of cocoa can be substantially higher than the rate at which such moisture can be removed by a normal ventilating process, even assuming the ventilating atmosphere becomes saturated as it passes over the cargo. Thus,
sweat damage under some circumstances is inevitable. It will be seen from the foregoing sections that moisture migration within, and from, a water-holding cargo must occur as the vessel moves through different climatological regions. The purpose of ventilation is to minimise damage to the cargo resulting from this moisture migration. However, it will also be seen that such ventilation cannot always be completely effective and under some circumstances can be at least partially self-defeating. It follows that with certain cargoes, especially those where moisture movement is rapid, such as bagged rice and cocoa beans – which have been taken as examples in this article – no normal ventilating system can prevent cargo damage occurring as result of the conditions encountered during certain types of voyage.

The rate of moisture migration and the amount of moisture moving in water-holding cargoes will vary between the two extremes of bulk grain on the one hand and rice or cocoa beans on the other; but because of the wide variety of voyages undertaken and types of product carried, it is impossible to give precise recommendations (except under special circumstance) as to when ventilation should be practised. Many surveyors at present, work on the ad hoc basis that ventilation should be practised whenever weather conditions permit and, if under these circumstances sweat is formed, they consider the ship’s personnel have taken all reasonable steps to ensure a sound outturn. This is subject to the qualification that what is crudely termed ‘moisture migration in reverse’ does not occur; in other words, that the ventilation air introduced into the hold does not give up its moisture to the cargo. Moisture will be absorbed into cargo whenever the dewpoint of the interstitial air is lower than the dewpoint of the ventilating air. Unfortunately, however, it is virtually impossible onboard ship to measure the dewpoint of the interstitial air, and thus the decision of when or when not to ventilate cargoes of this type must still be based on a compromise between the scientific theory of the textbook and the practical experience of those engaged in the trade.

**Ventilation experiments**

**Introduction**

When maize arrives damaged by heating, the cargo interests frequently allege that the damage is caused by unsatisfactory ventilation. Thus it may be suggested that inadequate ventilation has permitted sweat to form on the ship’s structure, with the result that the cargo has been wetted on the surface. Alternatively it may be claimed that, because the ventilation is inadequate, the heat produced in a cargo was not removed, with the result that the damage becomes progressive.

Damage as a result of ship’s sweat is readily recognisable, and takes the form of a layer of mouldy grain on the surface of the cargo.

In many instances, particularly where the amount of damage is appreciable, a defence against a claim for such damage is to demonstrate that if in fact ventilation had been practised, the air would have been sufficiently cold to have cooled the top layer of grain with the result that moisture in vapour form would have migrated from within the bulk to the cooler surface. But, on encountering the cooler cargo in the surface layer, the vapour would have given up its moisture in the form of condensation on the cargo.

Thus instead of ‘ship’s sweat’, there would have been ‘cargo sweat’ – the total damage however, about the same.

This is, simply stated, the theory of ‘moisture migration’, which was judicially considered in John v The Turnbull Scott Shipping Co. Ltd. (The Flowergate) [1967] 1 Lloyd’s Rep. 1 – see in particular, the evidence of Dr Milton, quoted on pages 32 and 33 of the judgement.

Serious claims for damage however, normally arise from heating up within the bulk of the cargo and the question of efficacy of ventilation in removing heat and minimising progressive heating up in such instances had never been thoroughly examined on a scientific basis. It was therefore decided to examine the changes in temperature within the bulk of maize cargoes during shipment from South America to Europe.

**Conclusion**

These experimental shipments indicated that maize of low moisture content, loaded cool, will carry well over a relatively long voyage whether or not the surface of the bulk is ventilated. They showed further that it is only the surface of the cargo that responds to ventilation, the bulk of the stow remaining unaffected. This perhaps, is not surprising when one remembers how resistant maize is to the transfer of heat; its coefficient of thermal conductivity is less than that of asbestos, and as an insulator, it is about one-third as good as cork.

In general it can be said that the experiments confirmed the view previously expressed by Dr Milton, namely that ventilation is irrelevant to the carriage of maize in bulk.

This article and full details of these experiments are available under *Moisture migration and surface ventilation in the Loss Prevention – Carefully to Carry* section of the Club web website www.ukpandi.com
Measurement of bulk cargoes

Draught surveys – practice

- The vessel should ideally be lying in still, calm water. Otherwise errors, without ease of correction, from reading the draught marks can result. For example:
  - Vessels lying at exposed berths or anchorages where wave and swell surface disturbance is almost inevitable; even to the extent that the vessel may be rolling and pitching. In these circumstances it is usual to assess the actual mean water level over a number of readings to be at two-thirds of the distance between the lowest and highest levels of water as seen against the draught marks. Some experts advocate that, after studying wave patterns, a mean of the average highest and lowest draught readings should be used
  - Vessels which are lying at a river berth or in tidal conditions when strong currents are running. Under these conditions the draught marks should ideally be read over periods of slack water (provided that at a low water slack there is sufficient under-keel clearance)
  - Currents of appreciable strengths are likely to cause the vessel to change trim or pitch slightly and/or sink bodily into the water from her static draught (‘squat’). This phenomenon becomes more pronounced in shallow waters (shallow water effect)
  - Strong currents will result in raised water levels against the leading edge of a stationary vessel lying in flowing water. This is especially true when the flow is in the direction of a vessel’s bulbous bow.
- Draught marks must be read on both sides of the vessel: forward port and starboard; amidships port and starboard, and; aft port and starboard or, alternatively, if additional marks are displayed on large vessels at all the designated positions.
  - Should draught marks not be in place amidships, distances from the deck line to the water line on both sides of the vessel must be measured. The amidships draughts can then be calculated from load line and freeboard data extracted from the vessel’s stability booklet.
- Draught marks should be read with the observer as close to the water line as is safe and reasonably possible, in order to reduce parallax error.
- Although it is common practice to read the offside draught marks from a rope ladder, a launch or small boat provides a more stable environment and brings the observer to a safer position closer to the water line.

