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CAREFULLY TO CARRY

A compilation of reports from the Association's Advisory Committee on Cargo Claims

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For and on behalf of the Managers of

The United Kingdom Mutual Steam Ship Assurance Association (Bermuda) Limited

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Preface

"The carrier shall properly and carefully load, handle, stow, carry, keep, care for and discharge the goods carried".

Hague Rules, Article III, Rule 2

The first report of the Association's Advisory Committee on Cargo Claims was issued in 1961, and while some of the problems discussed have disappeared, we believe that most of the advice given is still of value. However, we have tried to bring previous articles up-to-date and present them in a more logical format.

In re-writing many of the articles, we have tried to get the original authors to amend their earlier works. Where this has proved impossible, we have asked a number of practicing experts to assist. We would like to extend our thanks in particular to John Banister and Neil Gardiner for their tireless efforts, as well as to Jim Chubb, Kai Aamlid, Cliff Mullins and John Knott.

At the risk of stating the obvious, experience has shown that cargo claims could be reduced if greater care was shown by following some of the general principles of the safe carriage of cargo:

- Vessels being suitable for the particular cargoes and staffed by efficient personnel.
- Cargo presented for shipment in a suitable condition for transport by sea and adequately packaged where necessary.
- Proper stowage and care of cargo during the voyage, particular attention being paid to dunnaging, securing and ventilation.
- Supervision of cargo handling by stevedores.
- Proper tallying of cargo.
- Efficient security measures for guarding cargo whilst in the custody of the shipowner.

The Committee respectfully emphasises the importance of complying with the Association's Rule 5(N) that notice of impending claims should be given to the Managers. It is clearly advantageous if immediate reports concerning any circumstances likely to give rise to a claim are given to the local representatives both at the loading and discharging ports. The master and agents at ports of call should be kept informed of the Association in which the vessel is entered. It is suggested that this information may be given in the owner's letter of instructions to their local agents prior to the vessel's arrival.

Such action should allow closer co-operation between the vessel's local agent and the Association's correspondent, so ensuring that claims are given prompt attention as they arise. This early notice will allow the Association's correspondent to use, to the full, previous experience gained from similar claims and allow pertinent information to be passed from port to port

Seldom are reports of damage prior to loading sent to the Association's representatives at loading ports. It is important that this should be done, particularly on parcels which have already been subjected to a long journey from the hinterland. The Association's representatives will assist in assessing the extent of damage and in seeing that the bill of lading is properly endorsed. Prompt notification of damage in any consignment offered for loading is of great importance.

A close watch should be kept for the repetitive type of claim for damage to cargo, of the same cause or nature, occurring on a particular vessel or type of vessel, or in respect of certain cargoes, so that remedial action can be taken.

We trust Members will find the following reports from the Committee of interest. Should Members wish to put forward further topics for consideration by the Committee, these would be welcomed. All requests should be forwarded to the following email address: karl.lumbers@thomasmiller.com

Karl Lumbers

Chairman, Advisory Committee

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Section 1

Bulk cargoes – solid

Part 1

Measurement of bulk cargoes

It is widely accepted that during the transportation of bulk cargo, some loss will unavoidably occur but when the shortage exceeds a percentage regarded as customary in that trade the carrier is often held responsible. One of the causes of shortage claims is that it is virtually impossible to precisely determine the weight of large quantities of dry bulk cargoes either afloat or ashore.

Determination of weight onboard ship

Two methods of determining the weight of a dry bulk cargo loaded onboard a ship have in the past been used:

- On the basis of the 'free space' in a compartment (measurement and stowage factor).
- On the basis of draught surveys.

Measurement and stowage factor

On completion of loading, the free space in each cargo hold is measured and from this the volume occupied by the cargo is calculated. This volume when divided by an assumed stowage factor, gives the **approximate** weight of the cargo. **This method gives no more than an estimation**. Furthermore, the exact stowage factor is seldom known and the assumed figure may be quite inaccurate. The stowage factor can be ascertained correctly only by a laboratory analysis of samples from the cargo. Proper sampling is essential since the analysis must take into account the nature of the cargo, the moisture content, the percentage of foreign matter present and the age of the commodity. The figure may also vary considerably for other reasons. For example, in grain cargoes, so called 'spout lines' may develop since grain in a cargo hold tends to separate into heavier and lighter components. Also almost all bulk grain cargoes settle during transport as the kernels and shells collapse. The result is an increase in weight per unit volume and a lower stowage factor. It follows in such cases that the weight of cargo calculated on the basis of free space measurement after loading will indicate a greater quantity of cargo than that calculated before discharge, if the same assumed stowage factor is used.

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Draught surveys

Although a draught survey is simple in principle, in practice it is frequently a complicated and time-consuming way of attempting to ascertain the weight of cargo loaded onboard a ship. Many factors are involved, practically none of which can be established with a complete degree of accuracy.

A draught survey starts with a reading of the ship's draught, on both sides; forward, amidships and aft. There are a number of limiting factors:

- Often it is difficult to accurately read the draught because of the prevailing weather conditions and the presence of waves on the water surface.
- The draught should be read from a position as close to the waterline as possible in order to avoid parallax but this may not always be practicable.
- A ship moored in a tidal stream or current will be affected by squat, especially in shallow water and this will have a further effect.
- A draught can be affected when there is a large difference between the temperature of the air and of the water. This will cause a difference in the expansion of the submerged and the emerged sections of the ship. There is no currently acceptable method of correcting for this.
- When a ship is not on an even keel (as is always the case before loading and after discharge) the draught readings must be corrected for trim. It should be borne in mind that at such times, the draught marks are not in line with the forward and after perpendiculars.
- The draught must be corrected for the density of the water in which the vessel is floating. The determination of the density of dock water is not easy. It is difficult to obtain a reliable average density because this will vary at different levels and locations around the ship.
- Finally, the draught has to be corrected for hog and sag. This correction is generally calculated on the basis that a ship will bend parabolicly, which is not in fact the case.

Eventually a mean draught figure is obtained (a double mean of means) which by comparison with the ship's displacement scale, gives the corresponding displacement. The ship's displacement table may not however always be

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completely accurate. This is usually supplied by the shipbuilder and the methods used to make up the tables may not always be totally reliable. Similarly the trim correction may be derived by the use of various formulae not all of which are entirely accurate.

A draught or displacement survey

This method entails reading the draught before and after loading and thereafter comparing the two displacement figures. The difference between the two is the weight of the cargo loaded. Whilst this method eliminates the need to allow for the 'variables' and the 'constant', there are still certain disadvantages.

If, during loading and discharging, no shifting of weights were to take place other than the movement of cargo, then the calculation could be considered to be reasonably accurate. In practice, this seldom occurs. Frequently ballast is loaded or discharged during cargo work and it is unlikely that the exact amounts of ballast involved can be accurately calculated.

When sounding ballast tanks, especially with a large stern trim, it is difficult to ascertain whether a tank is completely dry. When a ballast tank is pressed up to overflowing it does not necessarily follow that the tank is 100% full. When tanks are filled quickly in the trimmed condition, up to as much as 10% of the tank capacity may be taken up by air pockets.

Moreover, the densities of the water in the ballast tanks may not be known to the necessary accuracy. This may affect the figures considerably, especially where large quantities of ballast are involved. Other 'variables' may also change during cargo operations as fuel stores and water are consumed or replenished. These amounts also can rarely be calculated with any degree of accuracy.

Determination of weight ashore

When dealing with claims for short delivery, which are commonly based on the accuracy of shore weights, the following points should be considered:

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Mechanical weighing

Mechanical weighing ashore may be effected by any one of the following methods:

- Weighing individual bags.
- Taking lorry loads of bagged cargo over a weighbridge.
- Taking lorry loads of bulk cargo over a weighbridge.
- Conveyor belt feed/automatic weighing direct into ship.
- Automatic weighing at ship through silo weigh-bins and chute systems.

Fixed and mobile bag weighers

These are manufactured to various specifications and include:

- Semi-automatic machines suitable for low output, low-cost bagging requirements.
- Portable automatic bag weighers which can deal with both sacks and bulk.
- Fully-automatic bag weighers which will record both gross and/or net weights and which are suitable for flow materials such as grain, granular fertilizer, seeds, pulses, pellets, plastic granules, rice, refined sugar and other similar products.

Mechanically these machines may be accurate to within ±1% for bags weighing between 20 and 50kg. When weights increase to 100 and 250kg accuracy will improve to between 0.5% and 0.2%.

The degree of accuracy depends upon:

- The index allowances set by the operator for the weight of an empty bag.
- The degree of care exercised by the operator in maintaining the mechanical system.

Automatic bulk grain weighers

These machines are suitable for weighing grain and free-flowing materials fed from elevators, conveyor belts, storage hoppers or silos. They are produced in

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various sizes and can record weight cycles from 30kg up to 5 tonnes. They can deliver at rates of up to 1,000 tonnes per hour. When this machinery is correctly installed and maintained by the manufacturers, and regularly inspected by a reliable local regulatory authority, an accuracy of ±0.1% is to be anticipated. Such degree of accuracy is a general requirement within the grain trade. It should however be stressed that the degree of accuracy attained depends upon regular inspection, servicing and maintenance.

Automatic load cell gross weighers

These machines are designed to handle dry materials and powders with grain sizes not greater than 25mm. They are used in continuous weighing cycles of 10-50kg and the accuracy of these machines is better than 0.2% in most cases.

Vibratory feed high speed net weighers

This type of machine is normally utilized for such commodities as coal, coke, processed fuel and similar commodities; five weighings of 25kg/minute or four weighings of 50kg/minute. Accuracies of better than 1.0% can be expected.

Conveyor belt weigh systems

There are a number of conveyor weigh systems. At best, the error is likely to be within 0.5% of true weight for capacities of up to 6,000 tonnes/hour, increasing to 1% to 2% of true weight for flow capacities of 2,000 tonnes/hour (i.e. these systems may be less efficient when the maximum flow capacity is not utilized).

Where an unexplained short-landing occurs at a discharge port this may prove to be a worthwhile field of investigation. If the cargo has been loaded and weighed on a conveyor system, then both the load-port terminal and the discharge port terminal should be asked to produce the manufacturers' full specification and brochures for the equipment utilized. If the guaranteed accuracy is not better than between 1% and 2% of true weight, considerable errors may arise. For a shipment of 100,000 tonnes, for example, an indicated 'loss' of 2,000 tonnes might be possible, where accurate weighing would have probably indicated a discrepancy of no more than 500 tonnes (based on a 'transport' difference of 0.5%).

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Weighbridges

These heavy-duty machines for the weighing of empty and fully-loaded road vehicles are produced in a range of types and sizes depending upon the environment and the local requirements. In most instances, they are intended to operate in a wide range of temperature conditions from -10°C to +50°C, dependent upon local regulations. In extreme conditions where temperatures may be regularly outside these parameters the manufacturers should be consulted. Weighbridges can be supplied to weigh from 20 tonnes in 5kg divisions up to 60 and 80 tonnes in 20kg divisions. In the United Kingdom, the Weights and Measures Authority certifies weighbridges for 10kg divisions up to 50 tonnes and for 20kg divisions upward to 80 tonnes. Because of the manner in which weighbridge scales are graduated and operate, manufacturers can do no more than guarantee an accuracy of half of one scale division or less. Thus, on a 20 tonne weighbridge, with 10kg divisions, the error could be ±5kg (±0.025%). An 80 tonne weighbridge will have an accuracy of ±10kg (±0.0125%). Most weighbridge systems can be indexed in the control house for any debris, water, ice, snow, which may have accumulated between one lorry being weighed and the next but, if the correct indexing is not applied (or is deliberately ignored or wrongly set) the weights recorded will be in error to a greater degree than would be expected by the manufacturers or the licensing authority.

Conclusion

It is probably reasonable to say that the accuracy of shore weighing of bagged and bulk commodities is unlikely to be better than within 0.2% and, in conveyor/weigh-belt systems, may be no better than ±2%. There are no technical means by which the exact weight of a dry bulk cargo on a ship can be accurately determined. The weights may be approximately determined by free space measurement or by draught survey but neither of these methods is sufficiently accurate to verify the weight of a cargo as stated by shippers nor to determine any loss of cargo in transit.

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The separation of products in the holds of bulk carriers

Over the years, a considerable trade has developed in the bulk carriage of relatively small quantities of cereals, oil seeds and their derivatives. Frequently a number of such products may be shipped simultaneously onboard bulk carriers. It is not uncommon for three or more consignments to be stowed in the same hold using separation material in order to avoid admixtures.

Incidents have arisen where, despite the use of separation cloths, admixtures have taken place and claims made by cargo interests.

The steps necessary to avoid any risk of admixture are not complicated but it may be worthwhile bringing them to the attention of ships' officers and others responsible for the stowage of such cargoes.

It is suggested that the following measures should be taken:

- Where it is intended to over-stow one bulk parcel with another, the lower parcel should be trimmed as flat as possible. If the surface is left uneven there is a risk that the separation material may be damaged either as the result of uneven stresses during the sea passage or as a result of contact with the grab or elevator legs and bulldozers which may be used during the discharge of these commodities. Provided this procedure is followed, a single layer of separation material of good quality is considered adequate. Recommended materials include woven polypropylene, polythene sheets or burlap.
- During loading operations it is essential that the distance between the separation material and either the top of the weather-deck hatch coamings or the deck head of the hold is measured and recorded. In this way it is possible to effectively locate the separations between the parcels during discharge and thus avoid any tearing or damage to the separation material.
- The loading of second and third parcels may entail pouring cargo from a considerable height. As a result the surface of the lower stow inevitably becomes depressed; this can be seen clearly on Figs 1 and 2. Because of the need to ensure a relatively even surface between any two parcels it may be wise to plan the stowage so that commodities with a high angle of repose,

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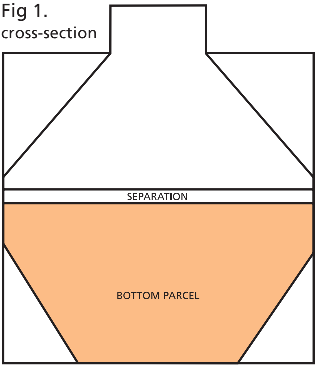
such as cereals and oil seed derivatives, are loaded below those with a low angle of repose such as canary seed or linseed.

Note: *Siting the separation material at a level between the slant plating of the upper and lower hopper tanks (Figs 1 and 2) will eliminate any difficulties on account of settling of the cargo, (Figs 3 and 4).*

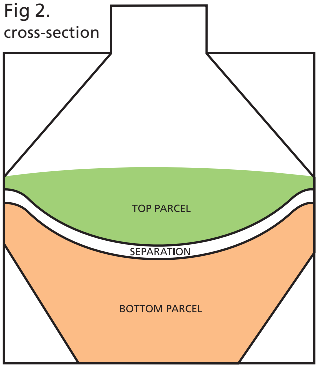
- Ideally, the level of the separation between any two parcels should not be located in the vicinity of the upper ballast tank hoppers (as in Figs 3 and 4). This will ensure that when the inevitable settling of the cargo occurs, during the course of the voyage, the surface area of the separation material will remain adequate, and prevent admixture; see Figs 1 and 2. This problem, of course, does not arise in the vicinity of the lower hopper tanks.

Fig 1.
cross-section



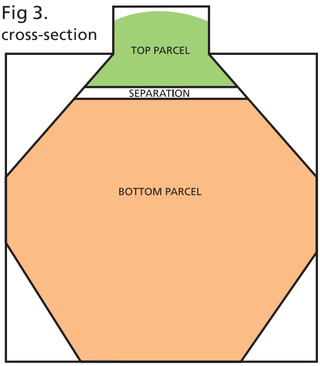
Situation prior to loading top parcel

Fig 2.
cross-section



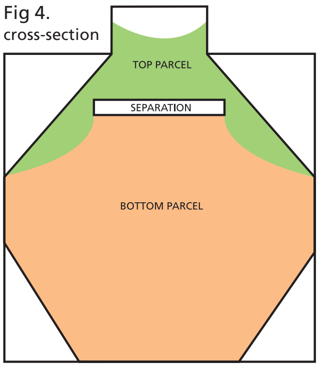
Situation shortly after commencement of loading top parcel

Fig 3.
cross-section



Situation in loading port

Fig 4.
cross-section



Situation in port of discharge

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Part 2

Karnal bunt

Karnal bunt is a fungal disease which can affect certain types of cereal grains such as wheat. The disease develops during the growth phase of the plant. It does not develop during post-harvest storage or transportation. Nonetheless, it can cause potentially serious problems for shipowners and charterers. Many countries prohibit the importation of wheat which is known or, in some instances, is even suspected to be affected by Karnal bunt. This can cause lengthy delays to ships while a solution is found for the disposal of the cargo. Definitive identification of the spores of the specific fungus causative of Karnal bunt in any consignment of grain, requires specialised and time-consuming test procedures which can take up to two weeks to perform.

Karnal bunt was first described in Karnal, India in 1931, hence the name of the disease. It has now been identified in all of the major wheat producing regions of India, Pakistan, Iraq and Afghanistan. It is also now well-established in north-western Mexico, probably having been introduced into Mexico on imported seed in the late 1960s. More recently it has also been found in durum wheat from Arizona. Following this discovery a flurry of surveys and inspections were carried out which resulted in quarantine measures being imposed in the state of Arizona and in counties in New Mexico, Texas and California.

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Karnal bunt

While the disease is not particularly damaging in terms of yield loss, it can cause significant reductions in grain quality and is strictly regulated in international wheat markets. The spores of the infecting fungus are believed to present no health risks to consumers through infected grain or grain products, but wheat containing more than 3% of so-called bunted kernels is commonly considered to be unfit for human consumption. The reason for this is that flour produced from wheat containing a significant number of bunted kernels may have a distinctive foreign odour. The potential for loss in grain quality and for market loss has caused great concern in the US wheat industry. In 1997 the USDA Animal and Plant Health Inspection Service was investigating methods to control spread of the disease in order to protect the current crop.

Karnal bunt is alternatively known as Partial bunt. The fungal organism responsible for the disease is *Tilletia indica*. Spread of the disease occurs by the microscopically small spores of the fungus being distributed by wind and then infecting the host plant during flowering and heading. Symptoms become visible only as the grain matures. Bunted kernels can be very difficult to detect in the field, especially in cases of mild infection, because normally not all plants in the crop are affected. Moreover, on any individual plant, not all kernels are affected. Hence the alternative name of Partial bunt. Bunted kernels, however, each contain millions of daughter spores of the fungus causative of the disease which become available to continue the further potential spread of the disease.

There are various other types of bunt besides Karnal bunt such as the Common bunt (sometimes known as 'stinking smut') prevalent in parts of Europe and caused by the related fungal organism *Tilletia caries*. However, these other types of bunt differ from Partial bunt in a number of respects. The main difference is that rather than infection occurring by wind-borne distribution of the spores, it is spores present in the soil which invade the germinating seed and then systemically infect the growing plant so that all kernels on an infected plant become diseased or bunted. These other types of bunt can be controlled relatively easily by pre-treatment of the seed with suitable anti-fungal dressings. In EU countries, however, a ban has been imposed in recent years on the application of hitherto traditionally used seed dressings of proven effectiveness. This has been held responsible for some resurgence in the incidence of Common bunt in certain parts of Europe.

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In contrast to Common bunt, Karnal bunt is much more difficult to control and, as far as is presently known, no effective solution to control this disease has yet been found. This is because the infection of growing plants with the fungal spores responsible for causing Karnal bunt occurs not via the soil but by wind-borne distribution of the spores.

For these reasons, a number of countries, more especially those in which wheat is a crop of major importance, look extremely critically upon the importation of wheat which is known or suspected to contain kernels affected by Karnal bunt and regard this disease as a quarantine pest. By early 1997, some 50 countries had adopted phytosanitary measures to prevent the import of Karnal bunt-affected wheat and it is anticipated that other countries may adopt the same policy with the passage of time. US officials have been, and still are, negotiating regarding the terms of import of US-grown wheat into these countries. Most of these countries accept wheat if the following additional declaration is stated on the phytosanitary certificate:

> *"The wheat in this shipment originated in areas of the United States where* Tilletia indica *(Karnal bunt) is not known to occur".*

Some countries accept US wheat from quarantined areas if it is certified that the wheat has tested negative for *Tilletia indica* by laboratory analysis on both pre-harvest and pre-shipment samples. Other countries, for example Mexico, require methyl bromide fumigation prior to discharge of the cargo.

It is impossible for ships' representatives to detect by visual inspection at loading whether a cereal grain cargo is contaminated with diseased kernels specifically affected by Karnal bunt. However if, during loading of a grain cargo, any unusual odour is detected which may or may not be due to the presence of substantial amounts of grain severely infected with Karnal bunt, the bill of lading should be claused. Other than that, the only realistic course of action open to shipowners wishing to protect their interests as far as possible, is to insist on the provision of a certificate from an authoritative source in the country of exportation, which unequivocally confirms that the cargo is free from Karnal bunt. Even though a particular cargo may not be affected, it may be advisable for shipowners to avoid carrying cargoes of wheat originating from countries where Karnal bunt is known to be prevalent. This particularly applies to cargoes destined for countries known to adopt a particularly severe approach to the importation of wheat from such countries.

When a ship has discharged a cargo known to be affected by Karnal bunt then, depending on future trading patterns, it may be necessary to carry out sterilisation treatment of the relevant holds in order to destroy the viability of any residual spores from the disease-causing fungus. The following are individual treatments for sterilisation of storage installations generally which have reportedly been applied and are claimed to be effective:

- Wetting all surfaces to the point of run-off with a solution of 1.5% of sodium hypochlorite and water and letting stand for 15 minutes. Thereafter the surface should be thoroughly washed down to minimise corrosion.
- Applying steam to all surfaces until the point of run-off so that a critical temperature of about 80°C is reached at the point of contact.
- Cleaning with a solution of hot water and detergent under a pressure of at least 2kg per sq cm. (30 pounds per square inch) at a minimum temperature of 80°C.
- Fumigating with methyl bromide at a dosage of 240kg per 1,000m^3.

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

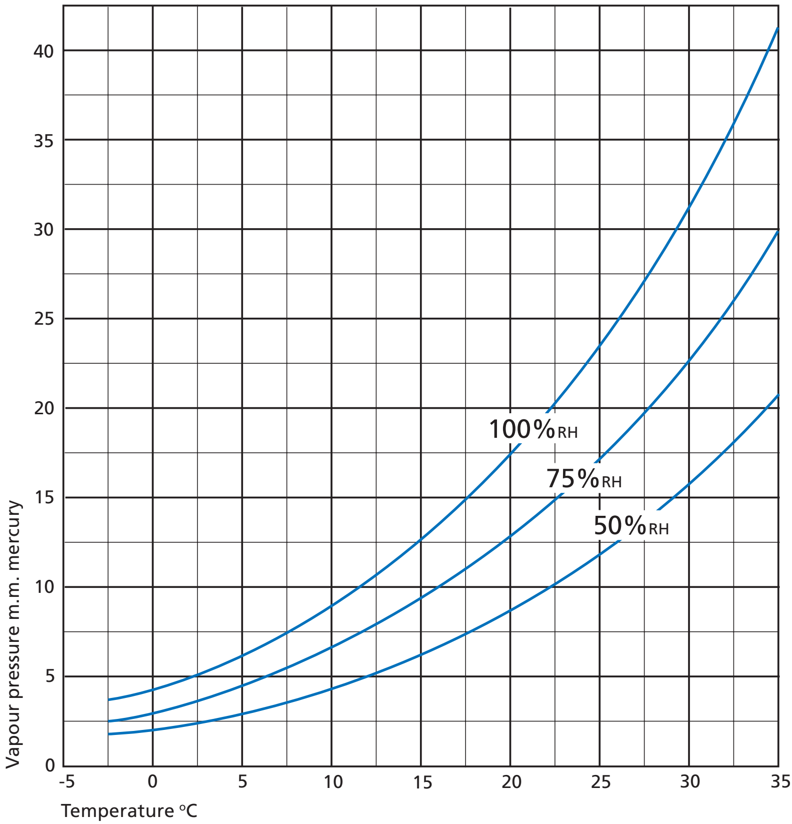
* Vapour pressure can also be measured in terms of other units – either in atmospheres or kilopascals. 1atmosphere (1atm) = 760mm mercury (mm Hg) = 101.325 kilopascals (kPa).

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

Relationship of vapour pressure and relative humidity at different temperatures



* Actually, there will be a very slight rise in vapour pressure, but this may be ignored for the purposes of the example.

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, 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,

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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

Temp °C	Equilibrium RH %	Vapour Pressure mm Hg	Dew Point °C
15	60.0	7.1	7.4
20	64.4	11.2	13.0
25	68.0	16.3	18.7
30	71.5	22.9	24.3
35	75.0	31.5	30.0

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.

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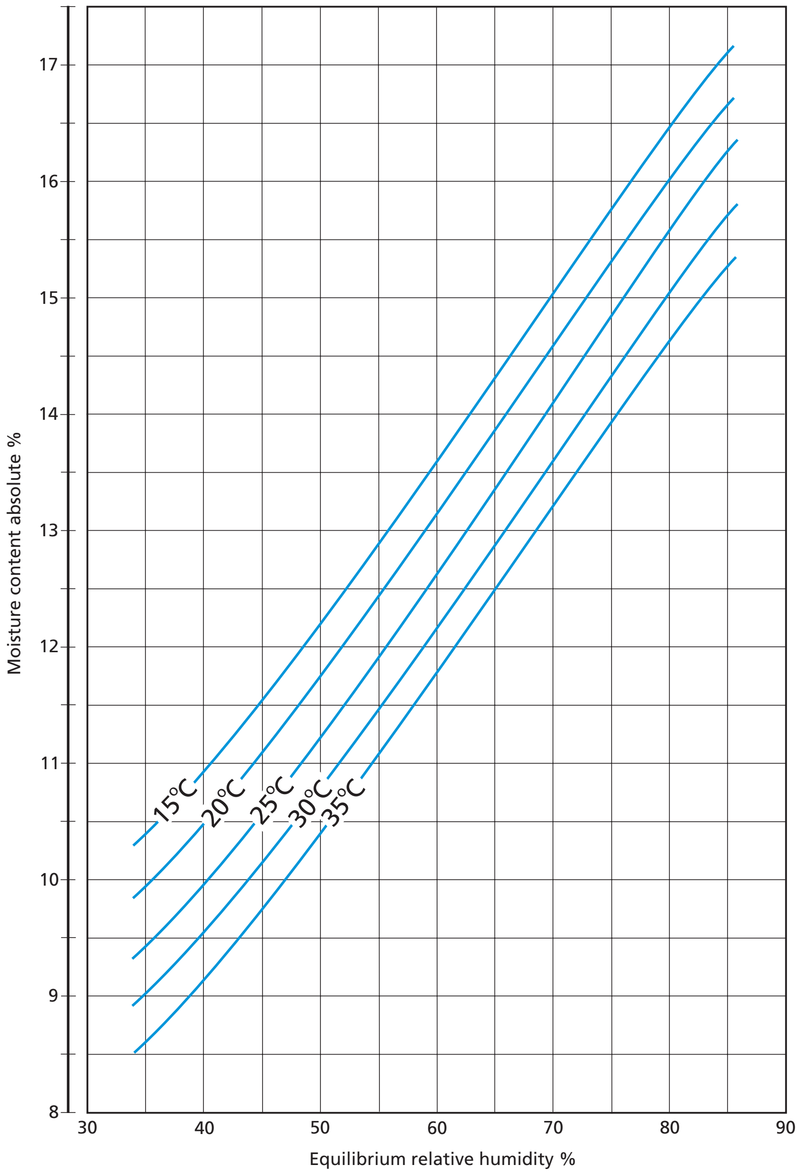
ARGENTINE MAIZE

The isotherm graph below shows equilibrium relative humidity plotted against moisture content.



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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.

* Studies have shown that cargo sweat, i.e. the depositing of liquid water on the surface of maize grains is extremely unlikely, either as a result of the transfer of moisture from warm ventilating air to a cold surface layer of grain, or from warm moisture-laden air rising from a bulk of warm grain towards a cold surface layer. However, moisture transfer would still occur in either situation causing the moisture content of the cold grain to rise. The effect is therefore the same.

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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

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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

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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

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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.

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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

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

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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 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.

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* Ayerst & Leniger: Report on heat damage to Argentinian maize during shipment to Europe, December 1967

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.

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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 text book and the practical experience of those engaged in the trade.

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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

* Studies have shown that cargo sweat, i.e. the depositing of liquid water on the surface of maize grains is extremely unlikely, either as a result of the transfer of moisture from warm ventilating air to a cold surface layer of grain, or from warm moisture-laden air rising from a bulk of warm grain towards a cold surface layer. However, moisture transfer would still occur in either situation causing the moisture content of the cold grain to rise. The effect is therefore the same.

heat and minimising progressive heating up in such instances has never been thoroughly examined on a scientific basis.

Ideally, of course, it would be desirable to find pockets of heating damage of equal size and intensity within an identical cargo in two cargo spaces on the same vessel, and to ventilate one and not the other and from this demonstrate whether ventilation had any effect. Such an experiment is completely impractical, and could probably never be satisfactorily achieved.

However, if ventilating the surface of a cargo is to have any effect on heating up within the bulk, it must be assumed that the ventilating air will have a cooling effect on cargo within the bulk of the maize. If this is the case, it must equally be true that ventilating air would affect the temperature of maize within a bulk whether heating up occurred or not.

It was therefore decided to examine the changes in temperature within the bulk of maize cargoes during shipment from South America to Europe.

In all, four ships were fitted with equipment capable of recording every hour, the temperatures registered by up to eight thermometers (thermistor probes) buried at various places in the cargo of maize in the ship's holds. Unfortunately, on two ships the experiment proved abortive.

On the remaining two ships, it was possible to complete the experiment as planned.