- When draught surveys are undertaken by independent surveyors, co-operation of the ship’s officers is essential.

- Independent surveys should be undertaken together, during the relative survey sections, with the vessel’s chief officer and chief engineer or their appointed respective deputies.

- Before undertaking the survey, it is recommended that the surveyor makes time to inspect a general arrangement plan in order to confirm the number and position of the various ballast, fresh water and oil bunker tanks on the vessel.

- Equipment which may be used in the survey:
  - Strong torch
  - Patent draught mark indicator or measuring devices (draught tubes, indicators etc)
  - Calibrated inclinometer or manometer
  - Steel tape measure with plumb bob / stainless steel sounding tape with brass plumb bob (preferably calibrated)
  - Sea water sampling bucket or can of sufficient volume
  - Calibrated patent draught survey hydrometer
  - Calibrated salinity refractometer
  - Ballast water-sampling device
  - Computer / calculator.

Reading the draught marks

- At the time of reading the draught marks, the vessel should be upright with a minimum of trim. The trim at survey should never exceed the maximum trim for which corrections may be included in the vessel’s stability book.
A vessel’s remote draught gauge should never be used for surveys, due to lack of the necessary accuracy and the possibility of errors, which may accumulate over the working life of the instrument.

When adverse weather conditions are being experienced, access to the offside draught marks may prove difficult or impossible. At these times the draughts on the nearside can be read and the offside draughts calculated using a manometer. This method should never be used when the offside draughts can be safely observed and accurately read. If, as a final resort, this method cannot be undertaken, the use of a fully calibrated inclinometer, graduated to minutes of arc, is strongly recommended. The type of inclinometer fitted to vessels is not usually of sufficient accuracy to be used.

Density of the water in which the vessel is floating

- It is prudent to obtain samples of water in which the vessel is floating at, or very close to, the time at which the draught marks are read. This is particularly relevant when the vessel is lying at an estuarial or river berth when density of the water may be changing, due to the ebb or flow of the tide.

- Depending upon the length of the vessel under survey, a number of samples, say between one and three, should be taken. In order to overcome the problem of layering, the samples should be obtained using a closed sampling can at a depth of approximately half the existing draught of the vessel. Alternatively, a slow-filling container can be used to obtain an average sample from keel to waterline.

- When reading the hydrometer floating in the sample of water, the eye of the observer should be as close to the water level as possible, to avoid parallax errors and also to avoid further errors due to the meniscus.

Ballast water tanks

- Ballast water tanks including peaks, even those said to be empty, must be carefully sounded or proven to be full by pressing up and overflowing from all air pipes when local regulations permit. If the ballast hold contains ballast water, this compartment must not be fully pressed up but be carefully sounded and the weights of the water carefully calculated.

- Spaces such as the duct keel and voids – especially those of the lower stools situated at the base of
transverse bulkheads, between cargo holds – must be checked when safe to do so, and proved in same condition at initial and final surveys.

These voids often contain the manhole access covers to the adjacent double-bottom tanks. If these covers are not totally watertight, then the voids will flood, or partially flood, during ballasting or pressing up of the tanks, potentially resulting in huge errors in the lightship or ballast survey.

- As noted above, the calculation of the weight of ballast water is undoubtedly the most usual source of errors which may result in very large, and unacceptable, inaccuracies of the cargo quantity as calculated by draught survey.

**Density of the ballast water**

- It should be established, with the chief officer, where the various ballast tanks were filled. If from a single source, the sea, a few random samples of the water will confirm its density. If from different sources, docks or rivers, etc samples must be taken from the tanks containing water from these various sources and relevant densities of the water in individual tanks established.

- Do not overflow the tanks substantially to obtain samples unless local regulations permit; instead use sampling equipment suitable for tanks that are only partially filled.

- When small samples are obtained, use a salinity refractometer to establish density (see below). When larger samples have been obtained, a draught survey hydrometer may be used. See details above.

**Establishing the correct weights of oils on board**

- This can be established either by sounding or ullaging of the tanks or, in the case of the engine room daily service and settling tanks, by reading the gauges.

- The volumes of oils in each and every tank should be measured and recorded.

- The relative densities of the most recently delivered oils on board can be obtained from the bunker delivery certificates. However bunkers are almost inevitably mixed with oils already on board, the densities of which are likely to differ. The relative density of the contents may be calculated using the following formula:

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\text{RD of tank contents at survey} = \frac{(\text{Old oil volume} \times \text{Old RD}) + (\text{New bunker volume} \times \text{New RD})}{\text{Total volume of oil in tank}}
\]

- After completion of the bunker survey the totals of each oil found must be agreed with the chief engineer and the master.

**Calculations and associated corrections of vessel's displacement from draught readings**

- Before extracting hydrostatic data from the vessel’s stability book, care should be taken by surveyors to familiarise themselves with the format and methods used to display the various particulars, especially the means of depicting positions of LCF (longitudinal centre of flotation) etc, relative to amidships or alternatively the after perpendicular.

- When using a recommended draught survey computer programme or alternatively calculating directly from data extracted from the hydrostatic particulars contained within the vessel’s stability book it is essential that the data is carefully and properly interpolated or, in what should prove to be a rare event, extrapolated.

- As mentioned below, one of the areas where significant errors often result is from the incorrect application of the sign in respect of the position of the LCF (in the first trim correction).

- When undertaking initial and final 'displacement draught surveys' to establish weight(s) of cargo loaded, or alternatively unloaded, the difference between the net displacement weights provides the ‘total cargo’ quantity. Nonetheless it is recommended for a cross check that, at the light ship / ballast survey, the vessel’s light ship weight is deducted from net displacement found. The resultant then provides the vessel’s ‘constant’ at that time. These unknown weights might also be termed the vessel’s ‘stores variable’. Although variable, for a number of reasons as later discussed, it should serve as a guide to the accuracy of the light ship / ballast survey.

Comparison between 'stores variable' quantities, or mean thereof, established at previous surveys should be treated with caution unless the variable is a direct comparison that can be made. For example, all surveys include a check and a record of the engine lubricating oil held in storage tank(s), etc.
Occasionally, surveyors report a ‘negative’ stores variable which is theoretically impossible unless, in extremely rare instances, the vessel had been subject to modification, and large quantities of structural steel removed, without being subject to a further inclining experiment and commensurate correction of the relevant data contained in the vessel’s stability book.

Charterparties often contain reference to an approximate quantity for the vessel’s ‘constant’, which may well create a discussion between master and surveyor should the constant found by survey to be substantially larger than that quoted by the owners. The surveyor, after relevant checks, should remain confident in the figure obtained, but always record on documents issued to the master and clients, any unusual factors or difficulties experienced during survey. These include any differences between surveyors, should owners, charterers or shippers each appoint separate survey companies to act on their behalf.

**Documentation**

- At completion of survey, a ‘survey work sheet’ or computer printout should be placed on board the vessel recording the data and calculations used to obtain the cargo loaded / unloaded quantity. This document is usually produced by individual survey companies, or by shipping companies for use by their officers.

- A formal ‘survey report’ should be submitted to clients at a later date. Specific formal documentation has been drawn up, amongst others by IMO, United Nations Economic Commission for Europe and various P&I Clubs.

- The formal report document should not only include details of the survey, but also:
  - Dates and times of surveys
  - Vessel particulars
  - Ship’s location
  - Weather conditions (and whether these were within acceptable limits)
  - Sea conditions (and whether these were within acceptable limits)
  - Tidal/current conditions (and whether these were within acceptable limits)
  - A record of any difficulties or defects in a ship’s documentation or equipment which might cause the calculated weight by draught displacement survey to be outside acceptable limits of normal draught survey measurement error.

**Expert opinion**

Surveys must be carried out to the very best of the surveyors’ ability, with each part of the survey conducted as accurately as possible in order to minimise procedural and/or measurement errors which could effect the quantity of cargo recorded by survey as being loaded or discharged.

The final report should include details of any defect or circumstance regarding weather, surface water, tides / currents or on board conditions which the surveyor considers might well influence the result adversely.

**Cumulative errors**

- Errors can occur when reading and correcting the draughts. The final fully corrected 3/4 mean draught should be within +/- 10 mm of the true mean draught.

- Errors of calculation. The main error to be avoided in this section is that of incorrectly positioning the LCF relative to LBP/2 the amidship point.

- Error of the water density in which the vessel is floating. Always ensure an average sample, or alternatively the average of a number of water samples are obtained and the correct type of certificated hydrometer is used to obtain the density.

- Sounding of tanks. Leaving aside documented tables which may not be accurate, the way of avoiding the main errors in this section of the survey is by ensuring, as best possible, that all volumes of liquids, especially ballast water, on board are both correctly quantified and attributed with correct densities. These factors, particularly when applied to ballast water, undoubtedly contribute to the largest number and degree of errors likely to be encountered in draught surveying.

Bearing these reservations in mind, a well conducted draught survey under reasonable prevailing conditions is capable of achieving an absolute accuracy of +/- 0.5%.

See following pages for a worked example

A full version of this article is available in the Loss Prevention – Carefully to Carry section of the Club website, www.ukpandi.com, under Miscellaneous – Measurement of bulk cargoes
**Worked example**

From the following information calculate the corrections to perpendiculars and the draughts at the perpendiculars. Also calculate the true trim.

**Vessel LBP 181.8 metres**

<table>
<thead>
<tr>
<th>Density at the time of draught reading 1.0185 t/m³</th>
<th>port side</th>
<th>stbd side</th>
<th>distance marks from perp.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forward draughts; 4.61m 4.65m</td>
<td>Fd = 2.94 m aft</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Midships draughts 4.93m 5.10m</td>
<td>Md = 1.44 m aft</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aft draughts 5.58m 5.60m</td>
<td>Ad = 7.30 m forward</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Forward mean = \((4.61 + 4.65)/2\) = **4.63m**

Midships mean = \((4.93 + 5.10)/2\) = **5.015m**

Aft mean = \((5.58 + 5.6)/2\) = **5.59m**

So apparent trim is: 5.59 - 4.63 = **0.96m**

And LBM is: 181.8 - 2.94 - 7.30 = **171.56m**

Forward corr’n = Apparent trim x Fd = 0.96 x -2.94 = **-0.0165m**

Midships corr’n = Apparent trim x Md = 0.96 x -1.44 = **-0.0081m**

Aft corr’n = Apparent trim x Ad = 0.96 x 7.3 = **+0.0408m**

Now:

Forward draught is 4.63 – 0.0165 m = **4.6135 m**

Midships draught is 5.015 – 0.0081 m = **5.0069 m**

Aft draught is 5.59 + 0.0408 m = **5.6308 m**

True trim is 5.6308 – 4.6135 m = 1.0173 **metres** = **101.73 cm**

¾ mean draught = (6 x 5.0069) + 4.6135 + 5.6308 = **5.0357 m**

From the original survey the following data was given in the vessels hydrostatic particulars:

**Scale density of hydrostatic particulars 1.025 t/m³**

<table>
<thead>
<tr>
<th>Draught</th>
<th>Displacement</th>
<th>TPC</th>
<th>LCF</th>
<th>Draught</th>
<th>MCTC</th>
<th>Draught</th>
<th>MCTC</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.00</td>
<td>19743</td>
<td>42.32</td>
<td>-4.354</td>
<td>5.50</td>
<td>445.5</td>
<td>4.50</td>
<td>434.9</td>
</tr>
<tr>
<td>5.10</td>
<td>20167</td>
<td>42.37</td>
<td>-4.289</td>
<td>5.60</td>
<td>446.6</td>
<td>4.60</td>
<td>435.9</td>
</tr>
</tbody>
</table>

The stability book stated that a negative (-) sign for Lcf indicated forward of midships.