Ship 1

This was a Liberty ship which loaded maize at Rosario and Buenos Aires in June and early July 1965. The thermometers were placed in the cargo stowed in holds 2 and 3. In each hold three probes were buried in the cargo; a fourth being placed on the surface of the cargo underneath the weather-deck hatch boards. The approximate position of the probes is shown in the diagram. Probe 3A in no. 2 lower hold ceased to function on the 18 June and was replaced at Buenos Aires with probe 3B in no. 2 tween deck on 2 July.

Each time a probe was placed in the cargo, a sample was taken from that vicinity, sealed, and subsequently tested for absolute moisture content. The results ranged between 12.8% and 14.5%. The temperatures of the samples, ranging from 15°C to 20°C showed that the cargo was in general hotter than

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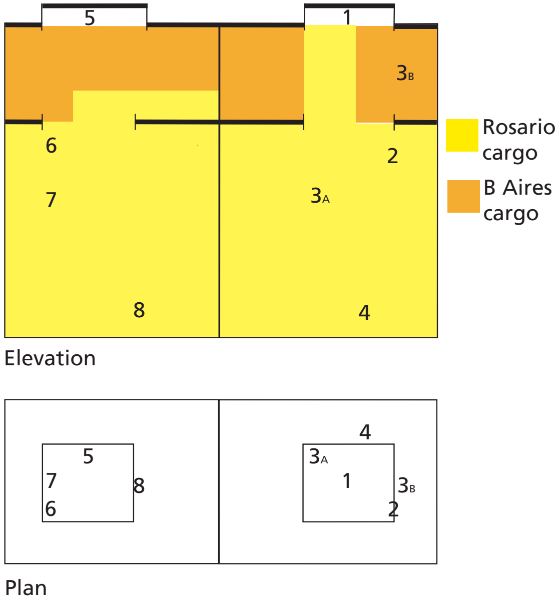


Ship 1. Plan and elevation showing position of probes in holds

the ambient air on the day it was loaded. Microbiological spoilage was not anticipated on these figures.

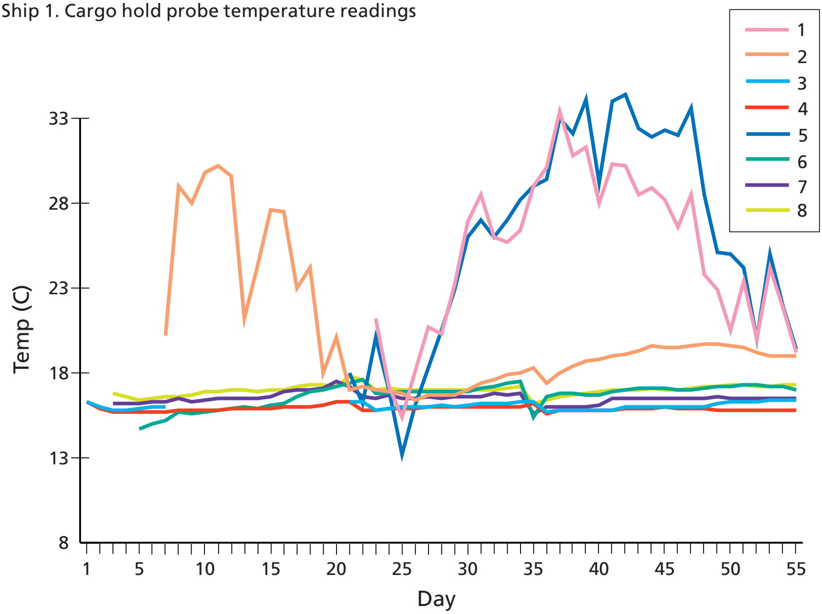
In order to keep the air space between the surface of the cargo and the deckhead to a minimum, the cargo was trimmed between the deck beams and into the hatch coamings. Prior to sailing, ventilator cowls were unshipped and the ducts plugged. During the crossing, which lasted 31 days, the cargo received no ventilation whatsoever.

The graphs show, firstly, the maximum temperature recorded daily by the equipment for each probe and, secondly, the temperature of the ambient air and the temperature of the river/sea water at noon each day as recorded by the ships (no readings of the river/sea water were taken between 23 June and 2 July as the ship's thermometer was broken).

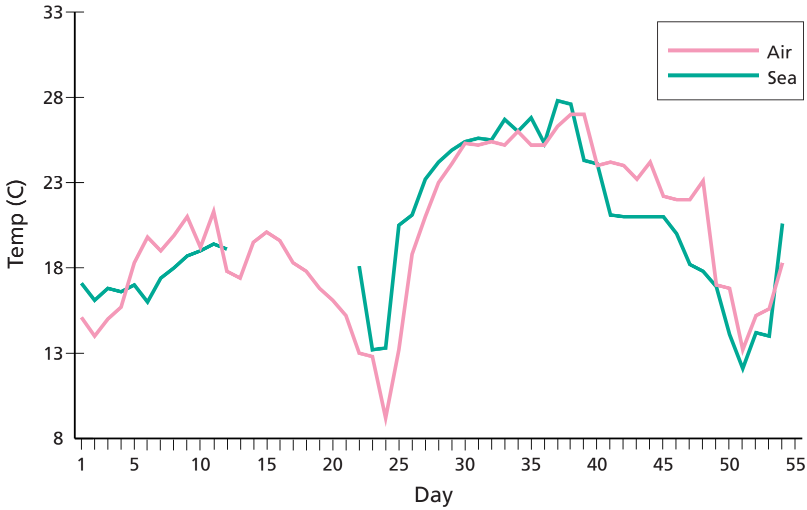
Apart from probes 1 and 5 which, being situated on the surface of the cargo close to the weather-deck, tended to follow the ambient temperatures, five of the six remaining probes did not show a temperature variation exceeding 2.7°C during the 69 days the cargo was onboard. The other, probe 2, fluctuated according to the ambient air until cargo was loaded into the no. 2 tween deck

Moisture migration and surface ventilation

Ship 1. Cargo hold probe temperature readings



Ship 1. Air and sea temperature readings



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at Buenos Aires. This seems to indicate that prior to that time, probe 2 was lying on, or very close to, the top of the Rosario cargo.

The maize outturned sound. Samples taken on discharge in the vicinity of each probe showed no evidence of deterioration.

Ship 2

This was a cargo vessel, built in 1961 in Yugoslavia, and equipped with the *Cargocaire* system of ventilation. This was one of the most sophisticated systems of surface ventilation available. It was designed to permit continuous ventilation of cargoes in all holds, regardless of the dew point of the ambient (external) air. Each cargo space was fitted with inlet and outlet ducts just below the level of the deckhead. Thus, in hold 2 for example, there were three sets of ducts, in the lower hold, in the lower tween deck and in the upper tween deck. The ducts ran into a common main duct in each hold, the main outlet duct being fitted with a suction fan and a dew point sensing element. The dew point sensing element was connected to a recorder situated on the bridge. This instrument recorded the dew point of the atmosphere passing through the main duct. In *normal* operation, external air was continually drawn in through inlet ventilators and exhausted through outlet ventilators. The dew point of the ambient air was also continuously recorded by the instrument situated on the bridge. Should the dew point of the incoming air have exceeded that of the atmosphere issuing from any hold, condensation could have occurred on the surfaces within that hold. Hence, when such a situation prevailed, pre-dried air was forced into the hold, the outlet duct closed and the injected air re-circulated.

Cargocaire had the following advantages over normal ventilation:

- It could be practised continuously.
- The use of inlet ducts permitted a more even air flow through the top of the cargo space.
- The dew point of the average atmosphere within a hold and also of the ambient air were measured continuously and more reliably than by normal methods.

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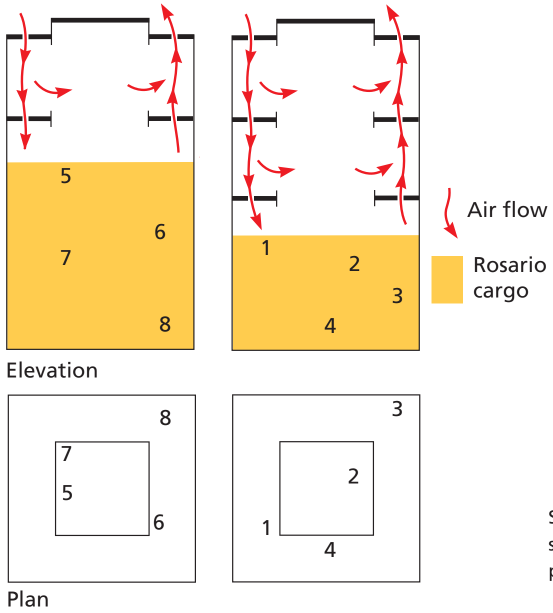
Moisture migration and surface ventilation



Ship 2. Plan and elevation showing position of probes in holds

Maize was loaded at Rosario in late June/early July 1965 and the probes were placed in holds 2 and 5. In each hold, three probes were buried in the lower hold cargo and the fourth was placed on the surface of the cargo in way of the tween deck hatch, the approximate positioning being shown in the diagram. General cargo was loaded in the tween decks of each hold.

Each time a probe was positioned, a sample of the cargo in the vicinity was taken, sealed and subsequently tested for absolute moisture content. The results again ranged between 12.8% and 14.5%. The temperatures of the samples, ranging from 19°C to 22°C, exceeded in every case the temperature of the ambient air on the day the cargo was loaded. On these figures, microbiological spoilage was not anticipated, unless the voyage was prolonged.

During the crossing – from 6 July to 25 July – the *Cargocaire* ventilation system was in continuous normal operation except for a brief period at Santos on the 9 and 10 July, when pre-dried air was circulated in the holds. The temperature of the river/sea water, and the temperature of the ambient air were both recorded each day, and are plotted on the graphs opposite, but as

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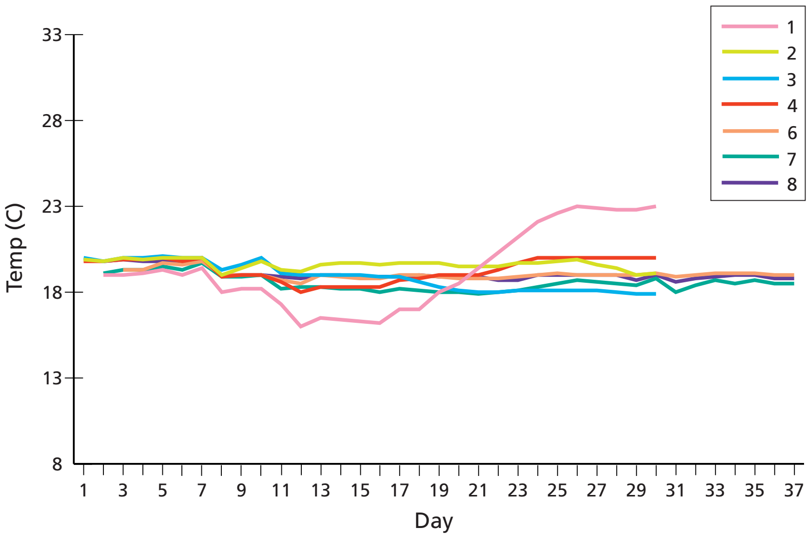
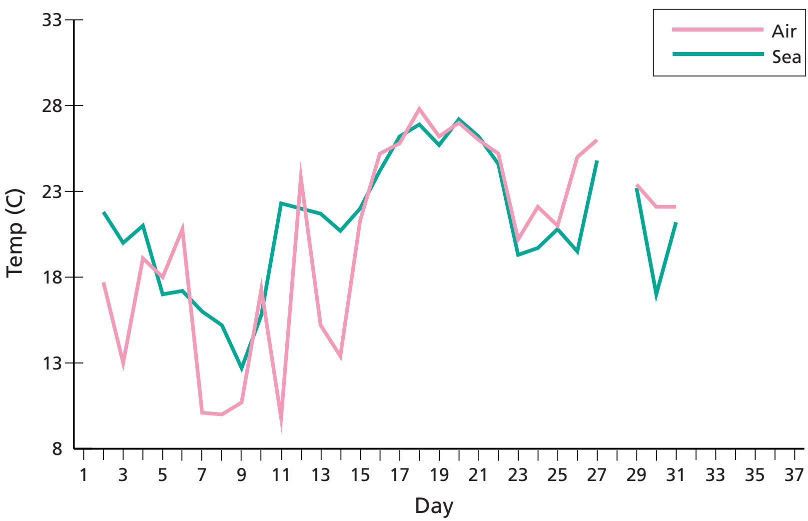
Ship 2. Cargo hold probe temperature readings



Ship 2. Air and sea temperature readings



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the equipment had apparently been used only intermittently during discharging, this date has been omitted for the period subsequent to the 29 July.

The graphs also show the maximum temperature recorded daily for each probe. Probe 5 was unfortunately stolen by the loading stevedores before any readings were obtained from it. Probes 1,2,3 and 4 were broken by the stevedores during discharging at Marseilles, and no readings were obtained after 28 July, until temporary repairs were effected on the 2 August and 4 August.

Apart from probe 1, no probe registered a variation over a period of 38 days in excess of 2.4°C.

The maize, some of which had been onboard for 42 days (discharge being finished only on the 9 August), outturned in perfect condition. Samples taken from the vicinity of each probe on discharge showing no signs of deterioration.

Conclusion

The experimental shipments indicate 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 show 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 confirm the view previously expressed by Dr Milton, namely that **ventilation is irrelevant to the carriage of maize in bulk.**

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Refined (crystal) sugar

The Committee is aware that although guidance on the carriage of raw or semi-refined sugar is readily available, little or no information has been published on the carriage of refined sugar.

Not infrequently, substantial claims have arisen on shipments of bagged refined sugar, where the complaint often relates to stickiness or caking of the product, sometimes wrongly attributed to conditions encountered during the voyage.

Unlike semi-refined or raw sugar, refined sugar is always carried in bags. In the past, jute outer bags were widely used with a polythene film inner bag. Nowadays the outer bags are often made from woven polypropylene. The purpose of the plastic inner bags is to keep out moisture but because the outer and inner bags are often stitched together, the seal is not always effective.

Refined sugar is normally a dry, free flowing commodity with very low moisture content.

If the sugar is found on delivery not to be free flowing, it is important to establish whether this is due to:

- Pressure compaction;
- Adhesiveness (stickiness); or
- Caking (agglomeration).

Pressure compaction usually occurs as a result of static pressure exerted by the weight of the sugar itself, especially when bags are stacked high. This condition can readily be corrected when the bags are handled and transported. However, adhesiveness and caking of refined sugar are both the result of too high a moisture content and possibly, to some extent, the temperature of the cargo at the time of bagging.

Adhesiveness, resulting in poor flow characteristics, occurs as a result of high moisture content, either initially or after packing. Caking may occur when over-moist sugar dries out.

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If the product comes into contact with extraneous moisture such as cargo sweat, this may lead to limited, superficial adhesiveness and to subsequent caking of the sugar at the mouth of the bags. This may also occur where bags have been damaged by stevedores' hooks. Extensive adhesiveness and caking may be caused by excessive moisture at the time of packing, particularly if the caking is found at the centre , extending towards the periphery of the bag, with the sugar crystals at the periphery adhering. This condition may be further affected if, at the time of packing, the temperature of the sugar is high, relative to the ambient temperature. Thus, it is vital that correct practices are observed during the manufacturing process.

It is of crucial importance that, immediately after production, the amounts of so called 'free water' and 'bound water' are at satisfactorily low levels. After processing, sugar is normally left in storage for a relatively short period, with appropriate ventilation, in order to 'condition' or 'mature' the product. The aim of this is to ensure that when the sugar is bagged, its moisture content is at an acceptable low level. If it is not, comparatively hard caking and possibly some adhesiveness can be expected to occur during subsequent storage and transport. When sugar is bagged with a low moisture content (0.02% or less) then there is no risk of adhesiveness or caking being caused by moisture migration. Some sale contracts stipulate a moisture content of '0.1% maximum' but it should not be assumed that such levels are acceptable if caking is to be avoided. Adhesiveness and caking do not affect the chemical nature of the sugar but may not be acceptable depending upon its intended use.

Because most marine reference books are silent on the carriage of refined sugar, it is often assumed that it is a relatively simple product to handle, subject only to the most general stowage and ventilation recommendations. Tight block stowage without height limitation is the customary and acceptable method, the height of the stow being limited only by the height of the cargo compartments. Cargo battens are not necessary as it is generally accepted that a separation of paper or cardboard sheets or of polyethylene or polypropylene cloth between the ship's structure and the bags is sufficient. Ventilation of refined sugar is not necessary under any circumstances. The purpose of cargo ventilation is to prevent or restrict the formation of condensation or moisture on the ship's internal structure. However, such condensation originates from within the cargo and will occur only when the cargo itself is moist and damp. Because refined sugar has a low moisture content and is enclosed in plastic film, there is no risk of sweat. Under certain circumstances, ventilation may even be detrimental, for example when holds loaded with cold cargo are ventilated with warm air, this can lead to the formation of sweat. Sugar has a low thermal conductivity which means that during the voyage, it tends to remain at the same temperature at which it was loaded, at least in the interior of the stow. If the sugar is loaded cold and later discharged in a relatively hot area, there is a risk of condensation forming during the discharge, on any bags having a temperature lower than the dew point of outside air. In such cases, rapid discharge is necessary in order to avoid any adverse consequences.

Summary

- The ship's hold before loading, should be clean, dry and free from any noticeable smell.
- Bags should be loaded only if outwardly dry with no apparent lumpiness of the contents.
- No bags to be loaded during any form of precipitation, including rain or snow.
- Cargo battens are not essential; where no battens are fitted, measures should be taken to prevent damage from any protruding cargo batten hooks or fittings.
- A separation of polyethylene or polypropylene cloth or paper sheeting between the ship's structure and the bags is sufficient.
- Tight block-stowage is the customary and acceptable method of stowage.
- If additional cargo is to be carried in the same hold as refined sugar, then this should be 'dry' cargo.
- The hold should not be ventilated; all ventilators and other openings should be sealed.
- The rapid discharge of any bags which may have been loaded at substantially lower temperatures than at the discharge port is necessary, in

order to prevent or restrict unwanted condensation on the bags during discharge.

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Part 3

Coal cargoes

Since the publication of this article in *Carefully to Carry* No.13, issued in April 1989, there have been major changes in the recommendations for the safe carriage of coal cargoes.

Following a spate of coal cargo fires and explosions, a research project was sponsored by the UK Department of Trade and Industry. A working group comprised of:

British Coal

P&O Bulk Carriers

Souter Shipping

Minton, Treharne & Davies Ltd, instructed by the International Group of P&I Clubs and the Salvage Association

The main aim of the project was to validate the use of gas measurement to detect spontaneous heating of coal cargo at an early stage. Data was collected from a large number of voyages, some of which involved heated coal cargoes. Recommendations following this research were included in the revised entry for coal in the IMO *Code of Safe Practice for Solid Bulk Cargoes* (the IMO BC Code).

Properties and characteristics

The Categories A, B, C and D have now been excluded from the IMO BC Code and the properties and characteristics are shown under BC 010, at Appendix B, pages 61-66 of the Code as follows:

- Coals may emit methane, a flammable gas. A methane/air mixture containing between 5% and 16% methane constitutes an explosive atmosphere which can be ignited by sparks or naked flame, e.g. electrical or frictional sparks, a match or lighted cigarette. Methane is lighter than air and may, therefore, accumulate in the upper region of the cargo space or other enclosed spaces. If the cargo space boundaries are not tight, methane can seep through into spaces adjacent to the cargo space.
- Coals may be subject to oxidation, leading to depletion of oxygen and an increase in carbon dioxide in the cargo space.

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- Some coals may be liable to self-heating that could lead to spontaneous combustion in the cargo space. Flammable and toxic gases, including carbon monoxide, may be produced. Carbon monoxide is an odourless gas, slightly lighter than air, and has flammable limits in air of 12% to 75% by volume. It is toxic by inhalation, with an affinity for blood haemoglobin over 200 times that of oxygen.

- Some coals may be liable to react with water and produce acids which may cause corrosion. Flammable and toxic gases, including hydrogen, may be produced. Hydrogen is an odourless gas, much lighter than air, and has flammable limits in air of 4% by 75% by volume.

General requirement for all coals

The Code states that prior to loading, the shipper or his appointed agent should provide in writing to the master, the characteristics of the cargo and the recommended safe handling procedures. These details should include whether the cargo may be liable to emit methane or self-heat. The master should be satisfied that he has received this information prior to accepting the cargo.

In our opinion this is an essential requirement for the safe shipment of the cargo, this information will decide the method of safe carriage.

- If the shipper has advised that the cargo is liable to self-heat, the master should seek confirmation that the precautions intended to be taken and the procedures intended for monitoring the cargo during the voyage are adequate.

- If the cargo is liable to self-heat or an analysis of the atmosphere in the cargo space indicates an increasing concentration of carbon monoxide, then the following additional precautions should be taken:

    - The hatches should be closed immediately after completion of loading in each cargo space. The hatchcovers can also be additionally sealed with a suitable sealing tape. Surface ventilation should be limited to the absolute minimum time necessary to remove methane which may have accumulated. Forced ventilation should not be used. On no account should air be directed into the body of the coal as air could promote self-heating.

- Personnel should not be allowed to enter the cargo space, unless they are wearing self-contained breathing apparatus and access is critical to the safety of the ship or safety of life. The self-contained breathing apparatus should be worn only by personnel trained in its use.
- When required by the competent authority, the carbon monoxide concentration in each cargo space should be measured at regular time intervals to detect self-heating.
- If at the time of loading, when the hatches are open, the temperature of the coal exceeds 55°C, expert advice should be obtained.
- If the carbon monoxide level is increasing steadily, a potential self-heating may be developing. The cargo space should be completely closed down and all ventilation ceased. The master should seek expert advice immediately. Water should not be used for cooling the material or fighting coal cargo fires at sea, but may be used for cooling the boundaries of the cargo space.

In our opinion, even if the shipper considers that the cargo is not liable to self-heat, the recommendations stated above should be closely followed. Monitoring the atmosphere of the cargo space is essential at least once daily, twice daily if rapid changes are detected.

Gas monitoring of coal cargoes

All vessels engaged in the carriage of coal cargoes should have on board an instrument for measuring methane, carbon monoxide and oxygen. The SOLAS Regulations Chapter 11 – Carriage of Cargoes gives strength to this statement:

Regulation 3

Oxygen analyses and gas detection equipment

- When transporting a bulk cargo which is liable to emit a toxic or flammable gas, or cause depletion in the cargo space, an appropriate instrument for measuring the concentration of gas or oxygen in the air shall be provided together with detailed instructions for its use. Such an instrument shall be to the satisfaction of the Administration.

- The Administration shall take steps to ensure that crews on ships are trained in the use of such instruments.

Appendix G of the IMO BC Code provides detailed procedures for gas monitoring of coal cargoes, equipment to be used, design and siting of sample points and measurement.

The Code details the requirements including the following:

- The ship should be suitably fitted and carry onboard appropriate instruments for measuring the following without requiring entry in the cargo space:
  - Concentration of methane in the atmosphere;
  - Concentration of oxygen in the atmosphere;
  - Concentration of carbon monoxide in the atmosphere; and
  - pH value of cargo hold bilge samples.
- These instruments should be regularly serviced and calibrated. Ship personnel should be trained in the use of such instruments. Details of gas measurement procedures are given in Appendix G of the IMO BC Code.
- The atmosphere in the space above the cargo in each cargo space should be regularly monitored for the presence of methane, oxygen and carbon monoxide. Details of gas monitoring procedures are given in Appendix G. Records of these readings should be maintained. The frequency of the testing should depend upon the information provided by the shipper and the information obtained through the analysis of the atmosphere in the cargo space.
- Unless expressly directed otherwise, all holds should be surface ventilated for the first 24 hours after departure from the loading port. During this period, one measurement should be taken from one sample point per hold.
- If after 24 hours the methane concentrations are at an acceptably low level, the ventilators should be closed. If not, they should remain open until acceptably low levels are obtained. In either event, measurements should be continued on a daily basis.

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- Other requirements relate to trimming the cargo, smoking, and use of naked lights etc.

Special precautions

The special precautions relate to coals emitting methane and self-heating coals.

Coals emitting methane

Methane is a flammable gas, and within the range of 5% to 16% in air can form a flammable mixture which can be readily ignited by a spark or naked light. The Code advises that if the shipper has advised that the cargo is liable to emit methane or analysis of the atmosphere in the cargo space indicates the presence of methane in excess of 20% of the lower flammable limit then suitable precautions should be observed including:

- Maintain adequate surface ventilation without directing air into the body of the coal.
- Venting any gases prior to opening the hatchcovers or other openings.
- Enclosed working spaces should be adequately ventilated with equipment safe for use in a flammable atmosphere.

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Self-heating coals

Low rank coal types are more prone to oxidation than the high rank anthracites and are thus more liable to spontaneous heating. High inherent moisture contents which can evaporate to create large internal surface areas susceptible to oxidation will assist this heating process. Frequently, cargoes may consist of coals of different ages and from different mines which can also lead to spontaneous heating problems.

The recommendations of the IMO BC Code are as follows:

- There are many robust instruments suitable for shipboard use. Methane, oxygen and carbon monoxide can be detected by the same instrument. It is essential that the instruments are used and maintained strictly in accordance with manufacturers' instructions.
- The research leading to the amendment of the Coal entry in the BC Code, indicated that meaningful results of the gas concentrations in a hold could be made from one sample point per hold. For convenience in case of adverse weather conditions the sample points could be fitted one on either side of the hatchcover. Measurement from either of these locations would be satisfactory. Use of these sampling positions provide:
  - An accurate picture of the gas concentrations in the hold;
  - Prevent the admission of air (oxygen) into the hold, which could assist spontaneous heating.

Acid conditions

Many coals contain sulphur. If the sulphur is in a soluble form it may react with moisture in the coal to form sulphurous and sulphuric acids. These acids will of course attack steel, corroding bilge systems, tank top areas and in some cases bulkheads. It is thus recommended that regular hold bilge testing should be conducted. If acid conditions are indicated, the bilges should be pumped regularly to minimise contact between the acids and the hold structure. Without acid conditions it is still advisable to regularly pump the bilges to prevent the accumulation of water drained from the cargo collecting at lower hold levels and thus creating problems at discharge.

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Entry to cargo spaces

As previously stated, coal will oxidize, and this oxidation process removes oxygen from the surrounding atmosphere. The oxygen content of a normal atmosphere is 20.8%. Tests of the atmosphere in a sealed hold carrying a coal cargo have indicated an oxygen content less than 4%. It is thus essential that prior to entry into a cargo space or a neighbouring confined space that suitable test procedures are followed. Appropriate recommendations are detailed in Appendix F of the IMO BC Code.

The importance of this test procedure cannot be over emphasised. We still learn of loss of life through entry into cargo spaces and confined spaces without prior testing of the atmosphere. However, it is encouraging to note that at least one major exporting terminal will not commence loading a coal cargo until they are satisfied that the vessel is equipped with the relevant test apparatus and persons trained in the use of the apparatus.

2001 Supplement to 1998 Edition IMO BC Code

An amendment to the 1998 edition of the BC Code includes ‘Brown Coal (Lignite) Briquettes’. Brown coal (lignite) briquettes are manufactured by pressing dried coal particles into compressed blocks; they are subject to oxidation leading to oxygen depletion and carbon dioxide increase within the cargo space. They are liable to self-heating and may lead to spontaneous combustion which in turn may produce flammable and toxic gases.

Boundaries of cargo spaces in which briquettes are stowed should be fire and liquid resistant. For details of particular stowage requirements, the IMDG Code should be carefully consulted. For full details of preloading, loading and post-loading operations and recommendations, the IMO BC Code supplement should be consulted.

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Direct reduced iron (DRI)

A brief article on DRI appeared in *Carefully to Carry* No.12 which was issued in December 1986. This present article deals briefly with the more recent and projected state of the market for the product, manufacturing technology and potential hazards still presented by the product when transported by sea.

The world market for steel is currently increasing and is expected further to increase very substantially over the next 20 to 25 years. The volume of steel produced by the now old-fashioned blast furnace process is already very low and will decline even more relative to the volume of steel produced by the electric arc process for which DRI is the raw material. The world production of DRI is currently almost 39 million tonnes per year and over the last decade has enjoyed an average growth rate of nearly 10% per year.

There are two types of DRI. One is the so-called cold-moulded type and the other is the hot-moulded type. Both types are covered by separate schedules in the the IMO *Code of Safe Practice for Solid Bulk Cargoes* (the IMO BC Code). Hot-moulded DRI is produced by compressing into briquettes, at high temperature, freshly produced cold-moulded DRI pellets. The additional processing involved in producing hot-moulded DRI briquettes renders this type of DRI more expensive than cold-moulded DRI although as detailed here hot-moulded DRI is considerably less hazardous than the cold-moulded product.

Both products are internally porous but the hot-moulded product has a considerably lower ratio of surface area to mass than the cold-moulded DRI. Consequently hot-moulded DRI is substantially less reactive with water and correspondingly much less hazardous than cold-moulded DRI. There have been only isolated serious heating incidents with hot-moulded DRI during transportation. Hence although this product is hazardous, there is no reason to believe that the product is not generally acceptable for ocean transportation provided the various requirements set out in the schedule, at Appendix B, pages 69-72, of the IMO BC Code, 1998 Edition, are met.

The remainder of this article will deal with the more hazardous cold-moulded product which is manufactured in the form of pellets (spheres) about one centimetre in diameter. These are produced from iron ore (i.e. principally

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iron oxide) which is crushed, partially freed from foreign material other than iron oxide and then compressed at normal ambient temperatures into iron oxide pellets. These pellets are then passed down through a furnace in which there is a counter-current flow of so-called reducing gas whereby the pellets are heated to a temperature below the melting point of iron. Concomitantly the reaction between the iron ore pellets and hot gas removes the chemically bound oxygen component from the iron oxide ore, thus leaving metallic iron pellets (i.e. cold-moulded DRI) with a sponge-like structure.