Interpolating the data from the table (it is easier to use centimetres in the interpolation rather than metres)

The difference in the tabulated draughts is 10 cm and the draught we are looking for is 3.57 cm more than 5 metres

*continued over*
Therefore:

Displacement for 5.0357 m draught = \[19743 + (20167 - 19743) \times 3.57 = 19894.37\]

TPC for 5.0357 m draught = \[42.32 + (42.37 - 42.32) \times 3.57 = 42.338\]

LCF for 5.0357 m draught = \[-4.354 + (4.354 - 4.289) \times 3.57 = -4.331 \text{ (for'd of mid)}\]

MCTC for 5.0357 +50 cms = \[445.5 + (446.6 - 445.5) \times 3.57 = 445.89\]

MCTC for 5.0357 – 50 cms = \[434.9 + (435.9 - 434.9) \times 3.57 = 435.26\]

Therefore \((dm - dz) = 10.63\)

The first trim correction is = \[\frac{101.73 \times -4.331 \times 42.338}{181.8} = -102.61 \text{ tonnes}\]

Second trim correction = \[\frac{1.0173^2 \times 50 \times 10.63}{181.8} = +3.03 \text{ tonnes}\]

Then vessels displacement at a density of 1.025 t/m³ is calculated as follows:

Displacement for 5.0357m = \[19894.37 \text{ tonnes}\]
First trim correction = \[-102.61 \text{ tonnes}\]
Second trim correction = \[+3.03 \text{ tonnes}\]
Corrected displacement in salt water = \[19794.79 \text{ tonnes}\]

This is the weight of the ship at the draught if it was in salt water of density 1.025 t/m³, which is the density of the ship’s hydrostatic scale.

However it is floating in water of apparent density 1.0185 t/m³.

So true displacement = \[\frac{19794.79 \times 1.0185}{1.025} = 19669.26 \text{ tonnes}\]
Silver nitrate test

For the detection of seawater contamination in cargoes

A solution of silver nitrate in distilled water is regularly used as a simple test for the detection of seawater contamination of ships’ cargoes. Whilst the test is a useful preliminary test for saline contamination it should be considered as indicative only. It has limitations and should not be relied on as definitive proof of saltwater contamination; more detailed laboratory analysis will be required to confirm this. The reaction is shown below.

This reaction results in the clear test solution turning a cloudy white as insoluble silver chloride is displaced out of the solution.

<table>
<thead>
<tr>
<th>Silver nitrate (clear solution)</th>
<th>Sodium chloride (salt) (contamination)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sodium nitrate (clear solution)</td>
<td>Silver chloride (insoluble white precipitate)</td>
</tr>
</tbody>
</table>

In order to undertake a ‘spot’ test in situ, surveyors will normally carry a small dropping/pipette bottle containing acidified silver nitrate solution. A few drops of the solution should be dropped onto both the suspected contaminated and apparently uncontaminated areas of the subject cargo.

Alternative samples of the cargo both apparently contaminated and uncontaminated should be obtained, placed into sealed plastic sample bags, and removed for later testing.

It is essential to use distilled water to wash the test samples as the presence of chloride in some waters may produce anomalous results.

The test solution should also be acidified with nitric acid to prevent the formation of other silver salts.

Laboratory identification of water origins

The source, or origin, of a particular water contamination can be identified in the laboratory by a number of different testing procedures. The testing procedures are as follows:

- Quantitative determination of anions (i.e. chloride, nitrate etc) and cations (sodium, potassium etc) by ion chromatography.
- Quantitative determination of metals, such as sodium, magnesium, calcium, potassium and strontium, using either inductively coupled plasma emission spectroscopy (ICPES) or atomic absorption spectroscopy (AAS).

Test procedures

Quantitative chloride determination by titration

Two methods are available, one involving titration against standard silver nitrate solution using potassium chromate as an indicator and the other, involving titrating against a standard solution of a soluble mercury salt using diphenylcarbazone as an indicator. The chloride concentration is calculated from (i) the volume of standard silver nitrate solution used (ii) the volume of sample taken and (iii) normality/molarity (strength) of the standard solution used.

Determination of anions and cations by ion chromatography

In this instrumental technique a sample (i.e. water) is introduced via an injection loop into the eluent passing through the system. The sample is then pumped through an analytical ion exchange column, which will separate the various ions (i.e. anions or cations). The

Typical anion chromatogram and standard
separated ions are then detected using a conductivity detector and the peak areas reported are directly related to the concentrations. The peak areas of the individual anions (i.e. chloride) are compared to standard solutions and the concentration in the actual sample calculated. Examples of a typical anion chromatogram and standard are shown on the previous page. The determination of the cations (i.e. sodium) is done separately using the same instrument but with a different eluent and column system.

**Determination of cations using ICPES or AAS**

These two analytical techniques will determine the concentrations of various metals/cations, such as sodium, calcium, magnesium, potassium, strontium etc in an aqueous solution. The two techniques can be described as follows:

- **AAS** is an analytical technique in which the sample to be analysed is converted into an atomic vapour by spraying the sample or solution of the sample into a flame. The absorbence at a selected wavelength for each individual metal/cation is measured and compared to the absorbence measurements of the sample and standard.