Close up of DRI pellets

Once the pellets consisting of approximately 90% metallic iron have been produced and cooled, the product has a propensity to re-oxidise (i.e. rust) back to iron oxide at normal temperatures given the availability of sufficient oxygen. This process is however extremely slow in dry conditions. The rate of oxidation is substantially increased by the presence of water. If the water contains dissolved salts such as sodium chloride (e.g. sea water) the rate of reaction is very substantially further increased.

The oxidation process is exothermic; in other words heat is generated. All rusting processes are surface reactions and the reason why substantial heating can occur when wet DRI pellets react with atmospheric oxygen is that, because of their sponge-like structure, they have an extremely large surface area. It is important to appreciate that DRI is a poor heat conductor. Hence heat build-up occurs quite rapidly.

Another property which makes cold-moulded DRI very hazardous is that, although oxidation rates are insignificant in dry air at normal temperatures, the product will react with atmospheric oxygen at a rapid rate if heated to a temperature called the 'autoxidation temperature' which it is reported can be as low as 150°C.

Hence, if there is a focus of heating initiated in a cargo due to wetting and this produces a rise in temperature of that cargo to above the autoxidation temperature, heating can spread to adjacent DRI cargo which would otherwise remain stable.

A final hazard associated with DRI pellets is that if they become wetted and substantially increase in temperature, water may react with very hot iron to produce hydrogen which is a potentially explosive gas. To retard or inhibit oxidation the DRI pellets may receive during manufacture, a special treatment called 'passivation'. This is a matter which is dealt with in both the schedule for cold-moulded DRI in the 1998 Edition of the IMO BC Code and in a circular to Members on DRI which was issued by the International Group of P&I Clubs in July 1982. The relevant section in the schedule in the IMO BC Code which contains reference to 'passivation' reads:

A *"Shippers should provide the necessary specific instructions for carriage, either:*

1) *maintenance throughout the voyage of cargo spaces under an inert atmosphere containing less than 5% oxygen. The hydrogen content of the atmosphere should be maintained at less than 1% by volume; or*

2) *that the DRI has been manufactured or treated with an oxidation and corrosion-inhibiting process which has been proved, to the satisfaction of the competent authority, to provide effective protection against dangerous reaction with sea water or air under shipping conditions.*

B *The provision of paragraph (A) above may be waived or varied if agreed to by the competent authorities of the countries concerned, taking into account the sheltered nature, length, duration, or any other applicable conditions of any specific voyage."*

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Direct reduced iron

DRI can heat to extreme temperatures when exposed to sea water

With regard to the reference to 'inert atmosphere' in the previous quotation, it is important to stress that the inerting gas used **must** be nitrogen. If carbon-dioxide is used this can be reduced by hot iron to carbon monoxide which is hazardous both from the viewpoints of severe toxicity and flammability.

In the International Group of P&I Clubs' circular of 1982 there was particular comment on paragraphs A(2) and B from the schedule from the IMO BC Code as previously quoted. The relevant part of the circular reads:

> *"In relation to paragraph A(2), the major manufacturers in Germany have used a chemical 'passivation' process to inhibit oxidation/corrosion. However, there has recently been a serious fire onboard a ship carrying this product and there must be serious doubts about whether such a passivation process renders the cargo safe for carriage by sea.*
>
> *The undersigned Assocations continue to believe that the only proven method of carrying this cargo safely is by maintaining the cargo hold in an inert atmosphere and believe the most effective method of providing an inert atmosphere is by injecting the inert gas at the bottom of the stow in order to force out the air within the stow. Therefore the detailed advice to shipowners and Managers on pages 2 and 3 of the circular of August 1981 stands.*
>
> *On present information, it is not thought that the length or nature of the voyage contemplated (IMO paragraph B) can ever justify the waiver of the requirement of maintaining the cargo in an inert atmosphere."*

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In the 1980s there was a lull in trans-ocean shipments of cold-moulded DRI. However, in the 1990s, numerous ocean shipments were effected. The Committee is aware that many shipments have been made in bulk carriers with no attempts having been made at the outset and during the voyage to maintain the cargoes under an inert gas (nitrogen) atmosphere. Under recent trading conditions and with shipments made in ordinary bulk carriers, the practicality on long trans-ocean voyages and the economics of shippers or shipowners providing and maintaining such inert conditions must be regarded as questionable. It is however understood that shipments of cold-moulded DRI not claimed to be passivated have been carried on relatively short voyages under inert gas with no reports of untoward incidents, although it is presumed that the costs of providing the inert conditions are borne by the shippers.

The Committee has learned that certain shipments of cold-moulded DRI forwarded for ocean transport in certain regions are claimed to have undergone a certain degree of 'passivation' treatment. There are reasonable indications that this treatment does indeed provide satisfactory protection against serious heat-generating oxidative reactions under circumstances where the product becomes wetted with up to a few percentage units of fresh water. However, clear evidence has emerged that the 'passivation' treatment provides no effective protection against the occurrence of serious heating problems when the product is wetted by sea water. It has been estimated that the containment of a bulk stow of this type of cold-moulded DRI with as little as 60 litres of water would be sufficient to initiate very serious heating problems.

Characteristics of burning DRI

Aspects of burning DRI are:

- Hot spots propagate relatively slowly. It may take a day or more for propagation to occur through a stow. This allows opportunity for actions to be taken. Clearing DRI away from bulkheads, making a fire-break between heating DRI and adjacent cargo spaces is one of the few options onboard.
- Temperatures can also become sufficiently elevated so that if water is sprayed over it, the DRI can evolve hydrogen – catalytic dissociation of the water by the hot metallic surface of the DRI. Sufficient concentration of hydrogen coupled with a heat source will result in the hydrogen igniting.

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A light spray of water, insufficient to quench combustion, thus creates flame as the hydrogen burns.

- Neither the fuel, which is iron, nor the combustion products, iron oxides, are gaseous, therefore no flame appears. DRI when burning is similar in appearance to burning charcoal, glowing red hot but without flame. However, as mentioned earlier, there may be a reaction between very hot DRI and moisture – possibly even atmospheric moisture – producing hydrogen, which burns with a blue flame. This flame often appears as a blue haze, best visible in low light conditions.
- When fuel oil double bottom tanks are below a hold with burning DRI, an added safety measure would be to inert the tanks – dry ice or CO_2 injected through sounding pipes / breathers is recommended. This does not conflict with earlier advice, as the CO_2 will not be in contact with the burning DRI.

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Mineral ore concentrates and other materials which may liquefy

This subject was previously discussed in some detail by the Committee in its seventh report. It is also dealt with in the IMO *Code of Safe Practice for Solid Bulk Cargoes*, (the IMO BC Code), 1998 Edition at Sections 4,7, and 8 and at Appendices A and D.

The recommended procedures for testing those materials which may be subject to liquefaction is covered in Appendix D1 of the Code.

Points to consider

The following points should be borne in mind by shipowners and masters when contemplating the carriage of concentrates:

Many minerals which are essentially insoluble in water and which contain mainly finely divided material, may liquefy on ocean voyages if they contain an excessive amount of water when loaded or if they subsequently become wetted. This applies even though they may appear to be in the form of dry powders of granular materials. Such liquefaction is basically due to energy being applied to the cargo. This can be as a result of vibration due to a ship's engine or due to motion in heavy seas. It follows that liquefaction may become apparent at almost any stage of a voyage. Any cargo of finely divided material which tends to flatten and which develops a putty-like surface during a voyage, has started to liquefy.

The presence of water on the surface of the cargo is also indicative of liquefaction. It must be stressed however, that liquefaction can occur without liquid water being observed on the surface of the cargo. If any of the phenomena described above are observed, the ship should take urgent action and should proceed to the nearest port of refuge, subject of course, to the requirements of good seamanship. It may be prudent to adjust course and speed in order to reduce the motion of the ship even if this means having to steam further before reaching a suitable port.

Liquefaction is unlikely to occur provided that when loaded it complies with the IMO requirement that the moisture content of the cargo is relatively

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This ship developed a severe list and sought refuge when her cargo liquefied

uniform and below the transportable moisture limit (TML) **in each hold**. The Committee has not heard of a case of liquefaction involving a cargo which in every respect complied with the IMO requirements.

Before loading any cargo which they know or suspect may liquefy, masters should carefully check all the documentation provided by the shippers or charterers. A list of cargoes known to liquefy is given in Appendix A of the IMO BC Code, but this list is not exhaustive. This point was illustrated recently when difficulties were encountered by a Member of the Association following the liquefaction of a cargo of fluorspar. This substance is not mentioned in Appendix A. It is therefore recommended that where a master is concerned about possible liquefaction of a cargo of mineral in a finely divided form, he should insist upon a written statement from the shippers or charterers confirming that the product concerned will not liquefy if it contains an excess of moisture. Alternatively, he should obtain the required documentation to satisfy his suspicions. If he is not satisfied with the response obtained, it is recommended that the Association be consulted, either through the owners or managers.

Documentation

After the completion of loading of materials known to liquefy and before

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starting a voyage, masters should be supplied with written documentation as follows:

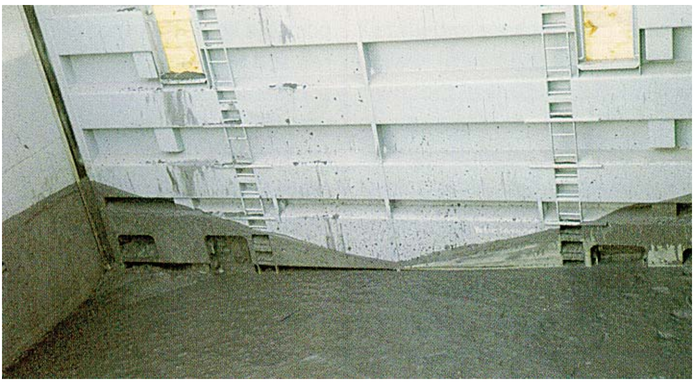
- A certificate should be provided stating the TML for the cargo. It is stipulated by the IMO that the testing necessary for the provision of such certificates should be carried out at least once every six months (see the IMO BC Code section 4.4.1. p.15). The Committee advises masters to ensure that this certificate is dated within six months of loading and that it is issued by a laboratory on which reliance can be placed. The test procedure for determining the TML requires specialised equipment and experienced technicians to conduct the test. It is reasonable to assume that certificates issued by major shippers of mineral ore concentrates as listed in the IMO BC Code are reliable. However, the Committee recommends that where there are shipments of less common materials or where shipments are from newly developed sources, the certificates should be issued by a laboratory known to have the necessary equipment and expertise reliably to conduct the test. If there is any doubt about this matter the Committee recommends that the master should notify his owners. They should then contact the Association in order to obtain expert advice on how to check that the laboratory has the necessary equipment and expertise.
- The master should also receive before loading commences, a letter from the shippers indicating that he will be supplied with certificates stating the average moisture content of the cargo loaded into each separate hold. It will be appreciated that sampling before shipment except in climates where there is no rainfall is not satisfactory. Many of the larger shippers use an automatic sampling procedure during loading in order to obtain satisfactory samples for moisture content measurement. Under these circumstances, actual figures for the average moisture content of cargo loaded into each hold can only be given at the end of the loading period.

Careful examination

Notwithstanding any evidence provided by the various certificates discussed above, masters are strongly advised to examine stockpiles of cargoes before loading. Water draining from such stockpiles must be considered to indicate the probability that a part of the material in the stockpile has a moisture content above the TML. A watch should be kept on the condition of the cargo being loaded. Any obviously wet material should be rejected as such cargo might form a shear plane on which a basically sound cargo loaded subsequently, might slide.

If masters are doubtful about the condition of a cargo, they can conduct a 'can test' described in the IMO BC Code, Section 8.3 at Page 24. It must be stressed however, that although an adverse result from this test indicates that the material tested is probably unsatisfactory for ocean carriage, the test cannot be used to confirm that the material tested is safe for carriage. The Committee wishes to warn masters specifically about the risk of loading cargo at sub-zero temperatures when cargo may contain ice crystals but not appear to be damp. It is recommended that when cargo is loaded under such conditions, samples are drawn from various levels including the bottoms of piles and that these are warmed and then tested by the can test.

The Committee also advises that under no circumstances should masters agree to the erection of shifting boards or other temporary arrangements in order to carry cargoes loaded at moisture contents above the TML. The Committee has heard of an incident where longitudinal shifting boards of six inches thickness secured to nine inch square posts were smashed by a shifting concentrates cargo. If bulkheads are to be erected to facilitate the carriage of this type of cargo, they must be constructed strictly as required in Section 7.2.2 at Page 22 of the Code.



Liquefied ore concentrate in ship's hold

It cannot be too strongly stressed that when carrying cargoes of this nature, failure to ensure that they are accompanied by the correct reliable documentation and to ensure that they are in generally uniform condition at the time of loading can, and has on a number of occasions, resulted in the loss of both a ship and its crew.

Dangerous reactions

There are two other dangers associated with concentrate cargoes. The first is that some concentrates may heat. Shippers should always be asked specifically about this possibility. Stows of such concentrates should be trimmed roughly flat using a tracked bulldozer or similar machine which also compacts the cargo. It is sometimes helpful to sheet such materials with heavy gauge polythene film which further restricts the rate of air penetration into the cargo.

The second danger arises from the fact that even if concentrate cargoes do not heat, they absorb oxygen such that the atmosphere above the cargo in a hold which is inadequately or not at all ventilated may become deficient in oxygen and enriched with nitrogen. Air contains roughly 79% nitrogen and 20.8% oxygen and as the oxygen is absorbed by the cargo, so the oxygen content may fall to as low as 4%. The minimum concentration of oxygen required in the atmosphere in order to support life for only a few minutes is 10%. There have been fatal accidents where persons have entered fully closed holds loaded with concentrates where the oxygen content was too low.

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Sulphur cargoes

Sulphur is a relatively cheap commodity, which is used in the manufacture of fertilizer. It is not only a by-product of the petrochemical industry, but also found in its natural form. After processing, it is often shipped in prilled form.

Substantial quantities of sulphur are produced in the Alberta province of Canada, most of which is shipped from Vancouver. It is shipped from other ports, including San Francisco, Long Beach, Aqaba and Jubail. Sulphur shipped from Vancouver is generally described as 'Canadian bright yellow formed sulphur'. The sulphur suppliers warrant strict purity specifications to their customers and so are concerned at the risk of contamination.

Dry sulphur does not react with bare steel, but wet sulphur (sulphur containing free water) is potentially highly corrosive. Cargoes of sulphur in bulk are normally afforded exposed storage and are thus subject to inclement weather and consequent moisture content. The stock will also include a percentage of sulphur dust particles. In order to prevent contaminated air emissions, it is the practice, especially in Canada and the USA, where loading wharves are situated in built-up areas and the dust is considered to be a pollutant, for the environmental authorities to insist upon the use of a water spray during handling to keep down the dust. This practice, now widely adopted in other loading ports, may lead to difficulties during and after the period of ocean transportation. Despite the fact that very large quantities of sulphur are carried annually by sea, the vast majority are carried without significant damage to the carrying vessels.

Corrosion

When sulphur is loaded, any retained free water filters to the bottom of the holds during the voyage. From there it is pumped out via the bilges. Some water remains on the tank tops, and together with the fines, produces a sulphurous mud. A great deal of research has been undertaken to understand and mitigate corrosion to vessels' structures during the handling and transportation of sulphur.

There are two processes whereby a corrosion reaction can occur, namely *acidic* and *electrochemical corrosion.*

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Acidic corrosion

This involves a reaction between an acid and elemental iron (steel). The acid involved is sulphuric acid (H_2SO_4). Corrosion does not become significant until the acidity of the solution increases to or below pH_2.

Electrochemical corrosion

It has been established that the electrochemical reaction involves a redox (reduction/oxidation) reaction between iron and sulphur. The specific requirements for this reaction to take place are that sulphur and iron are in direct contact and that the sulphur must be wet.

Much of what we know about the electrochemical process is based upon research carried out in the 1980-90s at the University of Calgary*. This work has established the characteristics of the reaction as follows:

- The reaction has a maximum rate at around neutral pH.
- The reaction displays auto-catalytic behaviour under anaerobic† conditions – the reaction product promotes further reaction to occur.
- The reaction proceeds to a greater extent and at a higher rate under anaerobic rather than aerobic conditions.
- The initial by-product of the corrosion process is ferrous sulphide (FeS), otherwise known as *Makinawite* – a black/brown substance, spontaneously combustible upon contact with oxygen.
- The reaction displays typical temperature dependence – the rate approximately doubles for every 10°C rise in temperature.

Experience has shown that it is electrochemical rather than acidic corrosion that is responsible for the largest proportion of damage occurring to a ship's hold structures on passage.

The IMO BC Code‡ states, in Section 9.3.1.10:

"Materials which present corrosive hazards of such intensity as to affect

* Professor JB Hyne and Dr Dowling
† Existing without the presence of oxygen
‡ The IMO *Code of Practice for Solid Bulk Cargoes*, 1998 Edition,

either human tissue or the ship's structure should only be loaded after adequate precautions and protecting measures have been taken."

The following prudent measures, to preclude risk of damage as a result of loading sulphur, should be adopted:

- Make good all damages to paint coatings on hopper tank plating, bulkheads, bulkhead stools, internal ship's side plating frames and internals to the height to which the cargo will be in intimate contact, and loose rust and scale removed from the underside of hatchcovers. Aluminium or epoxy resin based paints appear to be most effective.
- Whereas the current rules of Classification Societies do not require tank top plating to be coated, it is important and accepted that paint coatings serve to provide protection to the plates during the carriage of sulphur.
- Lime wash as per owner's/shipper's/charterer's instructions and to the satisfaction of the pre-load surveyor.
- Cover the bilge strainer plates with hessian.
- During the loaded voyage, maintain bilge levels below tank top level. Keep a careful bilge pumping record, which should also include estimates of the volumes of water ejected from the holds.
- Remove all residues of sulphur from the holds upon completion of discharge and thoroughly wash down the holds with sea water and finally fresh water.
- Should corrosion have occurred, it must be removed by chipping or shot blasting before washing. The bare steel touched up with paint coatings.

The presence of chlorides – in the form of salts, such as sodium and potassium chlorides – can hasten the interaction between the moist sulphur and ship's steel. Sodium chloride is for example, a major constituent of both salt cake and dissolved materials found in sea water, while potassium chloride (potash) is regularly shipped from Vancouver. Any trace of these substances will lead to an accelerated corrosion effect, so hold cleanliness prior to loading is of the utmost importance.

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To summarise, in order to determine if a vessel is likely to suffer from corrosion damage due to the carriage of wet sulphur and to what degree, the following factors should be taken into account:

- Cargo-related factors and in particular, residual cargo acidity.
- Length and duration of voyage.
- Temperatures encountered during the voyage.
- Effectiveness of lime washing and condition of underlying paint coating
- Proper bilge pumping to remove excess water.

Cleanliness

Prior to loading sulphur, it is recommended that the receiving holds should be in a 'grain clean' condition, which requires:

- Removal of all residues of previous cargoes, hard and loose scale from the holds. Access to the upper regions of the holds should be gained by safe equipment. Air wands should be used to dislodge residues of cargo from otherwise inaccessible areas.
- Thoroughly wash out the holds with sea water.
- Thoroughly wash out the holds with fresh water.

The IMO BC Code also states in Section 9.3.1.12:

> *"After discharge of materials, a close inspection should be made for any residue, which should be removed before the ship is presented for other cargo; such an inspection is particularly important when materials having corrosive properties have been transported."*

Lime washing

It should be noted that applying lime wash to cargo hold structures does not totally eliminate, but acts to slow or mitigate the corrosive reaction. Hence ideally, the lime wash is, or should be, applied over existing sound paint coatings. The lime wash acts then in two respects – as an additional physical barrier and also as an alkaline neutralising barrier between the wet sulphur and bare steel / painted surface. The lime wash's neutralising action will eventually

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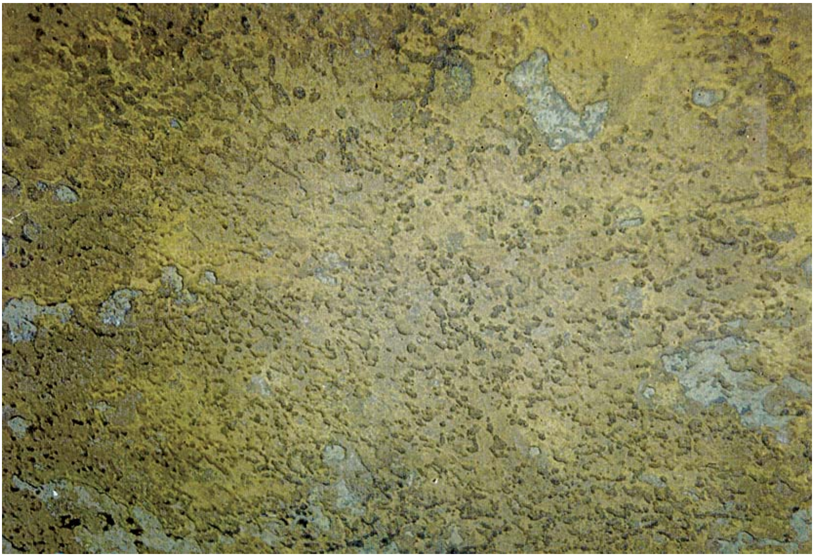

Pitting damage caused to tank top after 85 days sulphur/steel contact

result in it being 'consumed' by the sulphur – once this happens, and in the absence of an intact paint coating, the sulphur is once again in direct contact with the ship's structure and the electrochemical corrosion process can resume. Experience with Canadian sulphur has shown that the application of a single layer of lime wash can provide good protection to the steel for about 30-40 days, and in some cases even longer.

It is recommended that a mixture of approximately 60kg of lime to 200 litres of fresh water should be used. The lime wash should also be allowed to dry before loading commences, otherwise the protective 'glaze' may not form properly.

Gas emissions

Hydrogen sulphide

There are circumstances during the passage and after discharge whereby bulk sulphur can emit small quantities of hydrogen sulphide gas. All areas in which sulphur is stowed or used or which require the presence of personnel should therefore be thoroughly ventilated.

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Sulphur dioxide

Masters should also be aware of the possibility that sulphur dioxide may be generated during repairs involving heating/welding in spaces previously exposed to sulphur. Appropriate safety measures should be taken.

Flammability

A research report on the properties of formed sulphur was produced in 1989 by Alberta Sulphur Research Ltd., focussing on whether formed sulphur was a flammable solid within the meaning of the IMDG Code* Class 4.1: Flammable Solids definition. The result of tests included in the report led to the following declaration from the Canadian Coastguard on 7 August 1989 that:

> *"Based upon the results of the tests, as submitted, it is agreed that formed sulphur does not meet the criteria for classification in Class 4.1."*

However, masters should be aware that fire might occur when dry sulphur is being loaded as a result of static electricity building up on the loading pipes. These fires can be extinguished by dowsing with sulphur or by the use of a fresh water spray. Ferrous sulphide is pyrophoric† and can cause fires near the tank tops during discharge. Such fires maybe be controlled with the judicious use of a fine jet of fresh water.

* The IMO *International Maritime Dangerous Goods Code*
† May spontaneously combust on contact with air

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Part 4

Carriage of steel

This article emphasises the susceptibility of steel cargoes to damage, much of it pre-shipment in origin; hence, where damaged cargo is presented for shipment, bills of lading should be rigorously claused and any damage claimed on outturn intelligently surveyed.

Introduction

It is an economic fact that the world has a greater potential to produce steel than it has to use it. This means that steel trading is subject to what may be called a buyer's market. The profit margins are small and the competition is intense.

This trading climate has produced an industry where only the most efficient can survive, an industry that is highly automated, where the labour force, although comparatively small is highly skilled and highly paid, The plant is very expensive and needs to be used to its utmost potential if it is to be worked economically. Anything that leads to delay on the production lines, or that requires extra handling, increases the cost of the product. Any steel delivered damaged or blemished will almost certainly be the subject of a claim from the receivers. Indeed, if the cargo is discharged in anything other than the condition described in the bills of lading, then claims against the carrier can be expected.

The USA probably imports more steel than any other nation in the world, largely from Japan, Northern Europe, particularly from the port of Antwerp, and more recently from Russia. Steel is often imported into the USA by merchants who are in essence 'middlemen'. These steel middlemen in common with the industry in general, work to very narrow profit margins and are accordingly extremely claims conscious. A merchant may, for example, have ordered coils of say 1120mm width, knowing that he had buyers for coils of 510mm and 610mm widths. When the coils arrived he would cut them to the required size. If however the coils arrived with their edges crimped or cut he would be unable to do this. In the same way, while the bending of the flange at the extreme end of a beam may in itself seem unimportant, this beam may have been ordered in a 20 metre length, the merchant knowing that he has a market for 3 metre and 6 metre long beams. In both cases, the merchant may well find after cutting to the width and length he needs, that he is left with material on his hands of a width and length that is not readily marketable. Modern business methods do not encourage large stock holding and merchants do not want to keep capital tied up in goods which are deteriorating while they are in their custody.

Further the merchant is at the mercy of the steel market where rapid fluctuations in demand may play havoc with the price. A cutback in motor vehicle production, a change in the price of domestic steel, or a variation in the import regulations may leave him with large quantities of steel on his hands for which he cannot get a profitable price. In these circumstances, an aggressive attitude may be expected towards carriers with regard to any damage for which they can possibly be held responsible. In fact, the import of steel into the USA gives rise to more claims against ocean carriers than in any other part of the world.

This article describes the more common types of steel products transported and their susceptibility to damage. It emphasises the importance of clausing accurately the bills of lading and makes some recommendations as to stowage and the way in which cargoes found damaged on outturn should be examined. The article draws particulary on knowledge of the Antwerp trade, but much of what is said applies equally to the trade from Japan. Indeed, it is hoped that it will be relevant to those engaged in the carriage of steel by sea wherever in the world they may operate. It is also hoped that it will help to reduce the amount of claims directed against carriers by sea.

Types of steel products

Basically, there are three types of steel commonly carried by sea in appreciable quantities; sheets, rolled sections and small section material, rods and wire.

Steel sheet

Hot rolled coils

Steel sheet is mainly carried in the form of coils, but smaller quantities are frequently carried in packs. It is produced by heating and rolling steel ingots

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through reduction mills. As the thickness of the steel is reduced, its length increases and, for convenience in handling the long narrow sheet is rolled into a coil. The coil is then tightly strapped through the core and around the circumference and made ready for transporting to the loading port. These coils are described as hot rolled coils or raw steel and they will require further processing in the country of destination. The import of raw steel into the USA has been decreasing.

Photo 1. Coils of hot rolled steel
These coils are usually between 1.20 and 4.50 metres in diameter and weigh between 5 and 15 tonnes each

Cold rolled coils

Instead of being prepared for shipment as hot rolled coils, the steel may be further processed in the country of manufacture. In the first place, it is passed through baths filled with a weak acid solution to remove rust and scale. This process is described as pickling. The sheet is then washed, dried, oiled and re-coiled before being passed on to the cold reduction mill, where it will be cold rolled under tension, the end result being a product of better temper and improved finish.

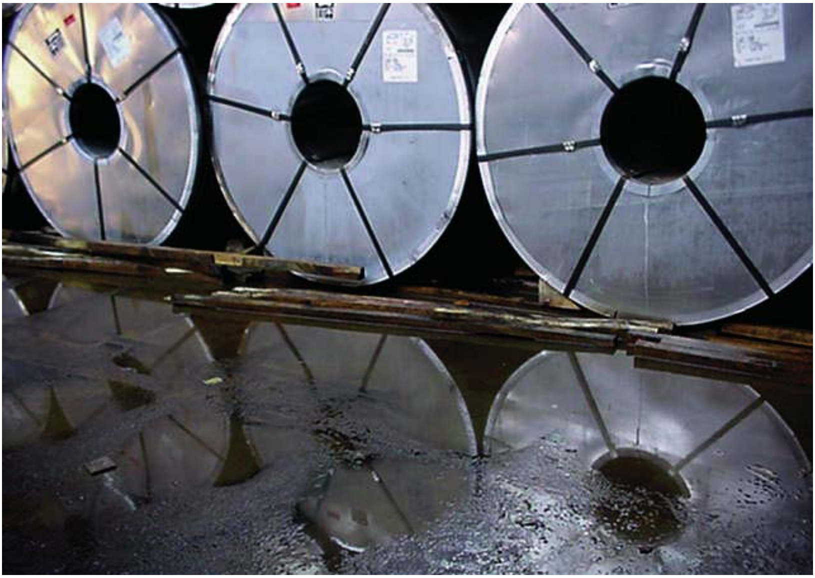

Photo 2. Coils of cold rolled steel
The higher quality surface finish of cold rolled steel makes it much more susceptible to rust damage. It is for this reason that cold rolled steel is usually packed in bituminous paper and kept away from moisture

Further processing

Cold rolled sheet may be further processed by dipping the sheet into a bath of zinc to produce coils of galvanised steel sheeting. Alternatively, tin plate may be produced by covering one or both surfaces of the sheet with a thin layer of tin.

Wrapped

Cold rolled steel, galvanised steel sheet and tin plate are of course very much more valuable than hot rolled sheet. Coils of cold rolled steel, galvanised steel sheeting and tin plate will be strapped in the same way as hot rolled coils and in addition, before leaving the factory for transportation to the port of loading, will normally be wrapped in bitumenised paper and then covered with fine gauge steel sheeting which is itself secured in place with metal strapping.

Packs

On occasions cold rolled sheets, galvanised sheets and tin plate may be carried in packs instead of coils. The bundle of cold rolled sheets forming a pack is secured with steel strapping. It is then usually completely wrapped in bitumenised paper and covered with a metal envelope. The package will then be secured by metal straps to wooden skids.

Rolled sections or constructional steel

Rolled sections or construction steel are usually fairly massive sections, in the form of 'H', 'I' or 'U' (channel) beams. They are produced by passing the steel ingots through a series of rollers.