- **ICPES** is an analytical technique where the sample solution is introduced into an inductively coupled argon plasma at a temperature of approximately 8000°C. At this temperature the individual elements (cations) become thermally excited and emit light at their characteristic wavelengths. This light is collected by the spectrometer and amplified to yield an intensity measurement that can be converted to an elemental concentration by comparison with known standards.

**Dry cargoes (spot test)**

As noted before, for many dry cargoes such as steel, for example, an indication of seawater contamination can be achieved on site by the ‘silver nitrate spot test’. The basis of the test is that addition of acidified silver nitrate to any solution containing chlorides will produce a white precipitate of insoluble silver chloride. The chloride content of most seawaters would be expected to be around the 20,000 ppm level. Therefore, the addition of acidified silver nitrate to seawater will produce a dense white precipitate making the solution appear ‘milky’. The test is performed by the attending surveyor by adding a small amount of acidified silver nitrate to any contaminating water found on the dry cargo. If the resulting solution appears ‘milky’ then it is possible that seawater contamination has occurred. However, as stated previously, to confirm the presence of seawater further laboratory analysis will be required. An alternative to the silver nitrate spot test is to take swabs of the contaminating water, which should then be placed in a suitable airtight container and submitted to the laboratory for further analysis.

It is important to note that certain other water sources, such as brackish or river water, will contain chlorides and would also produce a ‘milky’ solution with the addition of acidified silver nitrate. Even domestic tap water contains enough chlorides to give a slightly ‘milky’ solution when tested with acidified silver nitrate.

The silver nitrate spot test should be applied to galvanised goods with caution as it gives a black precipitate due to interference from the zinc present. In addition, the silver nitrate spot test can be misleading when applied to certain types of packaging, leather goods etc, which may, themselves, contain chlorides. Control samples of uncontaminated cargo should, where possible, always be obtained and/or tested in situ.

**Liquid petroleum cargoes (laboratory test)**

Unlike dry cargoes, any water contamination of a liquid petroleum cargo will become either suspended within the cargo and/or percolate through and settle on the tank bottoms. The nature of the petroleum cargo will dictate whether the contaminating water will settle to the bottom of the cargo tanks. For example, a viscous fuel oil cargo is more likely to retain the water in suspension than a gasoline or kerosene cargo.

Unfortunately, water contamination of a petroleum cargo will almost certainly not be spread homogeneously throughout the entire cargo, which makes representative sampling extremely difficult.

However, the identification of the type of water present can be achieved using either the AAS or ICPES techniques described previously. Prior to the use of either of these techniques, the petroleum/water sample will have to be ignited and burnt until only an ash remains. This ash is then dissolved in either an acid or a flux and an aqueous solution is prepared, which is then examined using either AAS or ICPES to determine the concentrations of the metals/cations present. The analysis of samples taken from various stages of the voyage (i.e. loadport shore tanks, after loading and before discharge) can be determined. In conjunction with the actual water content, it is then possible to produce a ‘cation fingerprint’ of the water present in the samples taken at various stages of the voyage, which can then be used to try and identify the source of the contamination.
Water sources (fingerprinting)
There are a number of different possible sources of water, such as seawater, domestic water, distilled water, brackish water, river water, spring water, production (oilfield) water etc, and each source of water will vary depending on the geographical location.

The following comments are useful in determining the type/source of any water associated with a dry or liquid cargo:

- Production (oilfield) waters have very high sodium and chloride levels, which are significantly higher than the levels found in seawater.

- The calcium levels in production waters are significantly higher than the magnesium levels, which are the reverse for seawater, where the magnesium levels are higher. The calcium/magnesium ratio is a useful indicator as to whether the water is seawater or production origin.

- River waters will vary in cation and anion levels, depending on whether it is tidal and the levels will vary during the day depending upon the state of the tide.

- Domestic tap water would be expected to have a chloride level of less than 100 ppm. However, other salts, such as magnesium, calcium etc, will vary, depending upon whether a hard or soft water area.

- The individual metal/cation concentrations will vary in seawater, depending upon the geographical location and it is possible that this type of analysis can indicate the location of the seawater. For example, the typical concentrations noted below vary significantly and the levels found say, in the Black Sea, are very much lower.

- The major cations and anions of seawater and some typical values are as shown below:

<table>
<thead>
<tr>
<th>Anion</th>
<th>Cation</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chloride</td>
<td>(Cl)</td>
<td>18,980 mg/kg</td>
</tr>
<tr>
<td>Sodium</td>
<td>(Na)</td>
<td>10,561 mg/kg</td>
</tr>
<tr>
<td>Magnesium</td>
<td>(Mg)</td>
<td>1,272 mg/kg</td>
</tr>
<tr>
<td>Sulphate</td>
<td>(SO₄)</td>
<td>884 mg/kg (as S)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2,652 mg/kg (as SO₄)</td>
</tr>
<tr>
<td>Calcium</td>
<td>(Ca)</td>
<td>400 mg/kg</td>
</tr>
<tr>
<td>Potassium</td>
<td>(K)</td>
<td>380 mg/kg</td>
</tr>
<tr>
<td>Bromide</td>
<td>(Br)</td>
<td>65 mg/kg</td>
</tr>
<tr>
<td>Carbonate</td>
<td>(CO₃)</td>
<td>140 mg/kg</td>
</tr>
<tr>
<td>Strontium</td>
<td>(Sr)</td>
<td>13 mg/kg</td>
</tr>
</tbody>
</table>

- Brackish water is defined as water having a chloride content in excess of 2,000 ppm.