Small section material rods and wire

Small section material

Small section material, rods and wire may be composed of special steel alloys or may consist of steel that has been given a special finish at the factory. Small section material is usually destined for use in the manufacture of machine tools, of components for electrical machinery, or of steel furniture. Other uses to which small section material is put are the construction of ladders for fire escapes, of racks in factories or warehouse, of railings and of numerous other appliances or fittings where a quality finish may be required. Small section material is shipped in bundles and may or may not be wrapped.

Reinforcing bars

Reinforcing bars may be mentioned here: they are often referred to as 'rounds' or 'concrete iron' or 'deformed reinforcing bars' or just 're-bars'. The use of the word 'deformed' means that the bars have ridges in various patterns introduced into their surface during production. These ridges improve the bond of the bar with the concrete and thus increase the constructional strength of the finished structure.

Wire rod

Wire rod is largely produced by drawing larger bars through dies. It is prepared for shipment at the factory by being rolled into coils and usually four or five coils are then strapped together to form a unitised coil bundle (see Photo 3).

Bright basic wire

In the country of destination the wire will be cold drawn through dies so that

Photo 3. Unitised coil – bundles of wire rods

the gauge is reduced and the wire elongated and polished to form what is called bright basic wire. Wire rod is used in the manufacture of numerous goods such as nails, wire mesh, galvanised wire and a large quantity of this wire is chromed and used in the manufacture of supermarket shopping baskets and trolleys,

Susceptibility to damage

Rust

All steel is susceptible to damage by rust. Rusting is a continuous and progressive process. The longer it continues, the greater the damage to the product. Rust that appears insignificant at the time the consignment leaves the mill or is loaded onboard the ocean-going ship, may develop to a serious extent by the time the consignment reaches the port of loading on the one hand and the port of discharge on the other, even though there has been no failure whatsoever on the part of the inland or ocean carrier to care properly for the cargo whilst it was in his possession.

Photo 4. Constructional steel ('I' beams)
Note that the beams are stacked correctly, with the flanges 'in and out'

Mill scale

When raw steel leaves the mill it is covered by a thin layer of hard oxide known as mill scale. This mill scale will protect the steel from deterioration by rust as long as it remains an unbroken skin covering all surfaces of the product. Unfortunately, mill scale is very brittle and is easily shattered or splintered off the steel, and when this happens, rusting takes place. Rusting is accelerated in areas where bare steel and mill scale are in close proximity. The ordinary shocks to which steel products are subjected in their transport to the carrying ship are sufficient to jar some of the scale off the surface of the steel. The scale will also gradually fall away if the steel is left exposed to the weather for any appreciable length of time.

Rust damage to coils

Where coils are concerned, the coiling process itself is often sufficient to loosen the scale and expose the steel to rusting. With hot rolled coils, much of the rust will probably be removed in the normal course of further processing in the country of destination; but if by that time the rust has developed so far that the

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surface of the steel is damaged or pitted, the steel may be unfit for the purpose for which it was originally intended. The higher quality surface finish of cold rolled steel makes it much more susceptible to claims for rust damage than is the case with hot rolled coils. It is for this reason that cold rolled steel is usually packed in bituminous paper.

Rust damage to constructional steel

Constructional steel on the other hand is usually not packed and will almost always be rusted to a greater or lesser extent. It is not unusual for steel producers to fill orders for constructional steel from stock which has been held on their premises for some time. It is usually transported from the factory to the loading port by rail, either in open or covered wagons, or in lighters which are usually covered but may not be weather tight so there is a danger of free water collecting in the bottom. Cargoes are frequently assembled a week or a fortnight before the ocean-carrying ship arrives at the loading berth, and as this steel is usually stored unprotected in the open, it will be exposed not only to the weather but also to the atmosphere. Where the atmosphere contains salts and/or is polluted the steel can be seriously attacked. The amount of rust on constructional steel will largely depend on the amount of handling to which it has been subject and on the length of time it has been exposed.

Photo 5. Typical small section steel

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Rust damage to small section material

As we have said, small section material may or may not be wrapped, in any event, it should be transported and stored under cover, protected from the elements. Unfortunately, this is not always done and frequently piles of small section steel rods are to be seen stored in the open, covered perhaps by very patched and old tarpaulins. Complaints can be expected if material of this type is received rusty since as already explained, much of it is used in the production of office furniture and fittings where appearance is very important. This is particularly true of painted material which is highly susceptible to rusting where the surface has been scratched.

Rust damage to reinforcing bars

Reinforcing bars are normally shipped unprotected in bundles which can retain a lot of water if they have been exposed in open storage for any length of time. As the wetness on the outside of the bundles dries quickly, the interior of the bundle may be considerably more rusty than is apparent from an examination of the outside. Unfortunately, the 'purpose-built' deformations on the bars are susceptible to erosion by rusting. If the reinforcing bars are subject to strict specifications (as for example in any US Federal project) then erosion of the deformation may mean that the goods are off specification.

Rust damage to wire rod

Wire rod is usually shipped unprotected, In many cases the pickling and other processing the wire rod later undergoes will be sufficient to remove any rust that may have formed. If on the other hand, the surface of the wire has been damaged or pitted, it may be necessary to eliminate this by reducing the diameter of the wire in which event the wire may be off specification.

Physical damage

As we have seen, the nature of the steel industry is such that any physical damage such as bending or denting is likely to give rise to a claim.

Loose and deformed coils

Where coils are concerned, care should be taken not to displace or break the steel strapping. It is particularly important where coils are brought forward in

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railway wagons, that they be well secured so that they do not come adrift with the motion of the train (which may be considerable if the wagons are shunted). If the strapping is displaced or broken the coil will become loose and possibly deformed. An added danger with loose coils is that abrasive matter may get between the turns of the steel and chafe or scratch the surface. We have already noted that any deterioration of the surface of either hot or cold rolled steel may be serious since, if pitting, scoring and chafing are not removed, the surface of the finished plate may be marred. Blemishes of this type cannot usually be eradicated without some waste of material.

Photo 6. Hot rolled coils which have telescoped

Telescoping

Coils may also become telescoped, that is, some laps may be projecting on one side of the coil; this in itself is not of great importance unless the telescoping is excessive, in which case it may be difficult to put the coil onto the de-coiling machine at the receiver's premises.

Crimped edges

The edges of coils may be crimped by the careless use of unsuitable lifting equipment. The misuse of handling gear can lead to chafing damage even when the coils are wrapped. The edge of packaged sheets may be crimped or bent or cut if they overhang the wooden bearers.

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Distortion

Constructional steel can also be damaged if the flanges are bent by the careless use of lifting gear, and if the bundle is incorrectly packed, the whole section may be distorted.

Kinked or bent smaller section material

If the smaller section material is bent or wire rod is kinked, the value of the material will be reduced. Thus if the rod is kinked or bent, it may damage the dies through which it is drawn and the finished product may have a score mark or nick that can only be removed by reducing the diameter of the wire, which again involves the risk of putting it out of specification. Heavily twisted or nicked wire cannot be straightened satisfactorily and therefore may be regarded as scrap.

Clausing bills of lading for pre-shipment damage

From all that we have said it must be obvious that before steel cargoes are loaded into the ship they have already been subject to considerable risk of damage, both by exposure to the elements, and by reason of the number of times they have been handled. It is extremely important that any pre-shipment damage be noted on the bills of lading and, to this end, it has been found by experience that the services of a skilled and conscientious surveyor are usually necessary. Masters and agents of ships stemmed to load steel cargoes should contact the local UK Club correspondent who can normally arrange for a surveyor to be instructed to attend the loading of cargo.

Rust damage

Nowhere is the need to clause bills of lading greater than in the case of rust. Without exception, whenever a consignment is rusty this should be stated in the bills of lading. Cargo interests may well insist that the rust to be seen is normal or customary, or will not affect the value of the cargo, or will be removed in any event by further processing, and therefore that the bill of lading can be issued clean without any danger of prejudicing the interest of the carrier Representations of this type are to be ignored. The best way of protecting the carrier's interests is to clause the bill of lading. If the rust is indeed normal or customary there should be no difficulty in the bills of lading being negotiated through the banks. The master's job is not to concern himself with the marketability of the cargoes that he carries, he should simply describe the condition of the cargo as he sees it.

Further, when clausing bills of lading against rust, it is essential not to qualify the word rusty in any way by using words such as 'atmospherically' or 'superficially' or 'slightly'. The reason for this is simply that rust which may appear on loading to be only slight, may have worsened progressively during the voyage (without there being any fault on the part of the carrier in the care of the cargo) to such an extent that the cargo is pitted or otherwise seriously affected on discharge. Commonsense would tell us that the damage seen on outturn in this type of case is directly consequent on the damage noted on loading, but it is not always so easy to persuade a court to see things in this way. If the damage on outturn is more severe than the damage noted on loading a court may be tempted to attribute the deterioration in the condition of the cargo not to the natural development of the rusting process but to some alleged fault of the carrier in the care of the cargo. One of the best ways therefore of minimising this danger is simply to describe rusty cargo as 'rusty'.

Club circulars

In 1963 and 1964 the London-based P&I clubs issued circulars setting out certain clauses that were suitable to describe pre-shipment rust damage to steel. Probably the most effective of these have been found to be the following (to be used where appropriate):

- Rusty.
- Rusty edge.
- Rusty end.
- Top sheets rusty.
- Rust on metal envelopes.
- Goods in rusty condition.
- Wet before shipment.
- Covered with snow.

Where goods are shipped packed the following clauses may be used where appropriate:

- Covers wet.
- Covers rusty.
- Packing wet.
- Packing rusty.

Physical damage

Any physical damage such as denting or bending should also be entered on the bill of lading. Where the packing is damaged this should be noted too, together with any obvious damage to the contents.

Describe accurately

It must be emphasised that the clauses used must accurately describe the apparent condition of the steel shipment.

Loading and stowage

Residues

Residues of previous cargoes which may have an adverse effect on steel, particularly salt and fertilisers should be very carefully removed.

Bulk carriers

It has been found from experience that the most suitable ships to be engaged in this trade from the point of view of loading and stowing are bulk carriers with wide, large hatches and unobstructed holds.

Handle with care

The loading and stowage of steel cargoes calls for skilled and experienced stevedores. Steel can easily be damaged or indeed damage the ship, if not handled with care, as each separate lift is likely to weigh in the region of five to twelve tonnes. In Antwerp, it has been found that the cranes used for loading and discharging containers are the very best equipment for handling steel cargoes, where conventional means are used, lifting gear such as wire slings, spring laid rope strops or chains should be adequately protected to avoid damaging the edges of coils. Winch drivers should be instructed to avoid violent acceleration or braking when lifting or lowering coils, Forklift trucks should have the forks adequately protected with timber, unless they are specially designed for use with steel cargoes and crowbars should only be used by stevedores in handling material not capable of being damaged thereby.

Steel is not an easy cargo to stow. In making recommendations, it should be appreciated that we are describing the ideal. In practice, the ideal is not always possible and we know from experience that satisfactory alternative arrangements can be made where the stowage cannot be effected exactly as we recommend. Our comments imply no criticism of other methods of stowage that may be adopted and which have been found to achieve equally good results.

Locking coils

Generally, coils should be given bottom stow. The method of stowing coils that has been used with considerable success in Antwerp consists of stowing them in athwartships rows with their major axes horizontal and in the fore and aft line. The bottom tier of coils should stand on double lines of good dunnage placed athwartships so that any moisture that may collect on the tank top or ceiling of the hold can run to the bilges without damaging the cargo. This dunnage also helps to spread the weight of the coils over the tank top plating. The first coils loaded are placed in the wings against the bulkhead and then the row is extended inwards towards the centre line of the ship. Invariably a gap will be left on the centre line and the first coil of second tier in that row will be placed in that gap. The next coils of the second tier will be placed in the wing above and outboard of the extreme wing coils of the first tier and these three coils, that is the one on the centre line and the one in each wing, will effectively jam and block off the first tier of that row. These three coils are known as the locking coils. The remainder of the second tier in that row will be placed in the cantlines of the coils beneath them. For each further tier the same procedure is followed until the first row has been built up to the required number of tiers Coils of up to ten or twelve tonnes in weight may be stowed in three tiers but over this weight it is better that they should be started in the same way, loading the first two coils in the wings and against the first row loaded. Working in toward the centre line and then placing the three locking coils. Reference to Fig 1 will help to make this method of stowage clear.

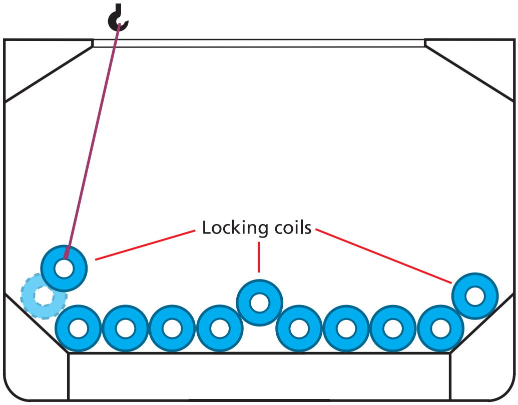

Fig 1. Locking coils

Loading and stowing coils

The manipulation of coils into place where the crane or derrick cannot plumb the coil into the desired position calls for the exercise of ingenuity and skill. If one attempts to swing into position the coils to be stowed in the wings or at the fore or aft ends of hatch, the coils may frequently be damaged by being positioned at the wrong instant. Equipment and the use of dedicated trucks has now been evolved which has improved immensely the means by which coils of steel can easily be properly handled.

It is better to stow coils at least two tiers high. A single tier of coils nearly always allows movement, and as result, the stow may work loose. If there are not sufficient coils to make two complete tiers over the whole surface of the hold then the hold should be partially floored out with two tiers of coils so that the stow ends in a brow or wall across the hold. The face of the coils should be protected by a strong timber fence when other cargo, such as constructional steel, is stowed adjacent to them

Each individual coil in the top tier of the stow should be secured by driving wedges between it and its adjacent coils on either side and fore and aft.

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Forward compartments

Particular attention should be given to cargo in the forward compartment of a ship where the effects of heavy pitching are more pronounced.

Coils of various dimensions

When coils of various dimensions and weights are offered for shipment, the lighter smaller, coils should be given a top stowage position. Furthermore, precautions should be taken to see that the smaller coils cannot work down too far into the cantlines of the rows of larger coils underneath. If they do so, they may become deformed. There is no objection to overstowing a coil cargo with wire rods, bales or other cargo and whether a floor of dunnage over the stow of coils is necessary will depend on the nature of the overstowing cargo.

Sheet steel in packs

Sheet steel in packs should also be stowed on double lines of athwartships dunnage. The ordinary principles of cargo stowage may be applied to the stowage of these packs. They are not as likely to shift in stow as coils since they stow more compactly.

Dunnage for constructional steel

The customary and recommended method of stowing constructional steel also entails the use of considerable quantities of dunnage. Quantities of timber amounting to between seventy-five and one hundred tonnes per ten thousand tonnes of cargo are quite common. This dunnage, usually 6" x 1" (15cm x 3cm) should be laid in double lines athwartships at intervals along the length of the steel which is stowed fore and aft. The dunnage is inserted to assist in reslinging the steel for discharge and to help bind the steel into a solid block. As the steel is very heavy it needs to be supported at intervals of about 10ft (3m) along its length, Care should be taken to ensure that each line of athwart ships dunnage is vertically over the line immediately beneath it (see Fig 2). If this precaution is not taken the steel may very well become warped. When stowing beams, it is important that the webs are kept vertical and that the flanges overlap in an 'in and out' manner (see Photo 4) as experience has proved that when all flanges are overlapping in the same direction the beams

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can become severely distorted. The stow should be kept level and complete. Efforts should be made to avoid mixing sizes as this may create gaps in the stow which can later lead to the whole stow collapsing. Athwartships stowage of steel beams should be avoided if at all possible. In particular, try to avoid the ends of beams stowed at the bottom of the hold in a bulk carrier resting against, or terminating adjacent to, the sides of the hopper tanks in the wings of the compartment. If during the voyage the dunnage compresses, the beams may settle, leaving the ends resting against the hopper tanks and the middle of the beams unsupported. As a result, the beams will probably be permanently bowed (quite apart from the risk of damage to the tanks!).

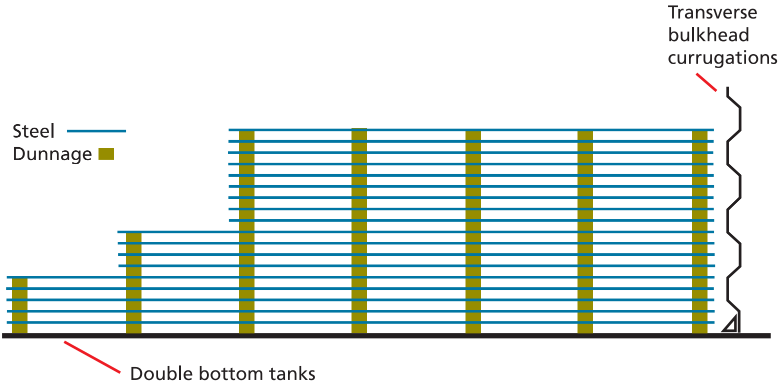

Fig 2. Dunnaging constructional steel

Small section material

Small section material, particularly rods and bars should, wherever possible, be given a top stowage position. They too should be stowed in a fore and aft direction, the stow being kept level to ensure that the material is adequately supported at frequent intervals along its length. Rods and bars should be handled only with rope slings and on no account should crowbars be used in manipulating the bundles into their stowage positions.

Unitised bundles of wire rods are usually stowed in the ship with their axis in a fore and aft direction and in a manner similar to that described for coils. It is not recommended to stow the coils of rod more than, say, six tiers high as the weight on the lower bundles may be excessive. As a result the lower bundles may become deformed and the stow may collapse. As with coils, a two tier stow in part of the hold is preferable to a single tier over the whole floor of the hold. The face or brow of the stow also needs to be fenced or secured in the same way. Loading slings should be made of composition fibre or of wire rope covered with rubber tubing. When forklift trucks are used, the forks should either be covered with timber or fitted with a specially constructed metal tube. One common fault with bundles of wire rod is that if the strapping bands break, or work round the coil to one particular point on the coil, the unsecured turns open out and become crushed, distorted and twisted in the stow.

Reinforcing bars

As far as reinforcing bars are concerned, the bundles should be given good, level stow and should be well supported throughout their length to avoid any bending or distortion which may make them unsuitable for the purpose for which they were intended.

Pipes

Considerable claims have been experienced in the carriage of pipes. They are usually shipped in bundles except where the diameter is very large. In that case, they are usually presented for shipment in single pieces. Special stowage is frequently called for, particularly in the case of lighter pipes, where top stowage is preferred. Where top stowage is preferred, pipes should be stowed fore and aft in the hold. On occasions where pipes have been stowed some fore and aft and some athwartships almost invariably one or other tier has become deformed owing to the weight of the over stowing cargo. These goods are most vulnerable at their ends, and where the ends are threaded then great care should be taken to ensure that the threads are not nicked or otherwise damaged.

Care onboard

Little has been said so far on the all important question of avoiding rust damage to steel cargoes while they are in the ship's care. Every effort should be made to avoid loading (or discharging) during wet weather, and all the hatches should be covered during rain showers. The shippers will frequently object and have been known to bring considerable pressure to bear on a ship's staff to

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continue loading when the latter have wanted to stop loading during wet weather. Such pressure should be firmly resisted. It is not advisable to continue loading in the rain even if the steel already inside the hatch has been covered with tarpaulins or plastic sheeting, since protection of this type has not been found to be of any great assistance in avoiding rust damage claims. One surveyor reports that within hours of covering a parcel of steel with plastic sheeting, that steel was covered with condensation and rusting had started.

Fact finding on discharge

If damage is suspected on arrival at the discharge port then the master should contact the UK Club's local correspondents direct and ask for the appointment of a competent surveyor to examine the hatches and the stowage of cargo. Contacting the Club's correspondents direct is usually preferable to contacting the ship's agents at the discharging port who may be appointed by, and closely identified with, the cargo interests.

Photographs

Frequently, the receivers of the cargo or the cargo underwriters also appoint surveyors who will want to board the ship and inspect the hatches and other openings into the holds. In the USA, and perhaps elsewhere as well, cargo interests can obtain a court order granting them access to the ship for this purpose. When cargo interests surveyors are onboard the ship they should be accompanied by the shipowner's surveyor wherever they go. The effect of cleverly composed photographs in enhancing the amount of damage apparently suffered by cargo is well known and photographs taken by the cargo interests surveyor should, if possible, be countered with photographs taken by the shipowners' surveyor showing the overall condition of the cargo. A responsible person should always be on duty at or near the gangway at all times to prevent unauthorised people boarding the ship.

Sea water entry or condensation?

Sometimes, on opening hatches, a pattern of rust extending right down through the stow coinciding with the hatch coamings or hatch joints is discovered. This may indicate that the hatches have leaked during the voyage;

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it may on the other hand be indicative simply of heavy condensation. In any event it is imperative that the pattern of damage in each compartment is accurately noted for only in this way will it be possible to distinguish between pre-shipment damage and damage incurred during the course of the voyage.

A careful examination should be made of any rust which is not pre-shipment in origin to establish whether it is caused by sea water or fresh water. An experienced surveyor should normally be able to say, fairly conclusively, which is which without resorting to silver nitrate tests, which can be quite misleading.

Stevedore damage

Any further damage caused by the discharging stevedores should also be noted so that recovery can be made from them for any claims that may be lodged for physical damage to the cargo caused by them.

Conclusions

The interests of the shipowner and the charterer are parallel, or should be. Both will be involved in any claims that arise and by persistently delivering damaged cargo the charterer may lose business.

We would again emphasise that when wrapped steel products, e.g. cold rolled material, tin plate, etc, which are highly susceptible to moisture damage, are being loaded and rain threatens, or becomes a reality, loading should be stopped and the hatches covered. With unwrapped hot rolled material fresh water exposure over a limited period should have no adverse effects, but some discretion should still be exercised as prolonged rain could result in large quantities of water collecting on the ship's tank tops. As a consequence, a cargo could stand in salty or brackish water for a significant period and the humidity levels in the holds could be increased. The dead-weight nature of steel cargoes causes the ship's structure to work more heavily in high seas and the maintenance and securing of the hatchcovers could be critical. In this respect we refer readers to the article on steel hatchcovers.

Hot rolled steel sheeting

There has, over the years, been an increase in the number of claims made in respect of rust on hot rolled steel products. Many of these claims are for rust caused by fresh water. In the majority of the cases they are not justified and should be strongly resisted.

The product

The most common way to carry hot rolled steel sheeting on ships is in coils, although it is often carried in bundles or in heavier scantling single plate form. The final product, in coil form, will usually have a plate thickness of from 1mm to 5mm in a coil of about 125cm in width. Each coil will weigh between 7 and 15 tonnes depending on the length and thickness of the plating, although coils of up to 30 tonnes are not uncommon.

Packing

Hot rolled steel coils which are destined for sea-borne trades are usually unwrapped and not therefore protected from moisture and the consequent development of rust. They are secured by a number of flat metal strapping bands passed transversely through the eye or core of the coil and by other bands secured round the outer circumference of the coil. In some cases, hot rolled coils are pickled and then oiled for protection, after which they are wrapped in moisture-proofed kraft paper, enfolded in a metal envelope and finally secured with flat metal strapping bands.

Industrial uses

Hot rolled steel coils may either be uncoiled and sheared into short lengths for use in the fabrication industry or processed and re-rolled to produce cold rolled steel sheeting.

Pre-shipment storage

Unwrapped hot rolled steel coils are often stored in the open, uncovered and exposed to the elements. Consequently, it is not unusual for such material to be partly or completely rusty in appearance when it is shipped. Wrapped, hot rolled steel coils, pickled and oiled should be stored in the dry as any rust on the plating is not acceptable.

Hot rolled coils awaiting shipment

Handling damage, often referred to as mechanical damage, frequently occurs during loading and discharging by stevedores. Damage is often caused when the side of the coil is permitted to strike some object which results in the plate edge becoming scored or torn. Damage of this nature is not acceptable to receivers if the plate is intended to be re-rolled and where the edges have been sheared to an ordered width. Buckling or bending of the plate is of less importance as, during de-coiling, rollers will flatten the bent edges except where the affected plating is folded or bent beyond the elasticity of the metal.

Another defect is 'telescoping'. This occurs when the plate edges are pushed out of line. If the edges are projecting too far, the chances of additional damage during handling increases.

When lifting coils, the use of chains and wires should be avoided. Only dedicated equipment such as broad braided wire slings and 'C' hooks should be used. Forklift trucks should be fitted with a circular bar prong.

Hot rolled coils awaiting shipment

Mill damage

Sometimes, the side edges of plating may be continuously jagged in appearance over a considerable length. This type of defect is not caused by transportation or handling but is a defect that develops during the rolling of the plating in the mill.

Rust

Both before shipment and after delivery, unwrapped hot rolled steel sheeting may spend a considerable time in open storage. The coils may therefore be exposed to rain and possibly to a polluted or salt-laden atmosphere. Free moisture will trickle down the edges of the plating and may penetrate over a limited distance between the laps of the sheeting. It is therefore not unusual for hot rolled steel to appear rusty or partly rusty. A thin film of rust on the surface of the plating caused by contact with fresh water is usually of no consequence since any remaining mill scale, rust or other extraneous matter will be removed by a pickling process before the goods are cold rolled or provided with a protective coating. If, however, the rust is excessive and corrosion pitting is evident then additional surface preparation may be required depending on the depth or extent of the pitting. The time taken for rust damage to become excessive will obviously vary from one area to another but several months of exposure would normally be required before excessive rust is formed.

Loading during rain

Unwrapped hot rolled steel sheeting is frequently stored in the open, both before shipment and after discharge. When it is stowed in the open at the loading port there is little point in refusing to load during short periods of light rain. However caution is advised if the rain is heavy, as free moisture may collect on the tank top and build up at the after end of the compartment, so that some coils may be partially submerged in water. The rainwater may also become contaminated either by salt residues after salt water washing of the hold, or from previous cargoes.

Whether loading during rain should be permitted or not will also depend upon any changes in temperature which are anticipated during the course of the projected voyage.

Consideration should of course also be given to the effect on any other cargo already loaded which might be damaged by rain, either directly, or by the high level of humidity that will be created within the cargo compartments.

In circumstances such as those described, bills of lading should always, in addition to any remarks concerning rust, be claused 'wet before shipment'. If problems arise, advice should be sought from the Association's local correspondents.

Contact with sea water

Sea water has a devastating effect upon steel products and rapidly causes a serious rust condition to develop. If action is taken in time, before corrosion has become firmly established, the rust and chlorides can be removed during the pickling process and the goods can be considered as sound and prime material. On the other hand, if the goods are left for some time before the salt and rust are removed then serious consequence will result. It is therefore of great importance that the master ensures the hatchcovers of his ship are absolutely watertight and that the holds are thoroughly cleaned and washed out with fresh water before loading starts.

Coils showing loose and broken strapping bands

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Prior to loading, the coils should be subjected to silver nitrate tests to establish if there is any presence of chlorides on the steel.

Strapping bands

Strapping bands on the coils at the time of shipment should be tight in order to ensure that the goods are delivered in a tightly wound condition. Coils which have slackened off, owing to broken or slipped securing bands, can cause instability of the stow and problems in handling. Difficulties may arise at the mill when uncoiling the material and claims may arise from any disruption of a mill's set programme for loss of production. In addition, stones and grit may penetrate between the turns of plating, causing serious marks to the surface of the steel when the coils are reversed to tighten the loose turns of plating.

Conclusion

It will be clear from the above comments that it is essential to clause mate's receipts and bills of lading with remarks accurately reflecting the condition of hot rolled steel coils. These remarks should correctly record the apparent rust condition, the presence of any chlorides and any mechanical damage. Great care should be taken in the loading, stowage and discharge of this cargo.

During the sea passage, the cargo should be kept in as dry an atmosphere as possible and any necessary ventilation, either mechanical or natural, should be recorded in the deck log book or ventilation record book with air and hold temperatures and dew points. The surface temperatures of the steel coils themselves should be recorded and the cargo should be ventilated in accordance with psychometric values. Tests carried out on the watertightness of the hatchcovers and other openings to the holds should be noted as work done in hold cleaning and maintenance records.

It is recommended that a surveyor be appointed at the loading port or ports to survey the cargo prior to loading and assist the master in clausing mate's receipts and bills of lading. The Association can arrange this, but the master should realise that the appointment of a surveyor does not abrogate any of his responsibilities to care for the cargo. The surveyor should help masters to decide exactly the condition of the steel coils and thereafter the remarks to be inserted on the mate's receipts and bills of lading. If the shippers insist on clean bills of lading they should present coils that are dry and without traces of rust. It should be noted that claused bills of lading for this type of cargo will not necessarily create any problems with letters of credit.

If all the above precautions are taken, there should be adequate evidence to enable the shipowner to reject any claim for damage by fresh water. It is more difficult to reject allegations of damage by salt water when chlorides are not detected at the time of loading, but are observed at the time of discharge. Accurate records can however help the owner to defend these claims.

Last but not least is the importance of photographs as evidence. Masters, ships' officers and surveyors should always be instructed to take a good set of photographs of any damage at both loading and discharge ports.

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Securing shipments of steel by flexible metal bands

The securing of steel coils since the late 1970s has been carried out most successfully using flexible flat metal banding secured by clips. Securing clips around the bands and tensioning the bands is being undertaken using pneumatically operated tools. This is not to say that the older traditional system of using steel wire has been totally eclipsed. Both systems should, when properly effected, be just as satisfactory and excellent cargo outturns should result.

Initially, some experienced surveyors familiar with the traditional methods expressed doubts about the effectiveness and strength of securing bands. However, since 1979 the majority of shipments of steel coils have been successfully carried using this system and cargo outturns have been just as satisfactory as when wire lashings were used.

It should be emphasised that when utilising strapping bands, it is essential that the correct procedures are closely followed at the time of loading and that the manufacturer's instructions are strictly observed. Correct stowage and lashing is vital when loading shipments of steel, the primary aim being to avoid any risk of cargo shifting during the voyage. The following points should be carefully borne in mind when the use of bands is contemplated:

- The strapping band system is cheaper than the wire cable system because fewer personnel are required to secure the cargo. Straps are easier to thread through the coils and rigging/ bottle screws and bulldog clips are not required.
- The straps can be rendered bar tight at the outset of the voyage whereas wires may still not have reached the full limit of their elasticity and may subsequently slacken off during the voyage.
- When strapping bands are used, it is necessary to utilise an air compressor. The pneumatic tools need constant servicing and require trained operators.
- Normal lashing wire of 16mm diameter loses 30% of its strength in the area of the bulldog clips. The actual breaking strain may therefore be

considered as 5.6 tonnes. Metal strapping bands have, in general, a breaking strain of 4 tonnes.

- When a 'key coil' is secured with 16mm wire lashings through the core and with additional cross lashings over the top, a breaking strain of 44.8 tonnes can be achieved (8 lashings x 5.6 tonnes = 44.8 tonnes). This compares with a breaking strain of 32 tonnes when single strapping bands are used. Such a lashing system would be considered adequate for coils weighing up to 15 tonnes. Where very heavy coils are carried, double strapping bands should be applied.

When properly utilised, the strapping band securing system meets all the necessary requirements, i.e. it is of adequate strength and is acceptable for securing average steel cargoes onboard ocean-going vessels.

It is, again, stressed that owners would be well advised always to appoint a surveyor on their behalf in the load-port in order to ensure that the securing system has been properly applied and that the manufacturer's instructions are carefully followed.

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Stowing and securing steel slabs

The Committee has noted that losses of ships laden with steel cargoes continue to be reported. Some of these losses involve steel slab cargoes. In some instances, such cargoes have been known to shift in relatively moderate weather conditions, putting at risk the safety of the ship and her crew. Not infrequently, cases arise involving heavy plates or steel slabs, where the methods of stowage are criticised.

The correct and safest method of carrying steel slabs, and heavy steel plates, is to stow with the longitudinal axis athwartships. This entails winging the stow out to the ship's sides and results in overlapping of horizontal layer ends. In the case of slabs, this method of stowage entails handling each slab individually in the hatch, using a forklift truck. Similarly, steel plates, depending on their weight per unit, can only be handled a few at a time.

The two Figures 1 and 2 show two satisfactory methods of stowage (see next page).

Fig 1 shows all slabs stowed athwartships.

In Fig 2 a variation of 1 is shown, which is useful when the complete tank top area is not to be utilised. Slab 1 is stowed athwartships. Slabs 2, 3 and 4 are stowed longitudinally in order to prevent movement of the stow.

It is essential that wooden dunnage be placed between plates or slabs, in order to correct any tendency to shift. In some cases, consideration may be given to the lashing of such stows with steel wires, preferably attached to steel eyepads. This applies particularly in the upper decks of tween deck vessels.

In recent years, other methods of stowage have been devised with the aim of speeding up the turnround of ships and reducing expenses. The Committee is highly sceptical of some of these practices and advises caution before they are adopted. One such system involves a series of heavy lifts into the ship. Each lift comprises a block of slabs or plates weighing in total a much as thirty-six tonnes or more. Each lift is landed in a convenient position and succeeding lifts are landed adjacent to each other, in the square of the hatch, where all the cargo is stowed. No dunnage is used between the individual stacks and there is

Stowing and securing steel slabs

Fig 1.

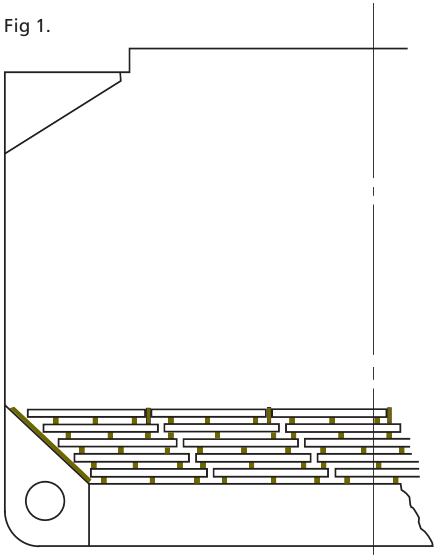

Fig 2.

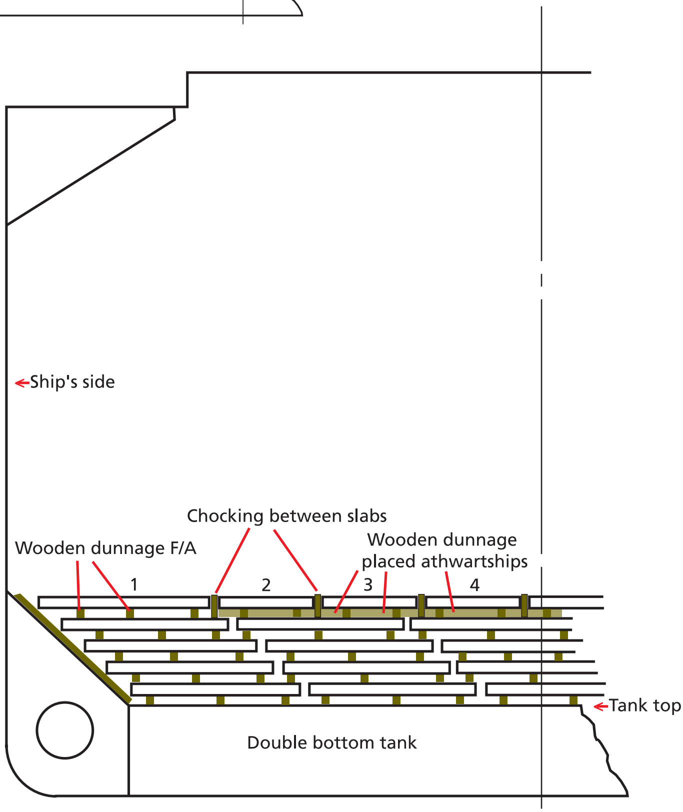

Photo 1. Correct stowage of plate steel

a huge gap between the cargo and the ship's side, both to port and starboard. Sometimes flimsy timber framings are erected to fill these gaps (see Photo 2). Metal strapping bands are sometimes used to secure each stack but, due to the sinkage of whatever wooden dunnage may be placed between slabs, are often slack before the ship sails. Such strapping bands should not, in the view of the

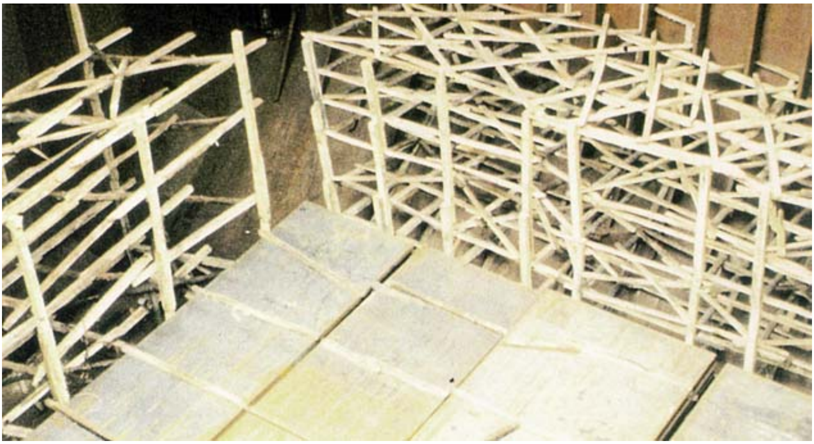

Photo 2. Flimsy timber framing

Committee, be used with these cargoes and are to be discouraged as dangerous.

The Committee is concerned that methods of stowage continue to be used which they consider to be unsatisfactory. The main criticism concerns block stowage of bundles of steel slabs by direct loading into the hatch squares of bulk carriers leaving the space above the sloping lower wing tanks free of cargo. Whatever lashing or securing is used in these circumstances there is still the potential for a shift of cargo which could have unfortunate consequences. Although some variations to the method of stowage previously recommended could be accepted it is of paramount importance that the stowage extends out to the ship's sides and that the top of the stowage is level. The only alternative would be to construct, and weld in position, substantial steel framing between the ship's side and the cargo above the sloping lower wing tanks. There is no objection to using block stowage methods in ships with box-shaped holds as long as the stowage extends to the full width of the ship and again the top of the stowage is level.

One of the most common forms of block stow encountered is the 'California block stow' devised by California Steel industries. This method of stowage has been in use for a number of years and the Committee is not aware of any accidents occurring when this stow has been used. However, they still consider it to be unsuitable for use in normal bulk carriers with sloping bottom wing tanks. The use of this method, or similar methods, may be stipulated in charterparties. Owners should be aware of the potential implications if they sign charterparties containing clauses mentioning methods of stowage not suitable for their ships.

The Committee wishes to advise masters to be on guard against situations where steel plates may be presented for shipment which are too large to fit the hatch opening dimensions.

Attempts may be made to persuade the master to carry such plates on hatchcovers or weather-decks. If steel plate is loaded on deck, care should be taken to ensure that the plates are individually stowed, dunnaged, chocked and lashed. There should be no plate-on-plate interfaces. It is also important, in such circumstances, to clause mate's receipts appropriately in order to reflect stowage on deck.

Part 5

Carriage of forestry products

Softwood and hardwood timber, plywood and paper products

Softwood timber

The main areas from which softwood timber is shipped are the Baltic and North America. Very few claims arise from the Baltic or the east coast of North America trades, but large claims have occurred on shipments of timber from the north west coast of North America mainly due to the very wet climate in this area.

Softwood timber is commonly shipped in bundles or packages of planks of various lengths and sizes, secured with flat metal strapping bands. The timber is usually unprotected unless it has been kiln dried, when it is normally protected by a loose plastic wrapper or shroud.

Softwoods, and especially pinewoods, carry a great deal of sap and are therefore very susceptible to fungal growth known as sap staining. This sap staining is of relevance only where strength or appearance is of prime importance. In this respect it should be borne in mind that clean timber is always a more attractive product. Blue staining occurs mainly in hardwoods and can be prevented by dipping the timber in chemicals. This must be done within one day of sawing the timber into planks or it may not be effective and may not prevent blue staining. This timber is often stored in the open, exposed to inclement weather, so that water may destroy the effect of the chemicals. Fungal development is purely associated with the moisture content of the timber and therefore kiln-dried timber that has been properly dried is normally not affected by fungal growth.

There is so much rain in the British Colombia area of the north west coast of North America that timber is often loaded during pouring rain and is wet before shipment in most instances. The problem is further exacerbated because the rain enters the ship's hatchways and the tank tops can become partially flooded. Apart from the bottom packages of timber becoming thoroughly soaked, the water may stain the timber with rust marks picked up from the ship's structure. It is therefore recommended that provision be made to keep the bilges pumped dry at all times when loading during rain. A further problem occurs in that the metal strapping bands securing the bundles of timber become rusty and the rust runs into the timber with resulting stain.

It is important to emphasize that many thousands of tonnes of softwood timber have been shipped over the years in a thoroughly wet condition on long voyages, with no ventilation between the planks or packages in the stow and with the timber remaining saturated for the entire voyage, without developing any defects as a result. Invariably, bills of lading are signed 'clean', as it is a well known fact that timber shipped from the British Colombia area can be, in most instances, shipped in a wet condition. However, claims can arise as a result of blue staining, rust staining, or in some rare instances, rotting. Claims may also arise after discharge for drying the timber. It is therefore recommended that bills of lading should be claused with appropriate remarks to reflect the condition of the timber as shipped such as 'timber rust stained', and 'wet before shipment'.

Hardwood timber

Although hardwood and semi-hardwoods are shipped from many tropical and semi-tropical countries in the world, much of this timber, especially from West Africa, is shipped as logs. Shipments of logs do not usually generate any cargo claims and therefore are not dealt with in this article.

Hardwoods and semi-hardwoods shipped from South East Asia, especially to Europe, are commonly shipped as boards in bundles or packages secured by metal bands. Most are unprotected. The following are some common types of timber from this part of the world.

MERANTI

A relatively light semi-hardwood suitable for general construction, interior fittings and furniture. The sub-groups include, meranti bakau, dark red meranti, light red meranti, white meranti and yellow meranti. This timber is not durable under tropical conditions and is difficult to treat with preservatives. However, it is easy to work and seasons without trouble. It is shipped into Europe in large quantities and used extensively for doors, window frames and other outside uses.

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MERBAU

A heavy, hard, fairly strong and durable wood used mainly for heavy construction. It is bronze or red/brown in colour, weathering to dark red brown.

RAMIN

A moderately hard, moderately heavy utility wood, easily treated with preservatives. It seasons quickly but is very liable to blue stain and it is therefore advisable to dip the timber in anti-stain chemicals after sawing. The timber is white in colour and usually free from quality defects. It is used extensively in the furniture trade and is highly susceptible to claims.

There are of course many other species of timber but most shipments into Europe from South East Asia include some of the types above

Loading and care of timber cargo

It is of paramount importance that cargo holds are thoroughly cleaned before timber cargo is loaded, of whatever type. Any grease and oil should be removed from the vessel's structure, as contact can stain the timber. All remnants of previous cargoes should be removed from the overhead beams and the underside beams of the hatch panels, as claims have arisen as a result of remnants of previous cargoes contaminating the timber. For example, iron ore dust when made wet by condensation can turn into a red liquid which can stain the timber; and ores or sand of an abrasive nature, such as ilmenite ore, can damage the saws in sawmills, if the timber has been contaminated.

If the steelwork of the hold is rusty, the timber should be kept clear of the rust by use of dunnage. Ship's sweat developing during the voyage and dripping on the timber may also result in rust stains, therefore, correct ventilation and dunnaging is of great importance.

Bad stowage often results in the bands securing the bundles breaking. This is usually as a result of not keeping the stow level or crossing the bundles in stow, or a combination of the two. It is the practice for stevedores to work fork-lift trucks on top of the timber in the square of the hatches in bulk carriers, when the stow has reached about half the height of the hold. The surface of the timber in contact with the trucks usually becomes damaged by scuffing and

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through oil dripping from the trucks. If this method of loading is to be used, then steel plates should be carefully laid over the exposed timber to protect it.

Care should always be taken during loading and discharge to use correct equipment. Wire slings tend to score the lower corner planks in the bundles, especially when the slings are overloaded therefore, rope or webbing slings are preferable. Fork-lift truck damage, caused by the forks of the truck being driven into the planks, is common. This results in deep score marks in the timber and, in many instances, splitting of the timber.

Careful supervision by the ship's officers can prevent much of this type of damage.

Seasoning of timber

Reduction of the moisture content of timber is achieved by either air drying or by kiln drying. Timber is fully seasoned when the moisture content has been reduced to the equilibrium moisture content of the local climate. This, in most cases, would be between 15 and 18%.

Air-dried timber

As the name implies, air-dried timber is timber that has been allowed to dry naturally, usually by stick piling the sawn planks in covered storage allowing natural air circulation between the planks. The time required for this process will depend on the type of timber and the climate. Once seasoned, the planks are secured in bundles with a number of flat metal strapping bands and are ready for shipment.

Often these bundles are stored in the open and exposed to the elements, resulting in moisture infiltrating the individual planks. Although this may result in the planks on the outside of the bundles having a higher moisture level than expected, these planks will quickly dry naturally. The condition of the internal parts of the bundles will depend on how long free moisture has been trapped within the bundles and also the nature of the timber, i.e. its resilience to the effects of wetness. In the worst situation, the planks will be mouldy, still wet and severely black stained.

In general, high moisture contents for air-dried timber, without staining, do not provoke claims. However, if the moisture content is excessive, it is not unknown for receivers to claim the costs of stick piling to re-dry the timber. If such timber is not dried and remains in store, mould may develop and could lead to staining of the timber.

Air-dried timber is often carried on deck with shippers' approval, without protection. It is therefore obvious that wetness and high moisture content are of no real concern in shipments of this nature. In most cases, air-dried timber has not been properly seasoned and has moisture contents well above the optimum levels which might be expected from the country of origin.

Kiln-dried timber

Because seasoning takes a long time when timber is allowed to dry naturally, and because the process is therefore expensive in terms of storage costs, the technique of drying timber in ovens has been developed.

The timber, after treatment, is generally referred to as kiln-dried timber. Sometimes, bundles of kiln-dried timber are protected by plastic wrappers, and have a stencil on the outside of the bundle denoting the fact that the timber is kiln-dried.

Kiln-drying certificates usually specify to what degree the timber has been dried. The usual parameters are 8-12%, 14-16% or 16-18%. Provided the timber has spent sufficient time in the kiln and has been properly treated, the moisture content at the heart of each plank should show the correct degree of drying within one or two percent, even though the surface of the plank may show a higher level of moisture through natural absorption after the kiln-drying process. Sometimes, the moisture content reading to the heart of the plank shows a higher reading than the outside of the plank and much higher than the drying certificate timber. This is a clear indication that the timber has not been properly dried. These points should be taken into consideration if receivers claim for re-drying costs on wet timber. When granting allowances for re-drying, it should be recognized that stick piling for air drying may be all that is necessary if the outer surfaces of the planks only are affected. Stick piling is normally considerably cheaper than oven drying.

Claims for re-drying of kiln-dried timber represent a large proportion of claims on timber cargoes. It is often alleged by cargo interests that to stow kiln-dried timber in the same cargo hold as air-dried timber is tantamount to not

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caring properly for the cargo. Provided the air-dried timber has not been exposed to rain before shipment and become saturated any allegations of this nature should be rejected. Whether timber is air-dried or kiln-dried it will eventually adjust to the optimum moisture level compatible with its equilibrium relative humidity, developed in due course, through contact with the ambient air. Therefore, loading of air-dried and kiln-dried timber in the same ambient air will not affect the kiln-dried timber to any noticeable degree during the voyage. Naturally, if dry timber is stowed in the same hold as saturated timber the moisture content of the outer planks of the dry timber will increase through absorption. Experience has proved that in these circumstances, the inner planks within the bundles are not affected during the course of a normal sea voyage. It is also true that wet timber, or timber with too high a moisture content, will not dry, irrespective of how well the bundles are ventilated in stow. On a normal sea voyage, the timber will not deteriorate. However, if the timber is not dried when discharged, it will eventually decay.

If timber is kiln-dried too quickly or the moisture level reduced too far, this can result in the timber cracking. Usually, any damage of this nature will not be seen at the time of shipment. Claims for this type of damage should be rejected.

Plywood

Plywood is a commodity which is transported in large quantities in sea-borne trades throughout the world. It is also a commodity which is highly susceptible to damage and is often insufficiently packed for shipment.

The manufacture of plywood has been described as 'the unrolling of logs of wood'. Very long thin sheets are shaved from the log which, after being cut to size, are glued together to form plywood of various thicknesses. These thicknesses vary from around 4mm to 25mm and the sheets vary in size, the most popular being 96" by 48" (244cm x 122cm). Moisture content of this manufactured product has been found to be about 9%.

The method of transporting plywood is to stack the sheets into bundles of about fifty sheets or more depending on the thickness of the plywood, which are secured together with metal strapping bands across the width of the base of each bundle. It is not unusual for plywood to be transported in a completely unprotected condition. In some trades the plywood is partly packed and, on rare occasions it is completely packed and protected.

Very often when packing is used, it is deficient, failing adequately to protect those areas which are vulnerable to handling damages, such as on the corners of the bundles. One of the most common forms of packing is an arrangement where the stack of plywood is placed upon a wooden frame after the plywood has been enfolded in a plastic sheet. The sides, ends and top are then covered with plywood sheets and strapped up with flat metal strapping bands. If done properly and with care, this packing can adequately protect the plywood from normal handling and stowage problems.

Often, this packing is applied without sufficient care. Any deficiency or tear in the plastic sheeting can allow moisture penetration into the bundle of plywood. The strapping bands are sometimes of inadequate strength and the method of joining them is often unsatisfactory. This results in a lack of rigidity of the bundle causing the plywood sheets to become misaligned during handling. In the worst cases, the bundle becomes loose with the damage to the

Plywood bundle showing torn plastic sheeting with loose and broken strapping bands edges of the plywood being considerable. If the plywood side, end and top packing is too short, corner damage can occur. It can be seen from the above that it is of the utmost importance that bundles of plywood should be examined by the ship's staff before loading, paying particular attention to the packing of the plywood, if any. Deficiencies in packing should be noted and suitable remarks inserted on the mate's receipts and bills of lading. Careful attention should be paid to stowage, to prevent corner damage both during the stowage and in the securing of the stow. The stow should be properly secured to prevent movement of the bundles of plywood during the voyage. Proper ventilation should be carried out during the voyage to minimize any possible staining from condensation. If possible, stowage should be away from the hatch square to prevent the possibility of moisture dripping down on the plywood externally, if the plywood is totally unprotected.

Paper pulp (wood pulp)

Paper pulp comprises principally of cellulose fibres which are normally produced from timber, although certain other raw materials which have a high cellulose content such as sugar cane residues may be used. The highest quality papers are still manufactured from textile (rags), but trade in these is insignificant.

There are two basic procedures used for separating cellulose fibres from timber. The first is a purely mechanical process whereby logs are stripped of bark, knotted and ground, using water as a coolant and transport medium for the fibres produced. The slurry of fibres is passed through screens and strainers to remove over-sized material which is returned to the grinders. It then passes over a cylinder board machine to convert it into sheet form. The sheets then pass through hydraulic presses to remove excess water. The sheets of pulp may be baled at that stage, but, for overseas trade, are normally further dried to a moisture content of about 10%, before baling in hydraulic presses and banding.

There are various grades of mechanical wood pulp which are used for the manufacture of different types of paper or board.

The second process for the production of paper pulp from wood involves stripping and knotting as described earlier. After this, the timber is cut into

Above. Unitised wood pulp. Note the use of airbags to secure the stow

Right. Discharging unitised wood pulp

wood chips. The wood chips are the raw materials for chemical treatment process. The most important of these is an alkaline digestion process known as the sulphate processes which produces sulphate or 'kraft' paper pulp. The other major process involves digestion with sodium bi-sulphite to produce 'sulphite' pulp.

There are various refinements to both the sulphate and sulphite processes which are designed to produce pulps with different properties, such as mechanical strength and softness.

Any type of pulp may be bleached to varying degrees to produce white pulps for paper or board manufacture. Ocean shipments of paper pulp usually involve the carriage of bleached material.

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The bales are banded under compression using special equipment and if bands are broken it is not possible to restore the bales. This is of particular significance because modern paper/board-making processes rely on bales being in sound condition up to the time the pulp sheets are fed into a re-pulping machine. The pulping machines (hydro-pulpers) are essentially tall cylinders with conical bottoms in which there are horizontally rotating blades. The bales are conveyed to the tops of the cylinders. At this point the bands are cut and removed and then the whole bales are dumped into the hydro-pulpers (which are partially filled with water). For this reason the same paper pulp which forms the sheets within the bales is used to form the protective outer wrapping. Shippers/receivers often claim that the outer 'protective' wrappers form a part of the contents. By such arguments we believe that the bales are unprotected and are thus insufficiently packed. See 'Soiling' on the next page.

Wetting

If bales become seriously wetted the cellulose will absorb water like blotting paper and swell, breaking the bands, with consequent problems, as discussed above. Prolonged wetting, such as would occur if bales were partly immersed in water, can also affect the strength of cellulose fibres. High quality pulps which have been wetted are sometimes considered unsuitable for their original use and the pulp is sold for manufacturing a different product at a reduced price. Comparatively minor wetting can result in rusting of certain types of bands. Obviously any resulting rust staining produces localized spots of discolouration on finished white papers. Any obvious spots are unacceptable. This type of wetting can result from inappropriate ventilation of cold cargoes. It must be remembered that much of the wood pulp traded around the world is shipped from countries which experience very cold winters. Masters must therefore ventilate cargoes and record their adopted ventilation regime according to established good practice as described in various articles in *Carefully to Carry*.

In theory, localized wetting of paper pulp can result in mould growth on the surface. However, there is normally sufficient moisture transfer through a bale to prevent this occurring particularly as cellulose does not provide adequate nutrition for most mould species.

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There have been occasions when the swelling of seriously wetted bales has resulted in structural damage to the ship. This is a remote possibility but the consequences can be catastrophic.

Soiling

Although paper machines are fitted with strainers, magnetic screens and similar devices, soiling of the outside of bales can result in particles of foreign material being incorporated in finished paper or board. Soiled bales, particularly where the soiling consists of particulate material such as grain or plastics granules, can be unacceptable to receivers. They can overcome the problem by tearing off the outer wrappers, but this not only results in loss of material but also is labour intensive. In an industry which is largely mechanised, providing suitable labour can be difficult and is costly.

Regenerated cellulose which is used to produce viscose rayon textiles and cellophane film is produced from very high quality bleached cellulose pulp. Because this process involves ejecting a solution of the cellulose through fine dies, any particulate matter in the solution can completely ruin the product. Pulp sold for this end use must be kept in scrupulously clean condition.

Taint

Cellulose will absorb odour and become tainted. Although many taints can be removed in the paper-making operation. Because massive amounts of water are used in paper making the water is recycled. Paper makers are particularly wary of introducing tainting materials into the water because in some instances the taint may be absorbed by the finished product. Such tainting would not be acceptable in products to be used in the food or other sensitive industries.

Fire

Paper pulp will burn. During handling, abrasion between bales can produce significant quantities of cellulose fluff that is particularly inflammable. It is evident that when a fire in a paper product gains hold, a massive amount of heat is produced. The heat is sufficient to cause structural damage to a ship. Extinguishing a fire at this stage is a major operation almost certainly requiring flooding of a hold.

Masters are advised that it is imperative that no smoking is allowed in or near a cargo of paper pulp and stringent precautions must be taken to avoid sparks from any source entering cargo holds. Bales of paper must not be contaminated with oil, particularly vegetable oil. Cellulose has a large surface area such that atmospheric oxidation of the contaminating oil can result in self-heating to the point of combustion.

Mechanical damage

Although this is less of a problem with paper pulp than with paper reels, bad handling may result in the breaking of bands or puncturing and contamination, which can cause difficulties as previously described.

Reels of paper and board

Paper and board are manufactured from paper pulp. This material is first re-pulped in water as described earlier and, after passing through various intermediate operations, such as straining to remove particulate matter, the aqueous slurry of fibre (about 0.5% cellulose fibres) is deposited as a continuous film on a re-circulating wire mesh of a moving felt band. The belt passes over suction boxes that remove water from the film to produce a continuous paper strip containing about 35% cellulose. This is sufficiently strong to be stripped off the belt and threaded through a battery of heated rollers where it is further dried so that the paper or board emerging from the end of the machine has a moisture content of about 5%. The warm paper is reeled and possibly slit simultaneously into predetermined sized reels, by means of continuous reeling equipment.

There are a large number of different types of paper which can be produced by using different types of paper pulp and by various treatments during the paper making operation, such as sizing, opacifying, treatment to produce wet strength, polishing (calendering), coating etc. It is evident that more complex papers are commercially more valuable than less complex papers. It is also evident that sophisticated paper products which are unacceptable for the intended purpose must either be sold for scrap or returned for re-pulping. The pulp produced will inevitably be used for low grade products.

Major uses of paper are for newsprint and the manufacture of corrugated fibre board. Newsprint reels are used on high speed printing presses. Any

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interruption in the printing process, due to fault in the paper, results in a substantial financial loss. Users take particular care to ensure that only sound reels or reels which can easily be handled to make them sound, are accepted.

Although the users of kraft paper are not constrained by time in the same way as newspaper publishers, they also employ high speed machinery of high capital cost and take the utmost care to prevent any interruption on a production line.

The two main forms of damage which cause problems with reels of newsprint and kraft are mechanical damage and wetting.

Mechanical damage

This may take the form of tears, cuts or snags. Where such damage occurs, the reels have to be unwound until completely sound paper is reached. It is possible to calculate the loss from the formula

$$\text{Weight of lost material} = \frac{R^2 - (R-d)^2 \times W}{R^2 - r^2}$$

where R	=	radius of reel
r	=	radius of core
d	=	depth of cut or other form of damage
W	=	weight of reel

The second form of mechanical damage is distortion which may result from unsatisfactory use of clamp trucks or any form of impact. Where distortion occurs, the paper web is subject to non-uniform tension during unreeling on a press or other machine. Because the web is under considerable tension, any non-uniformity can result in rupture.

Wetting

Newsprint reels are normally over wrapped with a wrapping system incorporating a waterproof barrier. Kraft reels are not so protected. However, significant wetting even of newsprint can result in the reels themselves being damaged.

Wetted reels, even after drying, normally present the same problems as

Above. Reels of newsprint showing tears and cuts both to the wrappers and paper before shipment

Left. Reel of newsprint that has been standing in water before shipment

distorted reels and again must be stripped down to undamaged paper before they can be used. Due to swelling of the fibres, severely wetted reels invariably split.

There are various precautions which should be taken by a ship's command to ensure the above-mentioned problems are minimized if not eliminated.

All reels should be examined at the time of loading for evidence of damage. As paper frequently originates from countries which are very cold in winter, they may sometimes be coated in a thin layer of ice, which is not detectable without careful checking. When found during loading, damaged reels should

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be rejected. If this proves impractical, mates' receipts should be claused giving details of affected reels, including the nature of the damage. Obviously bills of lading should be claused in the same terms as the relevant mates' receipts.

Ship's holds should be clean and dry before loading commences and preferably, the tank tops should be covered with kraft paper or boards.

Great care should be taken in order to ensure reels, which are always stowed vertically, are not subject to uneven pressure from such fittings as horizontal cargo battens or dunnage. Any objects which can snag reels such as projecting nails should be removed. Other projections should be cased in dunnage. Rough sawn dunnage should not be used in contact with reels. The most suitable contact material is plywood sheets. Reels should never be secured in a way which results in direct contact with wires or chains.