Glossary of terms

**Anion**: A negative ion.

**Cation**: A positive ion, molecule or radical.

**Chromatography**: A method for the separation of trace constituents of the sample by passing gaseous mixture through a column of finely divided powder which selectively absorbs the constituents in one or more sharply divided bands.

**Chromatogram**: The array of distinctive bands produced by chromatography.

**Eluent**: The aqueous carrier of the sample through an ion chromatography system.

**Ion**: An electrically charged atom, radical or molecule formed by the dissolution of an electrolyte.

**Molarity**: Gram molecular weight, concentration of a solution.

**ppm**: Parts per million.

**Spectroscopy**: The science and practice of using spectrometers and spectroscopes in chemical analysis and studies of atoms, molecules, ions etc.
Additional material

The UK Club has a large information resource on most aspects of the carriage of bulk materials. Most of these are accessible on the Club website www.ukpandi.com and some have also been published in printed form.

The following is a selection of what is available. Further information can be obtained by contacting the Club – details on the back page.

Carefully to Carry

The Carefully to Carry section is accessed from the main Loss Prevention page via Cargo Stowage Advice. It has a wide variety of topics on Dry Bulk Cargoes.

LP Bulletins

These bulletins are constantly updated on our website to keep Members up to date with current issues of concern or interest. Here are three examples:

743 - 02/11 - Asian Gypsy Moth high risk period - Canada

Date: 18/02/2011

The Canadian Food Inspection Agency has advised that the Asian Gypsy Moth high risk period for Canada will start on 1 March 2011.

All vessels that have called at high risk ports (in Russia, Japan, China & Korea) during the period June-December 2010 will not be permitted to enter Canada unless they have a PhytoSanitary Certificate or are inspected at the entrance to Canadian waters.

If any sign of Asian Gypsy Moth is found during inspection, the vessel will be rejected and not allowed to enter Canadian waters during the country’s high risk period, from 1 March to 30 June 2011.

15 October 2011.

The high-risk ports in Asia are as follows:

RUSSIA:
Kosmoino, Nakhodka, Orija, Plastun, Pos’yet, Russky Island.

JAPAN:
Ashi, Aida, Aomori, Chiba, Ehime, Fukuoka, Fukushima, Hakodate, Hakodate, Hamamon, Horoishima, Hokkaido, Hyogo, Ibaraki, Ishikawa, Iwate, Kagawa, Kagoshima, Kanagawa, Kobe, Kochi, Kumamoto, Kyushu, Mie, Miyagi, Miyazaki, Nagasaki, Oita, Okayama, Oita, Otsu, Osaka, Otsu, Saga, Sakai, Shikoku, Shimane, Shimogunigawa, Shizuoka, Tokushima, Tokyo, Tomakomai, Tottori, Toyama, Wakayama, Yamagata, Yamaguchi.

CHINA:
All ports in northern China, including all ports north of Shanghai.

KOREA:
All ports.

For Members convenience a list of Recognized Sources of PhytoSanitary Certificates and Pre-departure Inspection Certificates as given on the Canadian Food Inspection Agency is copied below.

QUOTE
List of Recognized Sources of PhytoSanitary Certificates and Pre-departure Inspection Certificates

Phytosanitary Certificates issued by the NPPO of Russia and the Republic of Korea.

Pre-departure Inspection Certificates issued by the China Certification and Inspection Co. Ltd. in the People’s Republic of China.

All Nippon Checkers Corporation (NAGCO)
Japan Export Vehicle Inspection Center Co., Ltd. (JEVIC)
Japan Grain Inspection Association (JGIA)
Nippon Kaikai Kogyo (NKKO)
Shin Nihon Kentei Kogyo (SNK)
Holkado Bioekologi Co. Ltd. (HBERG)
Kanto Fumigak Co. Ltd. (KFCO)
Kobe Plant Quarantine Association (KOBPEQA)
Kefjouchi Plant Quarantine Association (KOPQA)
Kyonan Bantou Co. Ltd. (KBC)
Maranor & Tomakamai Plant Quarantine Association (MPQPA)
Nihon Co. Ltd. (NCL)
Okayama-Ken Plant Quarantine Association (OKQPA)
Osaka Plant Quarantine Association (OPQPA)
Osaka Timber Quarantine Association (OSQPA)
Techno Kaiko Co. Ltd. (TKC)
Tokai Plant Quarantine Association (TOKQPA)
Tokyo Plant Quarantine Association (TPQA)
Yokohama Plant Protection Association (YPPA)

UNQUOTE

Source of information: CANADIAN FOOD INSPECTION AGENCY
59 Camelot Drive
Ottawa, Ontario, Canada, K1A 0X9
www.inspection.gc.ca/english/pests/pesttravelsyncmds/tsympsdse.shtml
741 - 02/11 - Trade allowances - Italy

Date: 04/02/2011

Nowadays, the majority of claims which might be faced by vessels discharging in Italian ports concern cargo shortages. There is much confusion and uncertainty about the trade allowances which can be enforced against cargo receivers who are claiming for cargo shortages, so there is a widespread tendency to settle these disputes out of court, because of the absence of clear and unambiguous judgements in this regard.

Very often the local correspondents (or their surveyors) suggest some criteria to identify the trade allowances to be applied to a certain shortage, which then result devoid of meaning and without any legal acknowledgement and are easily rejected by claimants’ solicitors. Recently many correspondents and surveyors do suggest to apply the decree law 56 of 12th January 2000, regulation laying down rules on natural and technical losses for goods subject to customs and excise duties bond. This law does not express a will of the legislator to establish the trade allowances to be applied in all Italian ports but, as stated in the title of the law, sets out the exemptions in weight allowed for the payment of taxes and customs duties on goods imported. Therefore this law is not enforceable against claimants.