Bearing in mind reels of differing widths are often to be loaded in one hold, special care must be taken with stowage to ensure a stable stow. Care should be taken to prevent wetting onboard. Hatchcovers must be closed when rain is threatened.

The ship should, of course, be watertight and if the ventilation system is used, ventilators should be closed whenever bad weather threatens. Paper reels originate from the same areas as wood pulp – i.e. often from ports where the temperature is very low in winter. Masters should either check temperatures of the reels, which is difficult to do as there may be significant variation through a reel, or assume the reels are at the same temperature as the ambient atmosphere and adopt a proper ventilation regime accordingly. After loading in ports where the temperatures are of a low order and proceeding through/to areas of higher ambient temperatures you should not ventilate.

Conversely, there have been claims due to wetting of relatively warm reels by ship's sweat when atmospheric temperatures are falling, or when ventilation is interrupted during a period when the outside air temperature is lower than the dew point of the air in the cargo compartment, i.e. the ambient air surrounding the reels which is influenced to a degree by the peculiarities or characteristics of the actual cargo.

Another problem which has given rise to massive claims is taint. This is discussed in relation to paper pulp. It is not always easy to detect taint to paper reels, particularly when this originates from residual odours from previous chemical cargoes. A case is known where bleached board was used for the manufacture of milk cartons and no taint was detected until complaints were received from the public who consumed the milk. The taint was traced to an earlier cargo of herbicides. Masters should obviously check, or arrange for surveyors to check, that holds to be used for paper products are not only scrupulously clean but also odour free. Because detection of odour is very difficult when the atmospheric temperature is low, when loading takes place under such conditions, it is recommended that known properties of earlier cargoes are reviewed.

Wetting and mechanical damage can occur at the time of discharge. Masters should obviously supervise discharging operations. Where damage is seen to arise as a result of mishandling by stevedores, the occurrence and nature of such damage should be reported in writing to the stevedoring company and recorded in the ship's log book.

Packaged timber deck cargo – dangerous densities

Sawn Brazilian hardwood

The IMO *Code of Safe Practice for Ships Carrying Timber Deck Cargoes* stipulates the number and strength of lashings to be applied to timber deck cargoes. The number of lashings is governed by the height of the stow above the weather-deck at the sides. For heights up to 4 metres, lashings are to be pitched 3 metres apart; from 4 metres to 6 metres height, pitched 1.5 metres apart; thereafter pitched 1.5 metres apart (unless required otherwise by the national administration.) All lashings are to have a minimum break load of 133kN (13.6 tonnes).

The Code does not relate the number and strength of lashings to the *weight* of timber deck cargo to be secured. Possibly when the Code was drawn up, it was assumed that all timber carried in packages would have a density less than 1,000kg/m^3. The Committee is concerned that under the current wording of the Code, a packaged timber deck cargo of 2,000 tonnes weight and 4 metres in height may not require a greater number of lashings than a cargo of the same height and volume but weighing only 500 tonnes. In this paper, the Committee considers the implications where the density of the timber may exceed 1,000kg/m^3.

Following losses of packaged timber deck cargo from Brazil, investigations revealed that the density of the timber was greater than 1,000kg/m^3: in other words the timber as a whole and as loaded dry, was heavier than water. Samples were cut from 14 timbers, each clearly different from the others, but shipped collectively as 'sawn Brazilian hardwood' . Scientific analysis of each sample revealed that 78% of the cargo by weight, had specific gravities (SGs) between 1.0 and 1.4 and that the remaining 22% had an average SG of 0.93. The overall average SG was 1.080 as compared with the SG of oceanic salt water, which is 1.033.

The article on *Timber Deck Cargoes* contains the following statements:

- When timber is correctly stowed on deck as referred to above, the ship may

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load to the timber load line irrespective of the quantity or type of cargo stowed below decks. The reduction in freeboard enjoyed by a ship which is assigned timber load lines is permitted because of the buoyancy contribution of the timber deck cargo to the ship's stability characterstics.

- When a full timber cargo is carried on deck and the ship is loaded to the timber load line, the statical stability curve may be derived from the cross curves of stability which have been computed taking into account the timber deck cargo. When the timber cargo is not correctly stowed, due to deficient height or other reason, the statical stability curve must be derived from the cross curves computed for the ship without timber deck cargo.

This underlines the technical philosophy of the Code, namely that a timber deck cargo will **float** and that if it shifts and causes a severe transverse list, it will provide **buoyancy** to prevent the ship listing further towards capsize. The average SG of a packaged timber cargo is 0.6. The data for the 'timber conditions' in most standard ship stability books indicates an SG of 0.4 where 'condition' volume is set against 'condition' weight. Thus, the lashings approved for such conditions are intended for cargoes of **x metres**^{3} and **y tonnes**. Where Brazilian hardwoods are carried as described above, the same lashings are required to hold **x metres**^{3} and **2.7 y tonnes** – an increase of 270%, while in addition, the cargo itself can no longer be assumed to provide buoyancy.

The Committee is not aware of any ship having capsized when carrying packaged timber deck cargo but instances are known where ships carrying very dense timber cargoes have suffered massive shifts of cargo, with severe listing followed by the parting of the lashings and cargo being lost overboard. This is then followed by a heavy roll to the opposite side with more lashings parting and more cargo lost. In such instances, the ship usually returns to the upright condition, often structurally damaged, but afloat and capable of navigation. Even if the lashings were not to part, the buoyant nature of the timber would to some degree, mitigate the danger. However, if the deck cargo had an SG of 1.08 and if the lashings were not to part, the ship would list and continue to roll from the listed angle, in circumstances where the presence of the timber would constitute a sinking rather than a buoyant factor. If the timber were then to shift, it is highly likely that a total capsize would result.

Conclusions

- A packaged timber deck cargo with an SG of 0.8 may not be so unusual as to require any special alert, bearing mind that it will still provide a measure of buoyancy.
- A packaged timber deck cargo with an SG in excess of 1.033 (as occurs with Brazilian sawn hardwoods) provides no measure of buoyancy. Such timber may well cause a ship to capsize if the lashings do not part.
- Where packaged timber is loaded and secured by height, as is most frequently the case, then the standard number and strength of lashings when applied to loads of high density timber, may result in no more than 40% of the holding power approved for less dense timber.
- When high density timber is loaded, the ship should not be loaded down to the timber load line.

In order to correctly calculate the ship's statical stability, the master requires to know the correct density of the cargo. It is now (since July 1996) a SOLAS requirement that the master be supplied by the shipper with all relevant cargo data, including its density.

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Timber deck cargoes

This article makes reference to the vessel's Cargo Securing Manual, which is required by the IMO; the IMO *Code of Safe Practice for Cargo Stowage and Securing*, and; the IMO *Code of Safe Practice for Ships Carrying Timber Deck Cargoes,* 1991, with the included interpretation of Regulation 44 of the International Convention on Load Lines.

Introduction

There continues to be a steady incidence of timber deck cargoes being lost overboard, sometimes with catastrophic results for ship and crew. It is therefore more important than ever to ensure that the carriage, stowage and securing of timber deck cargoes does not fall short of any currently accepted codes, rules, regulations or formal recommendations, including the IMO Cargo Securing Manual regulations mandatory since 1 January 1998 for all ships other than exempted ships. Those involved with the carriage of timber deck cargoes should have a full knowledge of the IMO Code and be alert to the ongoing probability of future amendments.

The practical applications

The provisions contained in the IMO Code are recommended for all vessels of 24m or more in length engaged in the carriage of 'timber deck cargoes' – a phrase defined as meaning a timber cargo carried on an uncovered part of a freeboard or superstructure deck, and includes logs and sawn timber whether loose or packaged. Basically, the following factors need to be considered:

- Type and compactness of timber cargo, e.g., logs, cants, ragged end packages, square (or flush) both ends, etc.
- Type of vessel – timber load line or not.
- Strength, pitch and tending of lashings.
- Height of cargo and stability considerations.
- Measures to deliberately jettison cargo.
- Keeping clear all sounding and air pipes necessary for the working of the

ship, ensuring means of safe access to all parts of the ship, keeping cargo hold ventilators clear for operation.

- 'Under-deck' and 'on-deck' bills of lading.
- Hatchcovers and other openings below decks should be securely closed and battened down.
- Hatches and decks, and the cargo itself, should be kept free of any accumulations of ice and snow.
- All deck lashings, uprights, etc, in position before loading commences.
- The cargo must not interfere in any way with the navigation or necessary working of the ship.

Type of timber cargo

Packaged timber should not be stowed on deck if the bundles are ragged at both ends. Generally speaking only bundles square at both ends should be used for weather-deck stows. It is recognised, however, that the Far East trade demands the stowage of a proportion of packages that are square at one end and ragged at the other. Wherever possible every care should be taken to ensure that ragged ends are kept to a minimum, stowed inboard of the perimeter, and that broken stowage is avoided. The IMO timber deck cargo Code does not allow the transverse stowage of packages to the outer sides of the deck stowage – any packages stowed athwartships must be within a perimeter of square-ended packages stowed fore-and-aft.

Logs may come in a variety of lengths and be of widely varying diameter. It is essential that uprights are used correctly, supported by transverse hog wires, all in addition to wiggle wires, and securing wires or chains pitched at the correct distance apart.

Cants are defined as logs which are 'slab cut', that is are ripped lengthways so that the resulting thick pieces have two opposing parallel flat sides and in some cases a third side which is sawn flat. Cant cargoes require similar arrangements to those for logs.

Any omissions from the lashing arrangements recommended in the IMO Code could lead to loss of cargo.

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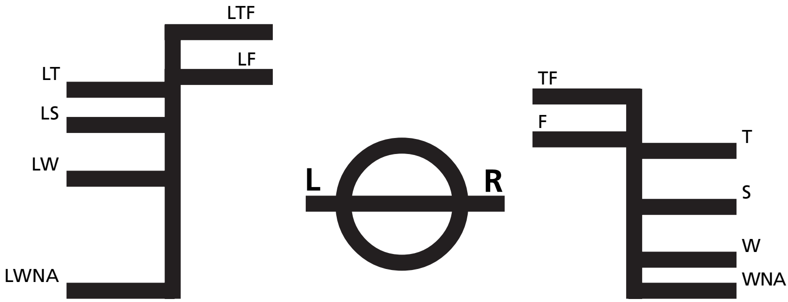
Timber load lines

Many vessels are marked with special timber load lines in addition to the normal load lines. The timber load lines are calculated on the premise that a full timber deck cargo will be carried, and an entirely separate set of cross-curves of stability is produced for the full timber deck cargo condition. The timber load lines allow the vessel to load to a deeper draught (and hence a larger displacement) than would otherwise be the case.



An example of typical timber load lines

Disputes have arisen between shipmasters and charterers, as to the strict application of the timber load lines. The following guidelines should be applied:

- When a ship is assigned a timber load line, in order to load to those marks the vessel must be loaded with a timber deck cargo which is correctly stowed in accordance with the deck cargo regulations and the IMO *Code of Safe Practice for Ships Carrying Timber Deck Cargoes*, 1991.
- These regulations require that the timber be stowed as solidly as possible to at least the standard height of the superstructure. For instance, in ships of 125m or more in length, this equates to a uniform height of not less than 2.3m. In ships under 125m in length, the stow should reach a uniform height of not less than the height of the break of the forecastle head.
- If the timber is stowed to a lesser height than indicated above or is not correctly stowed in any other way, i.e., not the full length of the well or not from side to side, then the ship is not permitted to load to the timber line.

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Timber deck cargoes

Left. An example of a full timber deck cargo, compactly stowed, ends butted prior to securing with chain lashings 1.5m apart

Right. Similar cargo, poorly stowed, improperly secured, widespread gaps in cargo. Total collapse of stowage, 50% deck cargo bundles lost overboard, widespread structural damage to vessel

- When timber is correctly stowed on deck as referred to above, the ship may load to the timber load line irrespective of the quantity or type of cargo stowed below decks. The reduction in freeboard enjoyed by a ship which is assigned timber load lines, is permitted because of the buoyancy contribution of the timber deck cargo to the ship's stability characteristics.
- When a full timber cargo is carried on deck and the ship is loaded to the timber load line, the statical stability curve may be derived from the cross curves of stability which have been computed taking into account the

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timber deck cargo. When the timber deck cargo is not correctly stowed, due to deficient height or other reason, the statical stability curve must be derived from the cross curves computed for the ship without timber deck cargo.

Strength, pitch and tending of lashings

It is important to realise that Regulation 44 of the International Convention of Load Lines 1966, still applies to the 1991 IMO timber deck cargo Code, but the spacing of the transverse lashings within the Code, although still determined by height, does not permit an interpolation between cargo heights of 4m and 6m. The straightforward interpretation of such spacing applies to a compact stow of square-ended bundles (flush at both ends) or near square-ended bundles – in the following manner:

- Each package (*along the sides, that is*) shall be secured by at least two transverse lashings spaced 3m apart for heights not exceeding 4m above the weather-deck at sides.
- For heights above 4m the spacing shall be 1.5m above the weather-deck at sides.
- When timber in the outboard stow is in lengths less than 3.6m the spacing of the lashings shall be reduced as necessary (*to comply with the requirement for each package to be secured by at least two transverse lashings*).
- The stowage of timber deck cargo should be tight and compact. Where packages are involved, they should be square-ended (flush) at both ends so far as this is possible. Broken stowage and unused spaces should be avoided. There is no absolute requirement for uprights to be used for packaged timber cargo although some national administrations may insist on their use when lashing arrangements are not otherwise fully satisfactory. Bundles of regular form when stowed in 'stepped-in' truncated, pyramid fashion will not benefit from uprights, even if they are fitted. The IMO Code does not allow uprights to be used instead of lashings. Where uprights are used they are in addition to the full number of lashings properly pitched and of full strength.

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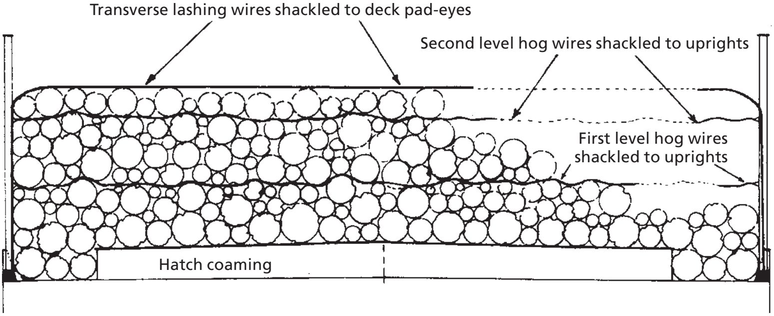
- The use of uprights when carrying logs on deck is a necessary requirement, and it is most important always to rig and attach hog wires between such uprights. The uprights' strength relies upon the weight of logs above the hog wires. This rule applies whenever hog wires are rigged – even with packaged timber. Never use uprights without rigging hog wires.



Always rig hog wires when using the deck side uprights for logs, packages and loose timber

Rigging hog wires for deck-stowed log cargo, as required by the IMO *Code of Safe Practice for Ships Carrying Timber Deck Cargoes*, 1991

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The correct use of wiggle-wires through snatch blocks – used to bind and consolidate the log stow – independent of the number and pitch of cross-lashings required. Photo shows chain cross-lashings pitched 3m apart for stow not exceeding 4m in height above the weather-deck at the ship's side

- Wires or chains used for lashings should have a break load of not less than 13.6 tonnes force (133kN). With wire and grips the IMO *Code of Safe Practice for Ships Carrying Timber Deck Cargoes* recommends that four grips per eye are used, and if that recommendation is followed – with the eye made up around a thimble – the holding power of the eye will be not less than 90% NBL, so a 6x24 galvanised wire rope of 19mm diameter will fully comply with the Code's strength requirements. (For the correct method to make up bulldog-gripped wire rope terminations, refer to the article – *Lashing and securing deck cargoes*).
- Where thimbles are not used, the slip-load of an eye properly made up, will be about 70% of the wire's nominal strain. More complex additional securing arrangements are required for cants, and reference should be made to the drawings and illustrations given in Annex D of the IMO Code.
- At sea, all lashing and securing arrangements should be tended daily, adjusting as necessary to take up any slack which may occur as the cargo settles. Where intermediate ports of discharge are involved, great care must be taken to ensure that the remaining deck cargo is levelled out and re- secured in accordance with the Code.

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Weight and height of cargo – stress and stability aspects

Weight factors

As mentioned earlier, the weight of the deck cargo should not exceed the maximum permissible loading of weather-decks and hatchcovers. Everyone involved with the loading and safe carriage of timber deck cargoes should be fully conversant with the stability requirements as set out in the IMO *Code of Safe Practice for Ships Carrying Timber Deck Cargoes* and the ship's 'standard conditions' stability book. The following additional comments may be of assistance.

It is important that the correct weight of the cargo is known and allowed for in the stability calculations. Instances have occurred where, because the standard stability booklet has indicated a given height of cargo as representing a given weight, the master and charterers have assumed that any cargo of the same height will have the same weight. This assumption has proved to be wrongly based and has serious consequences.

For instance, when the Code was drawn up, it may have been assumed that all timber, including logs and packaged timber, would have densities less than 1000 kg/m^3 (broadly speaking, an SG of 1.0), but following losses of packaged timber deck cargoes from Brazil (see, also 'Packaged timber deck cargo – dangerous densities') investigations revealed that the density of the timber involved was greater than 1,000kg/m^3. In other words, the timber as a whole and as loaded dry was heavier than fresh water. Samples cut from the cargo and scientifically analysed from 14 different types of timber confirmed that 78% of the deck cargo, by weight, had specific gravities in the range 1.0 to 1.4, and that the remaining 22% had an average SG of 0.93. The overall average SG for this deck cargo was 1.080 as compared with SG 1.033 for oceanic salt water.

The average SG of a more normal packaged timber deck cargo is about 0.6. The data for timber conditions in most standard ship stability books indicates an SG of 0.4 where 'condition volume' is set against 'condition weight '. This tends to underline the technical philosophy of the Code, namely, that a timber deck cargo should float and that if it shifts and causes a severe transverse list it

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will provide **buoyancy** to prevent the ship listing further towards capsize.

From this it follows that, when timber of excessive density is involved, lashings approved for cargoes of **x metres**^{3} volume and **y tonnes** weight will be required to hold the same volume but the weight may be as much as **2.7 y tonnes**, an increase of 270% in weight, such that the cargo itself cannot be assumed to provide buoyancy.

The ship's officers should conduct draught surveys at regular intervals to check the weights of cargo coming onboard. This is necessary particularly when all the under deck cargo has been loaded and before 'on-deck' cargo loading commences. Such draught surveys although subject to all their associated vagaries will, if affected carefully, provide acceptable information for stability purposes. To do this the master needs to know the correct density (or correct SG) of the timber being loaded and, since July 1996, it has been a SOLAS requirement for such information to be supplied to the master by the shipper. So beware of the dangerous densities and act accordingly.

The calculation of the metacentric height (GM) of a ship provides some measure of transverse stability, but additional calculations need to be made to produce the curve of statical stability (the GZ graph). The ship's dynamical stability characteristics can then be established for various angles of heel, and can be compared with the minimum characteristics required by the load line rules and the vessel's stability booklet.

The Committee's attention has been drawn to written instructions issued by some charterers or shippers requiring that the "*metacentric height (GM) should be maintained at one and a half per cent of the vessel's beam and should never exceed 2ft (61cm)*". The Committee considers such instructions to be poorly worded and incomplete, and positively dangerous in the instance of vessels of less than 10m beam where 1.5% would produce a GM of less than 0.15m when 0.15m is the statutory minimum. Ships' masters should call for expert advice if they face instructions to the contrary, and follow the IMO Code which says, *inter alia*:

> *"Operational experience indicates that metacentric height should preferably not exceed 3% of the* (vessel's) *breadth in order to prevent*

excessive accelerations in rolling provided that the relevant stability criteria are satisfied. This recommendation may not apply to all ships and the master should take into consideration the stability information obtained from the ship's stability manual."

Height factors

If the timber deck cargo is to be carried through tropical or summer zones, only, the following points should be observed:

- The height of the cargo does not restrict or impair visibility from the bridge. (In this connection the Committee would refer the attention of Members to M. Notice no. 1264 of January 1987 – Navigation Bridge Visibility).
- For any given height of cargo, its weight shall not exceed the designed maximum permissible loading on weather-decks and hatchcovers.
- Any forward facing profile of the timber deck stowage does not present overhanging shoulders to a head sea.
- If a timber deck cargo is to be carried through a winter zone, or a seasonal winter zone in winter, the height of the cargo above the weather-deck should not exceed one third of the extreme breadth of the ship. For instance, if the extreme breadth of the vessel was 15m, the height of the timber deck cargo should not exceed 5m. Similarly, a vessel of extreme breadth 21m could stow the cargo to 7m above the weather-deck, providing this did not contravene any of the other requirements of the Code. (See, also, under 'Timber load lines', earlier).
- It is important to appreciate that the 'weather-deck' means the level of the main deck measured at its junction with the sheer strake. It is not permitted to commence the vertical measurement at hatchcover level.

Disasters follow excessive cargo heights

There are a few anomalies in the IMO *Code of Safe Practice for Ships Carrying Timber Deck Cargoes*, 1991, one of which relates to the lack of firm, clear, guidance as to the closing down of lashings spacing where cargo heights become excessive.

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Earlier in this article it was explained that the 1991 Code requires that lashings shall be pitched 3m apart for cargo heights up to 4m and 1.5m apart for cargo heights above 4m, measured above the weather-deck at sides. Hence, as it now stands, for heights above 6m the lashings can remain at a 1.5m spacing with no hint that closer spacing and/or increased lashing strength should be considered.

The Committee considers this to be a most unsatisfactory situation, and it is salutary to consider the additional weight effects as timber cargo heights increase on a large, modern, timber carrier in which the horizontal hatchcovers are, say, 2.8m above the weather-deck at sides.

In such instance, and assuming all the timber is of more-or-less the same density, when the upper surface of the cargo is 4m above the deck, only 1.2m of that height is cargo, and the lashings need be no closer spaced than 3m. Going to 6m height gives 3.2m of cargo with the lashings closed down by a factor of 2, to 1.5m spacing, yet cargo weight has increased by a factor of 2.66. Going to, say, 8.9m gives 6.1m of cargo, with the lashings remaining at 1.5m, yet cargo weight has increased by a factor of 5.08. When cargo height goes to 10m – a not unknown occurrence – the weight of cargo has increased by a factor of 6. There appears to be little or no commonsense rationale that explains this unreasonable reliance on under-strength lashings.

There have been several catastrophic failures of packaged timber deck cargoes where the cargo height was 8.9m and the standard transverse lashings were pitched at 1.5m. In general terms, the overall breaking strength of the combined lashing system amounted to 560 tonnes. The static weight of the cargo was roughly 3,490 tonnes – that is 6.2 times greater than the lashings' strength, yet such arrangement apparently complied with the Code. (It is worth noting that if the 3-times rule for securing other deck cargoes had been applied the breaking strength of the lashings would have been about 10,400 tonnes.)

There is nothing in the Code to prevent increasing the lashings' strength and/or decreasing the pitch. Some traders do, indeed, weld additional interspaced pad-eyes or D-rings before loading commences, thereby reducing the lashings' pitch to 0.75m and doubling the holding power of the 1.5m spacing; but the majority do not.

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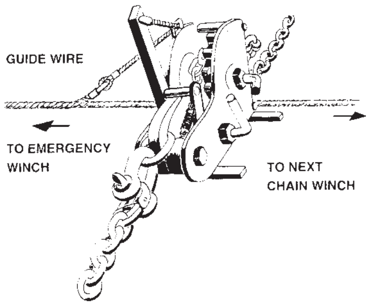
Also, at 10m height, and with 7.2m of that height made up of cargo, the down-acting force on the hatchcovers may well exceed the vessel's designed permissible hatchcover load. This, in turn, will create a deflection in the hatchcover panels greater than that for which they were designed; excessive flexing may occur, causing the cargo to vibrate towards slackness, and may thus be a contributory factor in the overall loss of the cargo.

So far as the Committee is aware, there is no record of any national administration enforcing a reduced lashing pitch even in instances where packaged timber cargo height has achieved 10m. Combined with other adverse factors, during the years 1982 to 1994 this had resulted in not less than 21 traceable vessel incidents of loss of, or severe shift of, packaged timber deck cargoes shipped from west coast Canadian and/or United States ports – certainly more if all were known and had been reported. This can hardly be considered a satisfactory state of affairs so far as cargo interests and their insurers are concerned.

Measures to jettison cargo

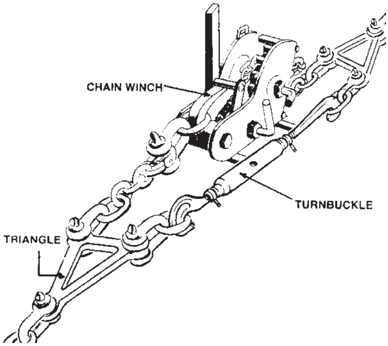
The present regulations for the jettison of cargo involve the use of senhouse slips or equivalent fittings, and require personnel standing on top of the stow

Emergency release (option)



All the chain winches are interconnected by a rope system. In case of emergency the guide wire has to be pulled by means of a rope winch or a warping head. The slip hook will be released and the timber load will be set free at once

Alternative system



Turnbuckle fitting to triangle plate allows on-going tightening of lashing. Emergency remote release cannot operate with turnbuckle fitted as shown

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to release the individual lashings. This can only be achieved at considerable personal risk and may cause serious damage to the structure of the ship. In *Carefully to Carry* No.13 of April 1989, the Committee remarked that it would be interested to hear of any simple method of deliberately and safely jettisoning cargo. The Committee is pleased to report that MacGregor-Conver OSR makes and markets such equipment as illustrated on the previous page. It is for the trade to decide whether or not to take advantage of this system without waiting for mandatory requirements to do so.

All the foregoing comments, however, only serve to emphasise the importance of ensuring at the outset of the voyage that the cargo will not shift. If, despite that care, the timber does shift to a dangerous degree, great caution must be exercised in any attempt made to jettison all or part of the cargo.

Sounding pipes, air pipes, and ventilation

The safe working of a vessel whether in port or at sea depends to a large degree upon the ability to obtain quick and safe access to all sounding pipe caps and air pipes. With this in mind it is imperative that any deck cargo should not be stowed over such pipes nor interfere with safe access to them, and that safe and efficient means of access be provided for all working parts of the ship, as required by the Code. Numerous instances continue to arise where ships and seamen are placed in danger because it is not possible to walk safely across the cargo to sound tanks, bilges, or to effectively close off the upper apertures of air pipes as required by the Load Line Rules. Care, also, must be taken to ensure that all ventilators of whatever type serving the cargo holds are kept clear and free for operation in the normal manner.

Hatchway coaming drainage channels

The Committee would also draw Members' attention to the fact that hatchways fitted with steel covers are provided, more often than not, with drain holes from the coaming channels, which, in turn, exit through drainage pipes. The lower open ends of these pipes are sometimes provided with loose canvas socks which close-off with the pressure of seas shipped onboard, thereby acting as simple (and effective) non-return valves, so long as they remain supple and not painted. Similarly, drainpipes are just as frequently fitted

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with patent non-return valves of one form or another, which are designed to exclude water on deck from working back into the hatchway coaming channels. Before loading timber deck cargoes masters should, therefore, ensure that all such non-return facilities are in efficient working order so that they do not require maintenance or supervision during the course of the voyage.

Bills of lading

The continuing trade in timber from tropical countries has resulted in more and more packages being offered for shipment as 'kiln-dried' and requiring under-deck stowage. Serious claims have arisen against some vessels where kiln-dried timber has been stowed on the weather-deck for a voyage to Europe and elsewhere. Masters must ensure that all such timber – even if wrapped, sheeted or otherwise fortuitously covered – is afforded below decks stowage.

Where shippers and or charterers insist on the vessel carrying such timber on the weather-deck, masters should issue a clear note of protest, ensure that all mate's receipts are claused accordingly, accept no letters of indemnity, and instruct the local agents to clause the bills and act accordingly.

Masters who allow themselves to be persuaded to do less than is necessary in the line of stowage and securing arrangements – for whatever reason – become everybody's scapegoat when cargo is lost overboard, the ship's structural seaworthiness is breached, and the port of refuge/re-stowage/ship repair/deviation delay and legal costs come home to roost. Stand your ground, and have things done properly.

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Section 2

Bulk cargoes – liquid

Bulk oil cargoes – shortage and contamination claims

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

Oil shortages

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

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

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

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

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Before arrival at the load port

The correct preparation of the cargo tanks in readiness for the grade of cargo to be carried is covered in the section dealing with contamination claims. Aside from ensuring the minimum safe quantity of clean ballast for arrival, the cargo officer should prepare a loading plan taking into account stability, trim and stress. Where draft restrictions permit, it may be advisable to plan for leaving the loading port with a trim that avoids the need for internal transfers of cargo during the loaded passage. The inert gas system, if fitted, should be fully operational in readiness for the forthcoming cargo operation. The oxygen content of the cargo tanks should be as low as possible before arrival and a record of all tank readings should be maintained.

On arrival at the berth

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

Before loading

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

During loading

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

The loading rate should be monitored and it is recommended that ullages and the corresponding tank volumes be recorded in the deck log at least at hourly intervals. Any changes in the loading rate or any stoppages must also be recorded.

During the final stages of loading the rate should be reduced to a minimum in order to permit measurement of the quantity of cargo so far loaded and to calculate the correct finishing ullage in the last cargo tank.