The Italian law has delegated to the local Chambers of Commerce to issue periodic collection of “Customs and Practices” that should establish trade allowances applicable on goods discharged at ports. Therefore, in order to identify the trade allowance for a given commodity in a given port, reference should be made to the provisions of the Chamber of Commerce of the province where the port is located. Obviously, this system implies that there are differences between each port and certainly cannot be drawn as a unique chart of trade allowances for all Italian ports, easily accessible by each foreign operator.

Shipowners or P&I Clubs. This is even more complicated by the fact that no Chambers of Commerce have drawn up the collection of “Customs and Practices” and, of those who have made it, do not have considered trade allowances for all types of goods. In this case, it’s our opinion that, where a Chamber of Commerce has not regulated the trade allowances for a port, it should be applied those provided by the Chamber of Commerce of the nearest port. Unfortunately, here too the doctrine is not helpful, since there are no judgements related to these cases. Anyway, we believe that this approach represents a valid instrument in order to mitigate or resolve a claim, even if not many lawyers are willing to undertake legal proceedings in order to obtain a full compensation for a shortage that is considered customary and tolerable in the most of Italian ports. Although, as above stated, trade allowances are not the same in all the ports, for your guide and reference, we herebelow report a scheme of average trade allowances for a number of commodities, in case of shortage, we highly recommend that you ask us for confirmation whether or not, as set forth below, the considered commodity is in a given port.

<table>
<thead>
<tr>
<th>Bulker Cargoes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ebars</td>
</tr>
<tr>
<td>Calcium</td>
</tr>
<tr>
<td>Cement</td>
</tr>
<tr>
<td>Coal</td>
</tr>
<tr>
<td>Coke</td>
</tr>
<tr>
<td>Fertilizer</td>
</tr>
<tr>
<td>Grains</td>
</tr>
<tr>
<td>Kolin</td>
</tr>
<tr>
<td>Metals</td>
</tr>
<tr>
<td>Oils</td>
</tr>
<tr>
<td>Petrol Coke</td>
</tr>
<tr>
<td>Pig Iron</td>
</tr>
<tr>
<td>Steel Scrapa</td>
</tr>
</tbody>
</table>

We would remind you, as mentioned in our previous bulletins, the best weapons to dismiss claims for shortage is appointing an independent surveyor at loading and discharging port. Please also note that, even if the Charterers exempt the Shipowners in the Charter Party from any cargo claims, if the Bill of Lading doesn’t contain in the front page the following specific clause: “all terms and conditions of the CIP (place and date of issue) are hereinafter fully incorporated, including the arbitration clause”, according to the Italian Courts, the vessel is responsible for cargo claims (including shortages) and the Charter Party couldn’t enforce against the Cargo Interests.

Source of information: Marco Guiglielmo

728 - 12/10 - Grain Shortage Claims/Trade Allowances - Saudi Arabia

Date: 03/12/2010

Similar numbers of claims are received from Jeddah and Yanbu, on the Red Sea Coast, and Dammam, in the Arabian Gulf. Bulker grain cargoes are generally discharged into trucks. In almost all disputes, the receivers seek to rely upon figures generated by shore weighbridges, rather than draught surveys. In some cases, the differences between the ship and shore figures produce large potential liabilities.

The local P&I Correspondent during the period 1985-87 faced with numerous bulk barley shortage claims, conducted a large investigation with the assistance of ESG.

The study revealed a close correlation between ship and load ports. Canadian barley had a very high level of good extension. Shortage rarely exceeded 0.25% and there were frequently a small excess. Australian barley likewise had generally good quality results. We find that those results are still relevant today. The majority of the large shortage figures appear to emanate from cargoes loaded in Black Sea ports, where we believe load figures can be in doubt. In particular, cargoes are being loaded from barges or railway trucks, from which load figures appear neither accurate nor reliable.

In general, the accuracy of port weighbridges in Jeddah Port appears to be good. They are calibrated about every 3 months, and we are able to verify the calibration certificates without question. The minimum measurement accuracy of the port weighbridges is 20 kg. The machinery records all weights to the nearest 20 kg. However, when multiplied by the total number of trucks used for discharge, a 20 kg difference per truck does not add up to an enormous shortage.

Cargo discharged into the privately operated silos in the port is a different matter. These silo operators are responsible for their own check and calibration. We have on occasion found very large inaccuracies, and poor operating procedures. The private silo operators have previously been unable to obtain an official customs certificate of shortage when the cargo is cleared from the port.

Security has become so tight in Jeddah in recent years, that we no longer think it possible to engineer the disappearance of complete trucks through the port gates. Even if it were possible, it requires the “disappearance” of a good number of trucks to produce a large shortage.

The local P&I Correspondent advise that best practice for minimising or avoiding such claims probably starts at the load port. Accurate draught surveys should be conducted and compared with the shippers’ figure. If material differences are noted, then the appropriate protests should be lodged. On completion of loading, the hatch covers should be sealed. At the discharge port, the Correspondents recommend that a surveyor be appointed to attend onboard and to issue with the receivers, who should be invited to witness the unloading of the hatch covers and to participate in draught surveys, and ensure that “Empty Hold Certificates” are issued on completion of discharge.

For all grain ships now arriving at Saudi Ports, the receiver will issue a notice to the agents advising that on completion of discharge, if any shortage is noted, they will require a P&I Club letter of undertaking for the value of the shorttended cargo, otherwise they will not permit the vessel to sail.

All receivers used to demand a P&I Club letter of undertaking for any shortage, and would not accept any LOI to include any reference to a trade allowance.