On completion of loading

Before the cargo hoses are disconnected, the ship's figures must be calculated in order to check that the correct quantity of cargo has been loaded. Whilst it is in the ship's interests to measure the cargo onboard ship, it is customary for

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

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

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

Ullaging

This is the measurement of the distance from the datum point at the top of a tank to the surface of the liquid cargo. This is usually done by means of a steel tape fitted with a weighted brass bob. Many tankers have fixed gauging equipment in each tank and electronic measuring devices are also available. Ullaging is best carried out when the ship is on an even keel and with no list: otherwise inaccuracies may creep in despite the application of trim corrections. A ship whether afloat, alongside a jetty, at anchor or at sea, is a moving platform. Whilst it is not implied that ships necessarily roll heavily when berthed, nonetheless slight movement will affect the accuracy of measurement. In any single tank, a difference of one inch in the ullage may involve a volume of several hundred barrels.

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

Water dips

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

Temperature

The temperature of liquid in a vessel's tank is generally obtained by the use of a cup case thermometer, although some vessels are now equipped with electronic temperature sensing devices. Cup cased thermometers are unreliable and errors of ±2 to 3°C are not unknown. When taking temperatures, great care should be exercised to ensure that the thermometer is not affected by the environmental temperature after it has been removed from the oil. The vertical positioning of the thermometer in a vessel's tank particularly at the discharge port is critical because significant temperature variations can develop within the cargo tanks during the voyage. Furthermore, as temperatures vary from tank to tank, calculations of quantity must be calculated using individual temperature corrections for each tank. The use of an arithmetical average for the whole ship is, as previously mentioned, inaccurate and contributes to 'paper losses'. An error of 1°C in temperature produces an inaccuracy in the volume at standard temperature of approximately 0.1%.

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Sampling

The ship when calculating cargo quantities, has to rely upon certain data supplied from the shore, in particular the density of the cargo which is calculated after the analysis of samples. Shoreline samples may however contain inaccuracies and cannot always be accepted as being representative of the cargo loaded. It is recommended that with crude oils, the standard sampling 'thieves' should not be used but that clean sample bottles be used for individual samples from each level, (i.e. top, middle and bottom of each of the ship's tanks) and clearly labeled. Regrettably, sampling is often undertaken using a one litre 'thief', each sample being decanted into a larger sample can. During such an operation volatile fractions may be lost to the atmosphere and the density established from the final mix does not represent the true density of the cargo in each tank. This, in turn, may later have a significant effect upon the calculation of weight and bottom sediment and water. The importance of sampling as a measure to counter contamination claims is dealt with later in the article.

Measurement errors

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

Completion of documentation

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

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

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

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

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

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

The master should note protest. He should certainly notify the ship's agents and instruct them to urgently inform the owners of the problem as well as the charterers, the shippers and any consignee, or notify party named on the bill of lading. The master should give full details of the available figures and ask the parties notified to inform any potential purchaser of the bill of lading of the discrepancy. It may be difficult for the master to contact all the parties named but the owner should do this at the earliest possible opportunity. Ideally, the master should be able to clause the bills of lading but in practice this creates many difficulties. He should, therefore decline to sign the bills of lading or withhold authority for anyone else to sign until the dispute has been resolved. In any event the master or owner should immediately contact the Association or the Association's correspondents.

Early departure procedures

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

Shipboard records

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

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

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

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

During the voyage

Provided the ship's fittings are properly maintained, the cargo will require little attention during the voyage unless heating is required. In such cases, it is important to follow the charterer's instructions particularly bearing in mind the specifications of the cargo carried. In some cases failure to heat the cargo properly may lead to severe difficulties. When crudes requiring heating are carried, particularly those with high wax content, it is important that the charterers provide clear instructions for heating both on the voyage and throughout discharge. Often, heating instructions are not sufficiently precise with the charterers relying on the experience of the master. Usually, it is wise to heat early in the voyage in order to maintain the temperature rather than to be obliged to raise the temperature of the cargo significantly at the end of the voyage. If there is doubt about the heating instructions, the master should check with the charterers. The tank temperatures should be recorded twice daily.

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

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

Before arrival at the discharge port

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

On arrival at the discharge port

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

Before discharge

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

On completion of cargo measurement, a comparison should immediately be made with the loading ullages tank by tank, in order to see whether there have been any appreciable changes since leaving the loading port. Should any differences be noted, then the reasons should be immediately investigated and fully recorded. The ship's responsibility should begin and end at the fixed manifold and the owners have no liability for measurements taken once the cargo has entered the complex of piping which forms the average receiving terminal. Claims are frequently presented on the basis of shore figures which are inaccurate and the most effective and economical way of repudiating liability may be to recalculate these figures correctly. It would be beneficial for a surveyor representing the shipowner to check the shore reception facility, where he may be able to witness the taking of shore measurements. He may also be able to check the pipeline system, to verify its size and length and the method by which its contents are ascertained before and after discharge as well as noting any valves which lead off those pipelines which are in use. Some shore facilities are reluctant to allow ship's representatives to make full checks in their terminals. It should be recorded if an inspection of the terminal or its operations is refused.

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

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During discharge

Once the necessary preparations have been completed aboard the ship and the shore installation has confirmed that the discharge can commence, the cargo pumps are started in sequence. Where one or more grades of cargo are carried, it may be possible to discharge each grade simultaneously subject to stress and trim considerations and any other restricting factors including the design of the ship's pipeline system. Once it has been established that the cargo is flowing correctly, the discharge rate should be increased to the agreed maximum. The rate may be restricted either by back pressure or by the capacity of the ship's pumps. The rate of discharge should be carefully monitored throughout and recorded at intervals of no more than one hour. These records should show not only the amount of cargo discharged by volume but also the shore back pressure, the pressure at the ship's manifold, the speed of the cargo pumps and steam pressure or, in the case of electrical pumps, the amperage. If COW is being carried out, this operation must be closely monitored. Careful recording of the discharge in the ship's logs is essential if claims are to be successfully defended.

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

Whatever type of oil is carried, it will be necessary to be able to demonstrate that ship's valves, lines and pumps were in good condition at the time of discharge, because this has an impact on the question of 'pumpability'. It might be assumed that oil is pumpable or unpumpable in the sense that it is liquid or not liquid. From the point of view of cargo claims however, it must also be

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considered whether, even if the cargo was liquid, it could be pumped by the vessel's equipment. It is possible that small quantities of oil, particularly where high gas cargoes are concerned, cannot be picked up by the pumps without the pumps gassing up. It could be that due to sediments from the cargo or shore restrictions on trim, the oil is liquid but cannot run to the suction. The master should call in a local UK Club surveyor if he experiences difficulty in obtaining a suitable dry tank certificate. If pressure is applied to the ship to sail before the surveyor can attend, the master should protest to the receivers and to the receivers' surveyor. If the surveyors are not prepared to certify cargo remaining onboard as unpumpable, they should be invited to inspect the ship's pumps. The receivers should be informed that if they consider the cargo to be pumpable, the ship is prepared to continue to attempt to pump it until the UK Club surveyor arrives. Owners should ensure that the maintenance records for the cargo pumps are carefully preserved and that they are available when such disputes arise. Surveyors who certify cargo as pumpable should be required to prove that they have tested the nature of the cargo and have ascertained that it can and does reach the suction in the cargo tank.

ROB claims may therefore arise in three different ways:

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

In the case of crude which does not require heating or which has a high vapour pressure, good crude oil washing and a good stern trim will overcome most problems. Frequently the charterparty will call for COW 'in accordance with Marpol' and will allow additional time for discharge when COW is performed. Naturally, if the receiving installation will not allow satisfactory stern trim or if they refuse COW either in whole or in part then the master should protest to the terminal and to the charterers, stating that the vessel cannot be held responsible for any resulting cargo losses.

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On completion of discharge

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

Dry tank certificate

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

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

Ballasting

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

In-transit losses and their potential causes

In the past the standard defence put forward by a shipowner to a cargo

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shortage claim was that the loss was below or equal to 0.5% of the total cargo. This figure, which originally stemmed from the cargo insurance deductible, has been used by shipowners and cargo insurers as a yardstick for transit losses for many years. However, a number of courts, particularly in the United States, have rejected the concept of an automatic 'loss allowance'. Nonetheless, there is every indication that the same Courts would allow a ±0.5% 'measurement tolerance'.

In transit losses and their causes can be considered under four headings:

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

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

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

Losses during discharge

The largest volumetric losses are likely to occur when there is transfer from one container to another. This means that quite large losses can occur when pumping the cargo from the ship to the shore. Where lightering is involved there will, inevitably, be a greater risk of volumetric losses between the ocean carrying ship and the shore tanks. Where COW is performed, the potential for

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volumetric losses is greater since the cargo is being formed into a high pressure spray and partially atomised.

The shore installation

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

In many countries the measurements taken at the time of custody transfer are witnessed by customs officials and if appropriate, the official customs documents should be produced.

Oil contamination claims

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

Many modern refineries, designed for the reception of cargoes carried by sea have desalination facilities in order to protect the distillation columns and refinery equipment from excessive corrosion. Such facilities, however do not always exist. The presence of water in certain crude oil cargoes may also cause emulsions to form with the hydrocarbons. This in turn may cause ROB volumes to be excessive and possible sludging of land tanks if efficient water draining is not carried out.

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

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

Precautions before loading

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

When carrying multigrade cargoes, effective segregation is a prime importance. When preparing the loading plan, allowances must also be made for trim and draft restrictions, it is not uncommon for multigrade cargoes to be loaded in more than one port and for several discharge ports to be involved. In some cases, additional cargo may be loaded during the voyage after the discharge of other products. Careful planning is advisable taking into consideration the quantity of cargo to be loaded and discharged, draft, trim and stress considerations as well as the consumption of water and fuel.

Before loading, all those concerned should have a clear knowledge of the intended loading plan and the pipelines and valves must all be carefully set and double-checked.

Because product cargoes generally have a low specific gravity, it is likely that the ship may not be loaded down to her marks even with all cargo tanks filled to the maximum permissible. When loading for a voyage which entails passing through areas where higher sea temperatures are expected to be encountered, it is advisable to take into account the expansion of the cargo which will occur as a result of those higher temperatures.

During the loading of sensitive products it is common for 'foot samples' to be loaded and for samples to be taken and analyzed before the rest of the product is taken onboard. When carrying multigrades it is an excellent practice to have as many samples of the cargo as possible taken at various stages of the loading and discharge, including samples taken from the shorelines. If claims for contamination arise, the analysis of such samples will often identify the source of the problem and may assist the shipowner in rejecting liability. A more detailed article on the sampling of liquid cargoes is included later in this Section, and a careful study of that article is recommended.

Conclusion

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

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

Appendix: definitions of terms used

API = API GRAVITY

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

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

AUTOMATIC SAMPLER

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

BARREL

Petroleum industry measurement unit equal to 42 US Gallons.

CLINGAGE

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

CRUDE OIL WASHING (COW)

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

DENSITY

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

DIP

Is depth of liquid = to American expression: gauge.

FREE WATER

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

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GAUGE REFERENCE HEIGHT

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

GROSS OBSERVED VOLUME (GOV)

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

GROSS STANDARD VOLUME (GSV)

The total volume of all petroleum liquids and S&W, corrected by the appropriate temperature correction factor (C_t1) for the observed temperature and API gravity, relative density, or density to a standard temperature such as 60°F or 15°C also corrected by the applicable pressure correction factor.

LOAD ON TOP (LOT)

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

NET OBQ

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

NET OBSERVED VOLUME (NOV)

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

ONBOARD QUANTITY (OBQ)

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

REMAINING ONBOARD (ROB)

Cargo or residues remaining onboard ship after discharge.

SEDIMENT AND WATER (S&W)

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

SHIP'S COMPOSITE SAMPLE

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

SHIP FIGURES

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

SLOP TANK

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

TOTAL CALCULATED VOLUME (TCV)

The total volume of the petroleum liquids and S&W, corrected by the appropriate temperature correction factor (C_t1) for the observed temperature and API gravity, relative density, or density to a standard temperature such as 60°F or 15°C and also corrected by the applicable pressure factor and all free water measured at observed temperature and pressure. (Gross Standard Volume plus free water).

TOTAL DELIVERED VOLUME (SHIP)

It is defined as the Total Calculated Volume less ROB.

TOTAL OBSERVED VOLUME (TOV)

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

TOTAL RECEIVED VOLUME (SHIP)

It is defined as the Total Calculated Volume less OBQ.

ULLAGE (OUTAGE GAUGE)

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

VOLUME CORRECTION FACTOR (VCF)

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

WATER (DIP) GAUGE

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

WATER FINDING PASTE

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

WEDGE CORRECTION

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

WEIGHT CONVERSION FACTOR (WCF)

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

Liquid natural oils, fats and fatty products

The products dealt with below include crude vegetable, animal and marine oils as well as fats. Some of the oils are edible and others are used in the production of soap, paint, lacquer, cosmetics and medicines. Occasionally, refined vegetable oils are shipped. When these products are transported by sea, a variety of difficulties may be encountered, the cause of which generally fall into two categories.

- Handling (basically temperature control).
- Contamination.

Handling

Claims still frequently arise which involve allegations of unsatisfactory handling by ships.

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

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

During the discharge of cargo, if the environmental temperatures are very low, further problems may arise as a result of solidification, which most commonly occurs when a tank is almost empty and the liquid level has fallen below the level of the heating coils. Under such circumstances, the final residues may be removed by sweeping or by steam stripping, provided the receivers are able to accept the fat and water mixture which is produced. Ship's officers responsible for discharging heated products in cold climates should ensure that the maximum pumping rate is maintained and that there are no interruptions during discharge, shore operations permitting.

Contamination

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

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

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

At the time of discharge, samples are always drawn by the receivers or their surveyors. Normal analyses conducted at both load ports and discharge ports are quite straightforward and the typical parameters determined are water, free fatty acid, unsaponifiable matter and odour. If there is evidence or suspicion that on delivery the cargo does not conform to either a specification or to the loading samples, more detailed chemical analysis may be performed. There are now reliable and effective procedures available for determining traces of chemical contaminants. Certain contaminants can be identified and determined at levels as low as 10 parts per billion (ppb). Contamination at this level will result from admixture of 10 grams of contaminant, with 1000 tonnes of cargo. Most chemical contaminant can be identified and determined at levels of 100 ppb or 100 grams per 1000 tonnes of cargo.

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

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

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the third previous cargo have been found when samples of damaged coatings were tested.

Another possible source of contamination is the penetration and softening of epoxy and polyurethane coating by a previous cargo. This may find its way later into newly loaded products. Masters should always consult the 'cargo resistance' list provided by the manufacturers of the tank coating. This will list those cargoes to which the tank coating is resistant. For cargoes not included in the list, or cargoes without resistance indicators, or when deviating from the maximum temperatures indicated on the list, the manufacturers should always be consulted.

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

On completion, the tanks should be clean, dry and free from residual odours. It may also be desirable to take wall-wash samples and have them analysed for traces of previous cargoes, but this requires skilled inspectors. The presence of an odour in a tank, which has been cleaned, indicates the presence of cargo residues and also indicates the need for further cleaning. It is advisable, when checking for residual odours, to make the test after the tank has been closed for a period. Testing should, in any case, be carried out by personnel who have not been working in or near the tanks for at least one hour.

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

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

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

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

Drain cocks which are fitted at the lowest parts of deck and manifold lines, as well as plugs at the bottom of cargo valves, should be opened and rinsed in order to remove any trapped cargo residues. These drain cocks may contain sufficient liquid to result in serious contamination. When clearing deck and drop lines it is important to ensure that the dead ends of these lines and drop lines are not overlooked. They should be opened and thoroughly cleaned.

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

The importance of proper tank cleaning procedures and the correct preparation of tanks and all related equipment prior to loading cannot be over-emphasized. Masters may wish to consider appointing an independent surveyor to verify the condition of the tank coating, heating coils and hatch openings after the tank preparations are completed. On completion of loading, an ullage survey by an independent surveyor may be appropriate, whereafter valves and hatches should be sealed. This process can be repeated at the discharge port. The practice of taking onboard samples at all stages of the loading and discharging operation which is referred to earlier, is also to be highly recommended. Should contamination occur at some stage in the course of transit, it may be possible, by analysis of such samples, to identify the source of contamination. By ensuring that the cargo is carried to the highest standards, the product should be well protected.

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Samples and sampling in the carriage of liquid bulk cargoes

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

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

The answer lies in an effective sampling system!

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

Many parcel-tanker owners have issued instructions to their masters to sample each type of cargo at the ship's manifold on commencement of loading, after the first test-load (so called 'first run' sample) and from the ship's tank after completion of loading. Such samples are numbered and entered in a

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special sample log book An additional advantage of this procedure is that the ship's officers who attended the sampling, or who actually drew the samples, are available for questioning at the port of discharge. It is so often the case that unilateral sampling by shippers at the loading port is not witnessed by ship's officers and samples allegedly drawn from ship's tanks are handed to the ship's staff just prior to departure. These problems confirm absolutely the need for a joint sampling procedure between shippers and carriers and carriers and consignees.

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

It should be emphasized that as with bulk or general cargo, the description on the bill of lading relates to the external and apparent condition of the goods. Claims on liquid bulk cargoes often involve the question of quality, which is not usually apparent and these claims may be based on a detailed analysis which the carrier has no means of checking. Furthermore, in the majority of instances, the ship's staff cannot question the condition of a product upon loading, except perhaps where the presence of free water, haziness or dull appearance, the presence of a strong foreign odour or an obvious deviation in the colour of the product is readily apparent. It is therefore important that samples carefully taken at the time of loading and prior to discharge are truly representative of the condition of the cargo and are available in the event that any dispute arises. Where loading port samples have been drawn and retained onboard, any uncertainty about the quality of the cargo at the time of loading can be clarified at relatively low expense.

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

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however, and will require the ship to discharge the 'first run' of cargo if this analysis shows it to be 'off specification'.

When loading operations are resumed it should not be assumed that the 'first run' of cargo will be in good order and condition. This may not necessarily be the case as the shipper may have found the product to be only slightly off specification and have decided to 'blend' the cargo during subsequent loading operations. Furthermore, water may be introduced into the product via the installation's pipeline system without the ship's staff being aware of it.

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

When cargo is loaded by shippers and discharged by consignees, it is their responsibility to ensure that the hoses and pumps supplied are suitable for the product concerned. The importance of sampling firstly, after the 'first run' of cargo has been loaded, secondly, after completion of loading and thirdly, prior to discharge, is paramount in order to establish by analysis whether or not any alleged damage or contamination could have been caused as a result of the use of unsuitable equipment supplied by the shipper or consignee, or by defects in the ship's loading system. It must also be emphasized that there is duty on the ship's crew to assist shippers and/or consignee with the proper connection of hoses and to ensure that, in the case of loading over the top, hoses are placed in the proper tanks. The crew should also ensure that where the ship's integral piping system is involved, the cargo is directed to the correct tank during loading, and that the lines used during loading and discharging are properly isolated to avoid contamination with other products onboard.

Sale contracts

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

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

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

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

Most sale contracts provide for the change of ownership of the cargo to take effect at the time of loading onboard ship and for a bill of lading to be obtained from the carrier It is therefore important for both seller and carrier to have evidence of the condition of the cargo at that time. The carrier's responsibility may however commence at an earlier time depending on the moment of taking charge of the cargo. The sampling activities of shipper and buyer often lead ship's officers to believe that nothing is required of them, as the carrier's position has been sufficiently protected. This however is not always the case.

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

Sampling

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

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- To enable protest to be made to the shipper if the product loaded is not in apparent good order.
- To enable the loading operation to be followed in all its stages.
- To provide evidence should the ship's tank coatings be found damaged upon discharge.
- To enable the carrier to provide evidence should local authorities lodge pollution claims against the ship.
- To enable the specific gravity and temperature of the cargo to be established.
- To investigate subsequent claims against the carrier for admixture or contamination.

Sampling prior to loading

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

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

Sampling during loading

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

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

Loading port samples other than those taken by the carrier

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

Sampling before discharge

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

In the case of edible oils and animal oils / fats, bottom samples should always be drawn to check for sediment. these bottom samples must be kept in separate jars, sealed and properly labelled for identification. It must be emphasised that sediments, if any, should always be regarded as belonging to the particular consignment involved.

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

Sampling procedures

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

Cargo sampling is a difficult process and one that requires most careful attention. It should be emphasized that each sample must be representative of the product concerned. Continuous sampling at the ship's manifold in order to obtain a so-called 'ship's rail composite' sample, though a time consuming procedure, may be of value in the case of homogeneous cargoes where tank samples taken prior to commencement of discharge have shown the product

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to be satisfactory at the time the ship arrived. A sample of the first cargo arriving at the ship's manifold, a 'first run' sample from the ship's tank and a sample or set of samples drawn from the tank on completion of loading are the most important. In the chemical (parcel) trade, running samples during the first five minutes of loading are sometimes also drawn. The object of all these sampling operations is to obtain a manageable quantity of cargo, the condition and properties of which correspond as closely as possible to the average condition and properties of the parcel being sampled.

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

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

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

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

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

Labelling of samples

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

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

It cannot be too strongly emphasized that the only way to be certain that the proper label is put on the proper sample container is for the ship's staff to participate in the whole procedure of sampling and sealing and to insist that the sealing and the labelling should take place onboard the ship. All labels should be properly dated and should indicate the local time when they were drawn, name of the product and its destination, the name of the shippers and whether the sample was drawn conjointly with them. The label should also record the quantity, tank number, the tank ullage and temperature, the bill of lading and voyage number and whether it is a manifold, pipe line, 'first run' or 'average' ship's tank sample after completion of loading. Care must be taken that all these necessary details will remain legible by the use of permanent washable ink. Having signed the labels, the ship is entitled to retain a set of the samples.

Storage of samples

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

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

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

Sampling instruments

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

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

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

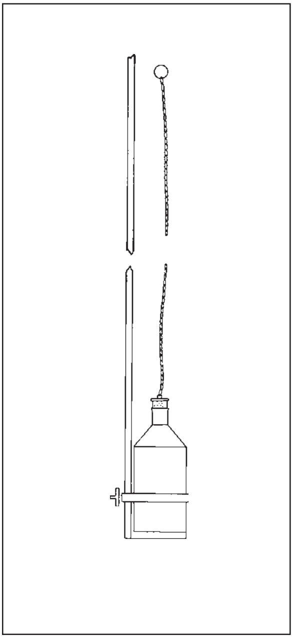

Fig1. Sampling bottle or can

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

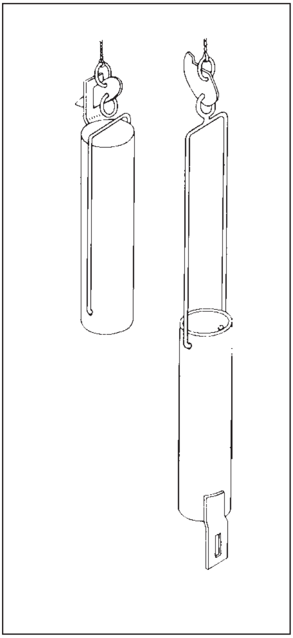

Fig 2. Sampling tipping dipper

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

Sampling liquid bulk cargoes

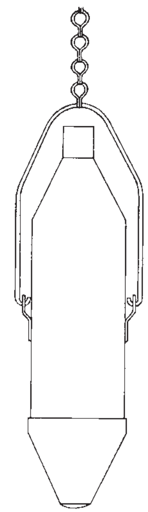

Fig 3. 'Go devil' sampling bottle

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

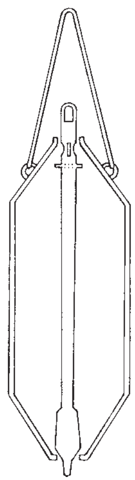

Fig 4. Bottom sampler or zone sampler

The bottom sampler or zone sampler is suitable for withdrawing bottom samples or zone samples at any level from tanks of liquid oil. To withdraw a bottom sample the apparatus is attached to a cord or chain and lowered empty to the bottom of the tank, when the central spindle valve automatically opens and the container fills from the bottom. On withdrawal of the sampler the valve automatically closes again

To withdraw samples at any level the apparatus is lowered empty to the required level and then, by means of an additional cord attached to the top of the central valve spindle, the valve may be opened and the container filled. When the sampler has filled, the valve is allowed to close and the container is withdrawn

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Section 3

Containers

Part 1

Agricultural products in non-refrigerated containers

A wide variety of agricultural products are carried in non-refrigerated containers, either ventilated or standard dry boxes. These include cocoa, coffee, tea, tobacco, dried fruit, rice, nuts, oilseeds, pulses and spices. Fresh fruit and vegetables are more commonly carried in refrigerated containers, although produce such as melons, oranges, potatoes, sweet potatoes, yams and onions are sometimes carried in ventilated or open containers.

Careful consideration should always be given to ensure that the choice of container, packaging and dunnage is appropriate for both cargo and voyage. Two frequent causes of major cargo damage are condensation and taint.

Condensation (sweat)

Almost all agricultural products have a considerable intrinsic moisture content. These are hygroscopic cargoes; they are in equilibrium with the air in the container and can emit as well as absorb moisture. The amount of water available within a container of such cargoes is much larger than for manufactured goods. Translocation of a comparatively small proportion of the total moisture available may cause substantial condensation problems.

Hygroscopic cargoes change temperature comparatively slowly. Thus, when a container is shipped across climatic zones, the cargo adjusts to the changing ambient temperatures much more slowly than the container walls and the air. This delay can cause considerable temperature differences within the container; these are a major driving force for moisture translocation and condensation.

Ventilated containers

Ventilated containers include those with passive ventilation openings, open containers and mechanically-ventilated containers. However, these are all comparatively rare, the vast majority of containers having no effective ventilation provision. Although the small air-expansion holes in the walls of standard dry boxes are sometimes called 'ventilation-holes', the air flow

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through them is insufficient to provide significant protection against condensation.

The International Cocoa Organization recommends using ventilated containers for all containerised cocoa shipments. Some coffee and cocoa shippers use such containers; however, this is not the standard throughout the trade.

The air inside ventilated containers is largely common with the surrounding air. This may present such additional problems as more ready transmission of taints, and the stowage location onboard requires careful consideration.

Desiccants

During carriage of hygroscopic cargoes in non-ventilated containers, condensation could in principle be prevented if the relative humidity of the air inside the container was kept sufficiently low that its dew point was always below the ambient temperature. This ideal situation is often unrealistic, but the dew point may be lowered, and the risk of condensation reduced accordingly, by using desiccants.

Desiccants (such as silica gel, Møler clay or certain polymers) are water-absorbent and remove moisture from the surrounding air. They may be supplied in bags, specially-lined sheets or as polymer-based paint. Once the maximum absorption capacity of such products is exhausted, they have no

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further beneficial effect. Thus, when using desiccants, their type and amount must be chosen carefully for the type of cargo and the voyage.

Because of their potential for significant moisture exchange with the air inside the container, hygroscopic cargoes place much greater demands on the capacity and sustained absorption rate of desiccants than do non-hygroscopic cargoes. Desiccants alone are unlikely to prevent condensation in the event of rapid temperature changes of large magnitude.

Dunnage, sheets and linings

A basic precaution for cargoes sensitive to condensation damage is to apply suitable dunnage to separate the cargo from the container's walls and floors. This cannot prevent the formation of condensation, but can greatly reduce its commercial implications. It is often recommended to use kraft paper or similar material to line the walls and floors of containers or as protective sheets on top of the cargo. Since these become quickly saturated they cannot afford significant protection against severe sweat, although they can absorb small amounts of condensation and in some circumstances prevent or reduce staining and similar damage. Sheets placed atop the cargo must be readily permeable to air; plastic is unsuitable for this purpose, as condensation could form between sheets and cargo.

Taint

Many foodstuffs can absorb chemicals and foreign odours from the air. This typically affects their taste and severely affects their commercial value even when there are no significant toxicological implications.

Coffee, tea and cocoa are particularly susceptible to taint. They are traded primarily on their delicate flavour balances, with sophisticated tastings of every consignment being carried out at various stages. A comparatively minor off-flavour or odour causes commercial damage to these high-value cargoes.

Some basic considerations to protect against taint damage are:

- Inspect containers prior to stuffing for odours, previous cargo residues and staining of floorboards. The container should be kept closed for some time until immediately before inspection.

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- Containers which have recently been used for the carriage of odorous chemicals should not be used for foodstuffs, even if no detectable odour remains. More generally, operators should consider keeping separate pools of containers designated for chemicals and for foodstuffs.
- Stow containers containing foodstuffs away from strong odours onboard. This is particularly relevant when using ventilated containers, where the air-exchange rate, and thus the potential for transmission of external taints, is much greater than for non-ventilated containers.
- Floorboards, pallets, crates, etc. are often treated with fungicidal wood preservatives containing chlorophenols. These are also contained in mould-inhibitors used on jute bags and the adhesives in some fibreboard cartons. Chlorophenols are themselves a potential source of taint. Although the levels used are usually insufficient to cause commercial problems, they can be converted to chloroanisoles by certain micro-organisms, especially in the presence of excessive moisture such as may result from condensation. Chloroanisoles are an extremely potent source of taint, causing a characteristic musty odour and flavour even in very minute proportions.

This article gives only a general introduction to the potential problems associated with the containerised carriage of agricultural products. Condensation in particular is a complex topic. The above may be of some assistance in identifying key areas of concern. However, if in doubt, specialist advice should be sought.

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Refrigerated containers

The international transport of temperature controlled raw materials and final products is an essential link in many industries between producers and consumers. Most cargoes have properties that will determine practical storage lives (PSLs), which are a key factor if they can be carried by sea.

A container operator observes evolving patterns of trade. Examples are:

- More countries exporting by sea – especially fruit, fish, flower bulbs and meat (see also 'Meat and meat products in containers' in Section 5).
- Some shorter life products spending more than half their PSL in transit.
- Demands from supermarkets for all-year-round supplies reducing seasonality.
- Lower stock holding with demands for just in time deliveries and inventory control.
- Some moves from airfreight – particularly cargoes needing due diligence records such as pharmaceuticals.
- Use of intermodal movements depending on local requirements and facilities.

A prudent carrier has to apply a systematic approach to ensure that the equipment and service provided is 'fit for the purpose intended'.