The legal position in respect of shortage claims, depends entirely on the contract of carriage and the evidence available. If the contract gives the owners no protection, the chances are high that the Saudi Courts will hold the owners responsible for shortage based on the usual customs certificate (based on weighbridge figures). However, there have now been significant developments with a number of shortage claims going through the Saudi Courts. There have now been 7 judgements issued by the Saudi Courts accepting the concept of a transport/ trade allowance, one of the judgements being final and unappealable. In view of this development, we are finding that the majority of Saudi receivers are now allowing a ship to sail on completion of discharge if any shortage is noted to be less than 0.5% of the manifested quantity, but some are still adamant and will still require a P&I Club LOI for the smallest of shortages.

There is no duty of disclosure of documentation in Saudi law, so we cannot insist that the consignee produce the sale contract or insurance policy, even though it is known to us that many cargo underwriters give cover subject to a deductible of 0.5%, which tends to reinforce the argument for the trade allowance. The current trend documents are not received in evidence unless we have good evidence to show that the cargo purchase is based on quality or draught survey, not Bill of Lading figures. This will require the supplier to confirm the basis on which the cargo was sold.

We strongly recommend that owners pay close attention to the detail of the contract of carriage:

1. Ensure that any shareparty is properly incorporated into the Bill of Lading by reference to date, place and form of the contract.
2. Ensure that the Bill of Lading contains a jurisdiction and/or arbitration clause.
3. If the cargo purchase is based on draught survey, the cip should similarly contain...
**Bulk Carrier Practice**

The second edition of the Nautical Institutes *Bulk Carrier Practice* is available at a 40% discount to Members (£75 instead of £125). The offer price also includes the Club’s DVD *Bulk Matters*. The Club has also published extracts of the book on its website to help raise awareness of issues in the bulk carrier trade.

**Soundings**

Importance of soundings: Throughout the loaded voyage, as at all other times, soundings of cargo spaces, ballast tanks, void spaces and burner tanks should be taken and recorded daily by the same competent person. The readings obtained should be inspected carefully for any unexplained increases or decreases in the values observed. When the sounding positions are located on the open main deck and when the vessel is in adverse weather with a low freeboard, it is often unsafe to obtain soundings on the ship’s weather side or even on both sides. This is unfortunate, though unavoidable once the ship’s design has been finalized. In these circumstances the chief mate should be alert for any opportunity occurring when in the lee of land or because of an improvement in the weather to obtain a set of soundings. Failing this the hold bilge should be pumped daily until suction is lost. Reasons for any failure to obtain soundings should be logged.

During the 1980s and 1990s there were numerous indications that aboard body-run bulk carriers a full set of soundings was sometimes not obtained for days or weeks on end. It is true that almost every case soundings, when taken only confirm what the chief mate already knows – namely, that the ship is not leaking. It is only when soundings are obtained daily, at the very least, that there is a reasonable chance that any damage or overspill will be detected promptly when it occurs. Water ingress detectors, if working properly, should detect serious flooding in forward or cargo holds at an early stage but will not detect water at tanktop level. Such water would seriously damage or even destroy a variety of cargoes and in addition would give warning that something was wrong. The safe delivery of cargoes can depend upon this seamanship precaution and the daily taking of soundings should never be neglected.

High soundings in ‘empty’ tank: Warning of a leak is provided by increased soundings in ballast tanks or void spaces and must be investigated promptly. First it may be necessary to pump out the compartment. Provided that the flooding is not too rapid such an investigation will normally involve entering the compartment – taking all the proper precautions when entering an enclosed space (see chapter 21) – and searching for the source of the leak. When the leak has been found, the problem can be assessed and the correct action chosen.

Interpretation of high soundings in a cargo space: When increased soundings are found in a cargo space loaded with bulk cargo there are a number of possible explanations and each should be considered. The water may have drained from the cargo or leaked through the hatch covers. It may have entered through an unbanked access hatch or an uncrapped sounding pipe. Water may have leaked through a fracture in the deck or the hatch coaming or through a damaged ventilator.

It is regrettable that officers of many ships have no accurate idea of the capacity of the hold bilge wells. This means that they cannot say whether an increase in sounding of 0.5 metres represents 1 tonne of water, or 10 tons. That makes it more difficult to assess the significance of any increase in hold bilge sounding. The solution to this is simple. Measurements should be taken when the holds are empty to prepare simple calibrations. Of greatest value are the soundings of the bilge when full and the approximate lançages of water contained by the bilge when full.

When preparing calibrations for the hold bilge wells two important points must be remembered: if the sounding pipe does not run vertically the actual full sounding will be greater than the vertical depth of the bilge well (Fig. 6.8) or it is the actual full sounding which is required, since that is what the sounding rod measures. On some ships a number of the bilge wells may have exactly the same dimensions, but every one must be inspected in case the arrangements inside are different. Details of design near the engine room or in a ballast hold, for example, sometimes require one or two bilge wells to be of a different shape and size to the others or to have the sounding pipe positioned differently and soundings will be very misleading unless this is known.

High soundings caused by drainage from cargo: Abnormal ship which is well operated and...
Checklists

Part of a new, well-received initiative are the ‘How to...’ checklists. These handy, pocket sized booklets are designed as an aide-memoire to essential operations on board ship. At the moment, two are specifically targeted towards current cargo issues – Indonesian coal and Indian iron fines.

Cargo photo library

The UK Club online cargo photo library has an extensive range of photographs which can provide a back-up to Members’ presentations and risk awareness programmes. Copies may only be made for outside use by permission.
Cargo Matters series (DVD)

At least seven out of ten cargo claims arise from incidents caused by human error. The ‘Cargo Matters’ series aims at increasing awareness of the causes of P&I claims for cargo damage and loss. The first ‘Cargo Matters’ concentrates on general cargo loss prevention and the rest of the series concentrate individually on specific trades – Bulk, Tanker, Container and Gas.

www.ukpandi.com – Current claims issues

The Club’s website is an information resource which is constantly updated. An example of this is the section devoted to current claims and their impact on the day-to-day operation of fleets.