To achieve the requirements needs:

- Containers of appropriate design that are maintained correctly.
- A process (temperature controlled chain) that is capable of remaining in control.
- A set of detailed procedures.
- A reliable information system.
- Trained staff.
- Shippers that correctly stuff containers with properly prepared cargoes to meet their customers' purchase specifications.

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Claims and incidents

The vast majority of cargoes outturn well and claims represent a fraction of 1% of the containers carried. Temperature controlled container carriage is developing and there are many things that can, and very occasionally do go wrong. The video issued by the Club, *If you think any fool can stuff a container – think again*, provides a graphic demonstration of how not to get cargo to its destination in good condition.

Experience is a great teacher and even the best-designed systems can be found wanting with 'Murphy's law' and human error ever present. An individual temperature controlled container may suddenly appear to have attracted multiple errors and faults while the many others carried in the same transit having perfect outturns. Cambridge Refrigeration Technology (CRT) runs a training course that uses a real claim as a short case study. Six individual separate faults, and errors, occurred. The cargo had a value of US$750,000 and unbelievably it was not a total write off!

The following list is not exhaustive but covers a typical list of ten critical areas of occurrence reported to a typical cargo claims, or cargo care, department that may result in a confirmed claim:

- Containers off-power and therefore off-refrigeration for extended times.
- Wrong settings caused by incorrect information.
- Failure to monitor properly and correct faults or wrong settings.
- Poorly pre-cooled or overcooled cargo.
- Cargoes with insufficient PSL.
- Badly stowed containers impeding air flow – many with low quality packaging.
- Excess fresh air ventilation for live cargoes thereby causing evaporators to ice up.
- Incorrect defrost interval where this has to be set manually.
- Incorrectly booked cargo leading to operational and commercial problems.
- Fahrenheit and Celsius temperatures interchanged or wrongly converted.

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This list is not in priority order with claims relative to the number of containers carried very low.

There is a long list of minor but important issues that relate to individual incidents. They can include physical damage, broken security seals, air probe temperature sensor failures, and partial or complete loss of refrigerant, generator failure during land transit and many more.

Patterns of claims and incidents

Because of the small number of claims the statistics are difficult to analyse. It is sometimes possible to observe patterns of claims/incidents by careful systematic review of all the factors. For example – the surprising patterns that continue to involve alleged temperature abuse of frozen fishery products. Additional points to check include:

- New export locations.
- Pre-shipment temperatures and the use of 'glaze (water)' to protect the product.
- Freezing of items individually (IQF) rather than as a block. (A less dense more temperature-sensitive cargo with a lower heat sink in the container).
- Low stuffing and unstuffing times to avoid temperature rises.
- The temperature set point. (The popular -18°C needs to be colder and -23°C is acceptable for most containers with many able to be set colder).

A difficult area involves a few subrogated claimants that are unwilling to accept that Lines do not guarantee cargo temperatures. The set point is the temperature of the air passing a sensing probe and is not the temperature of the cargo. Cost and time would be saved if these professional claimants attended an independent training course to understand how a modern integral unit operates.

Fortunately most temperature controlled containers built since 1994 contain data loggers that record a variety of information. They are like a simple aircraft 'black box'. Independent loggers are also available so that a wide variety of audits and checks can be made. When reviewing a claim/incident a download can show:

- Pre-trip inspection records.
- Set point plus supply and return air temperatures at preset intervals.
- Defrosts.
- Times off-power.
- Basic faults.
- Relative humidity.

This is a major step improvement from just recorder chart details. It will be some years before containers without digital electronics are replaced. This factor is delaying the full introduction of remote monitoring on vessels and terminals although most new vessels are so equipped. As always the data remains the property of the container operator.

Ways forward

The future trends are mainly positive and a selection follows:

- Integral containers:
  - More reliable with improved airflow, calibrated air freshening vents, dehumidifiers, and other programmable settings.
  - Improved insulation with lower degradation over time.
- New vessels providing faster transits, new routes, and some relaxation in inland road weights.
- Leading consignees and shippers working with lines to provide good logistics.
- Increasing uniformity of regulations between groups of countries reducing variations.
- Foods standards agencies or equivalent developing in key countries.
- EU/UN inspectors approving meat and fishery product facilities thereby improving standards.

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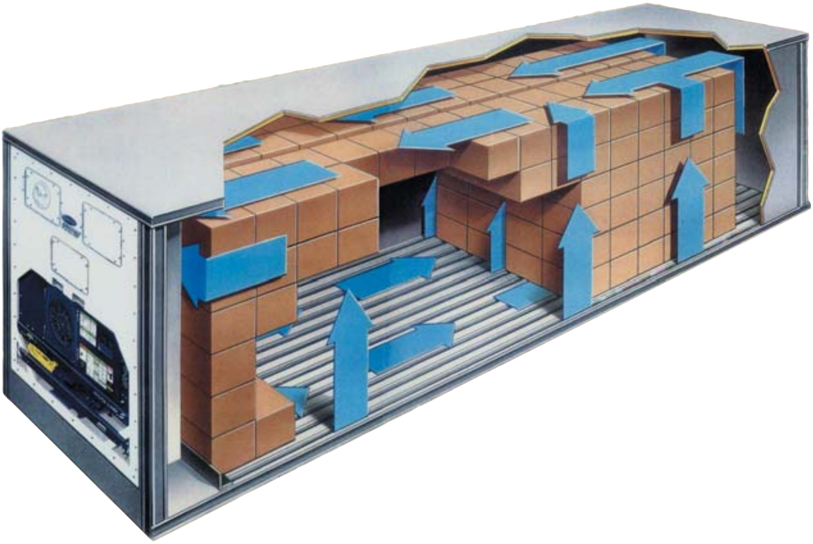

- US Food & Drug Administration moves from inspection to prevention mode.
- Acceptance of hazard analysis by big food companies and many countries as a safety measure.

In the meantime information and training continue as active methods of preventing claims. Examples are:

- The Internet (and Intranet in many companies) provide a systematic method of communication.
- P&O Nedlloyd has put its *Temperature Controlled Cargo Guide* onto its website.
- A booklet by the University of California provides good information on stowing containers plus very good photographs on troubleshooting some perishable product problems.
- Modern videos such as *If you think any fool can stuff a container – think again.*
- Training courses run by integral container refrigeration equipment manufacturers and organisations such as Cambridge Refrigeration Technology.

- Support of organisations such as International Cold Chain Technology.

The International Quality Standard ISO9000:2000 requires changes in approach if companies wish to retain, or obtain, assessment. It requires:

- Customer focus.
- Leadership.
- Involvement of people.
- Process approach.
- System approach to management.
- Continual improvement.
- Factual approach to decision making.
- Mutually beneficial supplier relationships.

Conclusions

The carriage of temperature controlled cargoes in containers is growing with the vast majority of outturns meeting both the shippers' and consignees' requirements. Advances in digital electronics are improving the ability to manage transits.

A systematic approach to analysing the causes of claims and incidents can lead to effective remedial and preventive actions.

Part 2

Calcium hypochlorite

The need to take the appropriate precautions in the stowage of this material still remains (see the UK Club's *Loss Prevention Bulletin* 116-11/99). Such matters were discussed in February 2000 at the International Maritime Organization's 5th session of the Sub-Committee on Dangerous Goods, Solid Cargoes and Containers (DSC5) and some changes to the existing IMDG Code were drafted. These changes have been confirmed by the Maritime Safety Committee (MSC 72) in May 2000. The anhydrous (UN1748) hydrated (UN2880) and bleaching powder (UN2208) forms of the material are to be stowed on deck only (Category 'D'). It should be stowed out of direct sunlight. Bulk packages are not allowed nor is transportation in bags. Packing the materials in drums will ensure the possibility of air flow through a stow of such receptacles when they are stuffed into a freight container. This is important as air flow will assist in the dissipation of heat generated by these reactive materials.

The International Group of P&I Clubs (IG P&IC) submission to the IMO recommended changes to rules on package sizes. A maximum package size of 45kg net is still being recommended by this Group, although the IMO failed to recognise the need for the use of small packages. Also some delegates at the DSC5 meeting argued against the need to stow these cargoes 'clear of living quarters'. The IG P&IC continues to recommend that stowage should be 'clear of living quarters' because when this chemical decomposes it gives off the highly toxic gas chlorine.

The reasons for the IG P&IC recommendations are based on a better understanding of the properties of the hydrated form of the material UN2880 than had been available when, in the late 1970s, the IMDG Code entry for this material was discussed. Research carried out in Australia has highlighted the need to be more aware of the sensitivity of these materials to heat spontaneous decomposition, which leads to explosion and fire and which could occur at temperatures in the low 30°C for freight containers stuffed with large drums (about 200kg) of UN2880. Such temperatures are encountered in the holds of container vessels where there are heated fuel oil tanks. Thus the materials should not be stowed where the critical ambient temperature of the materials can be attained. If there is a risk with on deck stowage that the freight

containers could be subjected to long periods of direct sunlight, steps should be taken to restow these freight containers. If this is not possible the freight containers should be covered with tarpaulins to provide shade.

The ocean transportation history of calcium hypochlorite suggests that all forms pose special challenges concerning safe carriage. The safety issues are complex and are aggravated by a high degree of product variability.

The 2000 amendment to the IMDG Code (Amendment 30), effective from 1 January 2001, states the following for calcium hypochlorite, UN Nos: 1748, 2208 and 2880:

> " *Stowage and Segregation*
>
> *Category D.*
>
> *Cargo transport units should be shaded from direct sunlight and stowed away from sources of heat. Packages in cargo transport units should be stowed so as to allow for adequate air circulation throughout the cargo. 'Separated from' powdered metals and their compounds, ammonium compounds, cyanides, hydrogen peroxides and liquid organic substances.*"

Should the new requirements fail to address the issues of package size and stowage away from accommodation, the IG P&IC plans to reaffirm its existing guidance to shipowners. This draws attention to the association between fire risk and package size and the importance of stowage away from accommodation.

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Some synonyms for calcium hypoclorite

B-K POWDER

BLEACHING POWDER

BLEACHING POWDER, containing 39% or less chlorine

CALCIUM CHLOROHYDROCHLORITE

CALCIUM HYPOCHLORIDE

CALCIUM HYPOCHLORITE

CALCIUM OXYCHLORIDE

CAPORIT

CCH

CHLORIDE of LIME

CHLORINATED LIME

HTH

HY-CHLOR

HYPOCHLOROUS ACID, CALCIUM SALT

LIME CHLORIDE

Some calcium hypochlorite is being shipped out of China declared as:

PRECHLOROISOCYANORIC ACID (UN 2465), and

SODIUM DI-ISOCYANORATE (UN 2466)

It may also be shipped as water purification tablets and swimming pool cleanser

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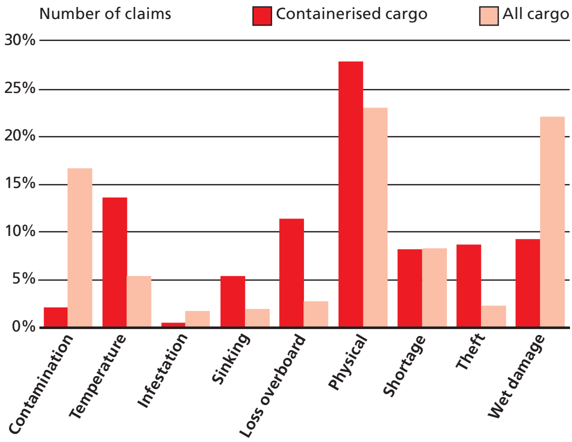
Cargo damage – the causes

The container revolution of the 1960s was deemed to be the solution to limiting cargo damage, but has experience proved otherwise?

A considerable proportion of the UK Club's time is taken up handling container cargo claims where 25% of the damage is physical, 14% temperature related , 11% containers lost overboard, 9% theft and 8% shortage.*

The graph below shows how these compare to damages of all the UK Club's large cargo claims and highlights some of the real benefits, or otherwise, of containerisation.



Large cargo claims – Type of damage

It is worrying that one of the biggest contributory causes of container cargo damage is bad stowage – causing nearly 20% of the claims. It would seem that we have merely shifted the cargo damage problem further back up the transit chain.

Shore error now accounts for around 27% of large container cargo claims compared with 19% for all types of cargo claim, tie this in with bad stowage

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*Source: Analysis of Major Claims

statistics and it seems to point to problems originating at the time of stuffing.

We seem to have substituted problems in one large container (the ship) to problems in a lot of smaller containers (the container). With around 12,000,000 containers in circulation and 95,000,000 loaded container movements each year, this seems to be a real problem for the industry.

Although it is a major cause of container cargo damage, it would be wrong to lay the origin of all container cargo claims on bad stowage alone. Listed below are many other reasons for damage:

- Lack of export packaging.
- Increased use of weak retail packaging.
- Inadequate ventilation.
- Wrong choice of container.
- Poor condition of container.
- Lack of effective container interchange inspection.
- Ineffective sealing arrangements.
- Lack of clear carriage instructions.
- Ineffective internal cleaning.
- Contaminated floors (taint).
- Wrong temperature settings.
- Condensation.
- Overloading.
- Poor distribution of cargo weight.
- Wrong air flow settings.
- Wrongly declared cargo.
- B/L temperature notations misleading/unachievable.
- Lack of reefer points.

- Organised crime.
- Heavy containers stowed on light.
- Stack weights exceeded.
- Heat sensitive cargoes stowed on/adjacent to heated bunker tanks or in direct sunlight.
- Fragile cargoes stowed in areas of high motion.
- Damaged, worn, mixed securing equipment.
- Poor monitoring of temperatures.
- Wrong use of temperature controls.

As an insurer finding and highlighting the problems and where the money goes is easy. Rectifying those problems unfortunately is not.

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Coffee

The carriage of bagged coffee beans, now mostly containerised, was discussed at length by the Advisory Committee in an article included in its 14th Report. The article dealt mainly with coffee shipments from East Africa, West Africa and Brazil delivered to ports in North Europe. Coffee is now being imported from the Far East in increasing quantities and although the advice offered earlier remains valid, some additional problems have been identified which are worth mentioning and which could be avoided with vigilance on the part of ships' officers.

Generally, coffee shipments from the Far East suffer more condensation damage than coffee from other sources. The Committee wishes to re-emphasise that the main cause of condensation damage to bagged coffee in containers shipped into Northern Europe from ports worldwide occurs after discharge when the containers remain on the wharf for long periods, often exposed to large variations in temperatures. It is also the containers on the outside of the container stack which suffer most damage – those on the inside being partly protected by the other containers. Rapid stripping of the containers after discharge, or storage of the containers in a warehouse, is the only solution to this problem.

Another reason for condensation damage is the practice of sealing the container ventilators with tape. This is done for fumigation purposes prior to

Condensation from the container roof has dripped on to the bags

Sealed ventilation openings

shipment and often after fumigation, the tapes are not removed thus preventing airflow and resulting in excessive condensation as well as mould growth. The volume of the air space at the top of the container should be carefully checked. When containers are loaded with 250 x 70 kilogram bags, a space of about 50 centimetres is left between the top of the stow and the roof of the container. When loaded with 300 x 60 kilogram bags, a minimal space remains. It has been found that, in the latter case, the cargo is more prone to condensation damage. There is no obvious scientific explanation for this phenomenon although it is well substantiated. Although ships' staff cannot control the stuffing of containers such damage may well be attributed to the ship, with allegations of incorrect ventilation during the passage.

Water has penetrated through all the openings

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Dangerous goods

When towards the end of a voyage four seamen on a UK Club ship were sent to check lashings little did any of them realise what the future held in store. Unbeknown to anybody on the ship, a shipment of cylinders of deadly gas had been placed inside a freight container which had been loaded aboard. Although the gas was properly packaged and the cylinders were properly labelled, they had not been declared to the shipping company, the container was not placarded and the cylinders were either badly secured or not at all. Furthermore, the ocean had caused the cylinders to roll, damaging the valves and letting the gas escape. A declared shipment would have gone on deck, but nobody knew so there it was underdeck – and this particular gas was much heavier than air.

If only this story were the product of a fevered imagination. However, regrettably, it was a tragic real-life case and two lives were eventually lost but it serves to dramatically underline how vulnerable the ship and its crew can be, even with packaged dangerous goods. In fact, despite the millions of man hours spent in discussing, devising, updating, publishing, training and implementing the dangerous goods rules at international, national and company level, **if the cargo originator fails to carry out his part either through ignorance or intent, the whole concept collapses, just like a pack of cards.**

Shipments of packaged dangerous goods are quite substantial – it is estimated to be anything up to10% of total tonnage carried and this dictates that there is a need to ensure that there is widespread knowledge and understanding of the rules throughout the maritime transportation chain. After all, the rules have been built up over many years and are often the result of accident or incident experience in the past. The fact that there is wide understanding is shown by the millions of shipments made and completed properly, safely and successfully every year.

However, it is also clear, and there can be no doubt, that there is widespread non-compliance to one degree or another with the IMDG Code and that this indicates a certain level of ignorance of the requirements. This does not mean that it has become dangerous to carry dangerous goods although, if it is not

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brought under control, it could well become so. The annual surveys carried out by maritime administrations and reported to the Dangerous Goods, Solid Cargoes and Containers Sub-Committee (DSC) of the IMO has told its own story. Starting with the USA in 1985, a large number of countries have submitted reports over the years. Separate reports have been compiled by Finland, three Western European nations, followed by five Western European nations, Japan, Sweden, then Canada, the UK, the Netherlands, the USA and Norway. The vast bulk of these reports has revealed considerable shortcomings in the situation found.

An analysis of the reports from 1995 to 2000, for example, shows:

- Over 9,000 cargo transport units (CTUs) were checked.
- Average number of units found to have a dangerous goods deficiency – 27.6% (lowest 17.2%, highest 75%).
- Most common deficiency – labelling, marking, placarding.
- Second most common deficiency – stowage within the CTU.
- Followed by:
  - documentation.
  - packaging.

Also significant was the finding that an average of nearly 10% had damaged, unreadable or out-of-date CSC plates.

What can the shipping company do about this? Movements with such deficiencies are against the law. However, the transportation chain cannot, and should not, simply rely upon enforcement agencies and preventative action to control the situation. Only Finland has been able to report to IMO a reduction in the deficiency rate to a low level (3%). The rules themselves which are enshrined in the IMDG Code are basically quite clear. There should therefore, in theory, be no excuse for not knowing what is needed and not implementing it. However, it is an imperfect world and how is the exporter in the middle of, say, a landlocked country or even in the middle of a maritime nation going to know what is required, let alone appreciate the stresses that a ship and its cargo moving across the oceans will undergo.

Despite the pressures of the commercial world and the need to minimise turnround times, the hazards from the carriage of dangerous goods are too great and the issue too important to ignore. Each shipping company needs to have a strategy backed by commitment and support if this increasingly important cargo is to continue to be carried safely.

The first requirement must be to ensure that the ships' officers and crew are alert and aware of this type of cargo. With major retraining needed for the new Code introduced during 2001, it is an ideal opportunity to raise general awareness at the same time. However, it is very clear that the ship cannot possibly run its own checks as the goods come aboard. It has to rely upon the shoreside to do this and, therefore, the second requirement is to ensure that there are good checking systems in place at the export port. These should cover the basic essentials such as documentation (declaration and container/vehicle packing certificate), placarding, marking, signing and labelling. They are the aspects which can readily be checked in the port and they also represent some of the most common deficiencies found (it is amazing how poorly some declarations are completed). A partnership needs to be established between the port and the ship as both benefit from a good standard whereas both are likely to suffer from a poor level of compliance.

That leaves the original customer – the shipper – and this is where the main effort must be made. In its revised *Recommendations on the Safe Transport of Dangerous Goods and related activities in the Port Area* the IMO introduced the term 'cargo interests' to cover all those who are responsible for the cargo which arrives at the port and the ship. It recommends that they should be given training commensurate with their involvement. New ways need to be found, perhaps in company with the ports industry, to target shippers in a way which will not only reach them but which will influence their activities. Perhaps the use of electronic communications will enable a response to be generated, giving essential dangerous goods information whenever a freight booking is made. Some shipping companies (and ports) run short information courses, which are free to their customers. Others produce information material – videos, pamphlets, booklets and cards. These are widely distributed and these efforts must be continued.

A missing placard, an imperfect declaration or a less-than-effective securement within a CTU **might** not, by themselves, render a situation dangerous. However, in certain circumstances each on its own could be crucial and there is a need to set a high standard of expectation. The truth is that we will get the standard we set and it could be alleged that we are not setting a high enough level. **The challenge is not to set and maintain a standard we can live with, but to set a standard that we could not live without.**

Part 3

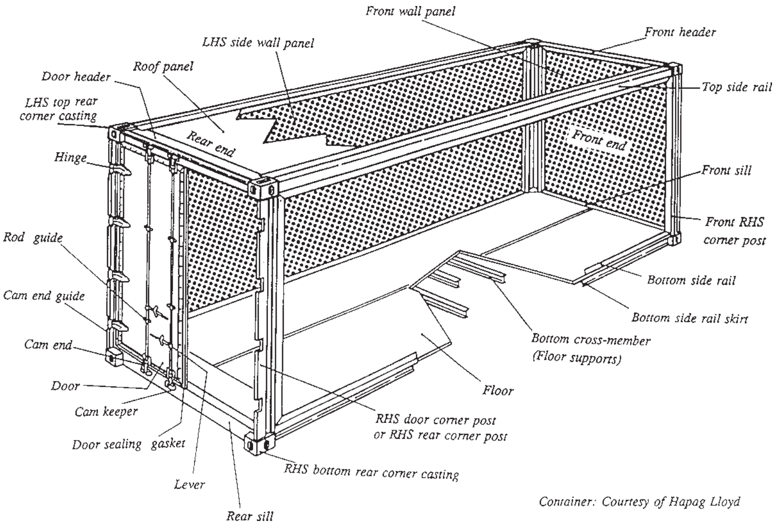
Containers in non-cellular ships

What is an ISO container?

The letters ISO stand for the International Standards Organization, which in general terms defines a container as an article of transport equipment:

- Of a permanent character and accordingly strong enough to be suitable for repeated use.
- Specially designed to facilitate the carriage of goods by one or more modes of transport without intermediate reloading.
- Fitted with devices permitting its ready handling, particularly its transfer from one mode of transport to another.
- So designed as to be easy to fill and empty.
- Constructed to dimensions and to quality criteria set out by the ISO.

The classic and standard ISO container is the 20ft unit, traditionally a fully-enclosed and rigid rectangular box 20ft in length and of 8ft x 8ft end cross-section, fitted with a pair of hinged doors at the rear end provided with hardware to close, lock and secure its contents. Within the shipping industry, this is known as a TEU (a twenty-foot equivalent unit).



Container: Courtesy of Hapag Lloyd

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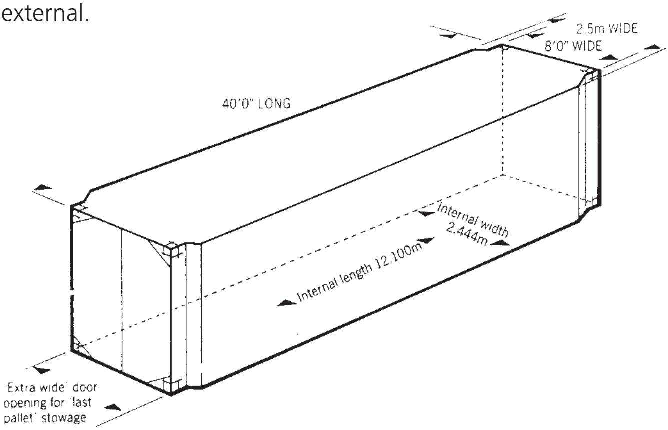
Containers in non-cellular ships

In recent years there has been a demand for containers of 8ft 6ins in height. A demand which has made this higher unit standard in some trades. Unit heights of 9ft 6ins are also not uncommon. Both have created problems for stowing and securing containers in adjacent stacks of mixed heights.

The longitudinal extension of the basic container is the 30ft and 40ft rectangular box. Some shipping lines use containers of 35ft and 45ft length. Another variation is the CUC Cellular Unit specially designed to carry two rows of 2.1m x 1m Europallets without wasted space. All these dimensions are external.



ISO conforming containers, usually with a timber floor, may be constructed of various materials:

- Entirely of steel sides, ends, roof and floor constructed of flat panels or corrugated sheets.
- Various aluminium alloys in similar flats or profiles.
- Marine plywood of various thickness.
- Glass-reinforced plastic (GRP) .
- Two or more materials.

The corner posts, corner castings, bottom rails, under-bearers and sills are of steel and should meet the dimensional tolerance and strength specifications as established by the ISO, and additionally as surveyed and approved by several of the ship classification societies.

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From the basic TEU a multiplicity of variations has evolved, i.e., the open-top container, the tilt-sided container, the flat rack, the various types of reefer units, and bulk-liquid tanks of various shapes fitted with ISO structural frames. There are also variations in length and height. Reference to *Jane's Freight Containers and Containerisation International Yearbook* provides detailed insight into the range of units available.

Left. 20ft all-steel opening roof container

Below. 20ft x 8ft tank container. May contain highly corrosive and/or toxic liquids

Source: Jane's Freight Containers

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A normal 20ft unit has a tare weight of between 2 and 2.5 tonnes, a cargo weight (payload) capacity of between 17.5 tonnes and 18.5 tonnes, with a maximum gross weight of about 22 tonnes. A 40ft unit has a tare weight of between 3.5 tonnes and 4 tonnes, a cargo weight (payload) capacity of about 26 to 27 tonnes, with a maximum gross weight of 30 to 32 tonnes. Special 20ft units for the carriage of steel coils, manufactured to much more stringent specifications, are able to carry cargoes of up to 27 tonnes weight. It is important that the relevant recommended gross weights are not exceeded.

The *International Convention for Safe Containers* (CSC) 1996, lays down structural requirements for containers and requires countries who ratify it to establish effective procedures for testing, inspection, approval and maintenance. The Convention also requires that a safety approval plate be affixed to every approved container. Amongst other things, this plate should record the maximum operating gross weight, the allowable stacking weight and the transverse racking test load value.

All persons concerned with the packing and carriage of containers should also be conversant with the contents of the IMO/ILO/UN ECE *Guidelines for Packing of Cargo Transport Units* (CTUs) 1997, which now supersedes the earlier IMO/ILO *Guidelines for Packing Cargo in Freight Containers or Vehicles*.

Securing containers

Despite the length of time that ISO containers have been in use, there is still little uniformity in the method and systems adopted for securing containers to the ship's structure and to each other. The wide range of equipment and fittings manufactured throughout the world for securing containers tends to give rise to diverging views as to what constitutes a safe and secure lashing system. One essential is that the securing gear used is of the correct strength. This can be readily established. A number of international companies produce and market container securing equipment and maintain their own specialist consultancy services, which provide advice on how to stow and lash containers safely in a particular ship. Where shipowners have sought the advice of experienced manufacturers/specialist consultants about lashing and securing arrangements, the plans produced are generally effective and when fully and conscientiously implemented result in a very low incidence of loss and damage.

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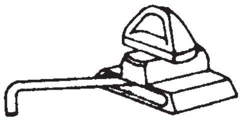
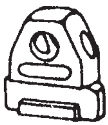
The wide variety of container securing fittings on the market is matched by an equally wide range of technical terms used for the components involved. It would be of great assistance to shore-based personnel if ships' officers and surveyors, when referring to container securing devices, used only those words and terms appearing in the handbook of the manufacturer concerned, together with a photocopy (or photograph) of the type of component involved. Manufacturers of securing equipment are usually willing to provide, on application, catalogues of components with detailed line drawings and pictures and the appropriate handbooks should be kept onboard the ships. It should also be borne in mind that, as from 1 January 1998, all vessels (other than dedicated bulk carriers, tankers, and certain exempted vessels) are required to have a cargo securing manual onboard, approved by the national administration or by a duly appointed certifying authority.

The following are line drawings of some of the many components available in different container securing systems, reproduced by kind permission of International Lashing Systems and Coubro & Scrutton Ltd, Securing Division, to whom the Association extends its due acknowledgments and thanks



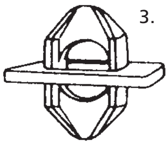
1.

1. Flat based, shoe fitting twistlock, used in connection with slide shoes fitting. Sometimes known as a dovetail twistlock



2.

2. A single, sliding lockable base cone for use with keyhole foundations



3.

3. A single, non-lockable, inter-layer stacker, sometimes known as an intermediate stacking cone. When the horizontal plate is extended to accept two such fittings the item is known as a double inter-layer stacker or double intermediate stacking cone. They may be for transversal or longtitudinal applications

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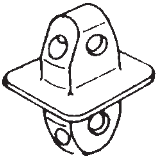
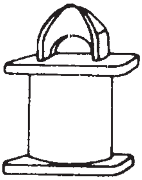
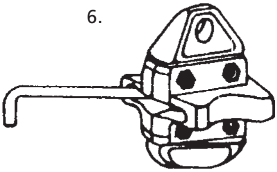
Containers in non-cellular ships


4.

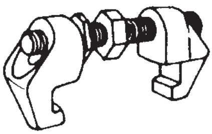
4. A single, lockable inter-layer stacker, or lockable intermediate cone, used with right-handed locking bars or blocking pins


5.

5. A 6" spacer with single stacking cone, sometimes supplied with two opposing cones. Used to bring the tops of unequal size adjacent containers in stack to the same horizontal line so that screw-bridge fittings may be attached to corner castings (see 7.)

6.


6. A handle-operated turn-foot twistlock, or inter-layer twistlock, to secure a base corner casting to a deck fitting and/or to secure the top corner casting of the container to the bottom corner casting of the next container above

7.


7. A screw-bridge fitting, sometimes referred to as a bridge fitting or a tension clamp or compression clamp, or container bridge. Used to connect the upper corner castings of a top layer of containers in stack

Inter-layer stackers, twistlocks, turnbuckles, lashing rods, chains, deck connections, etc., are all subject to deterioration or physical damage of one kind or another and should always be inspected before use. Operational structural failure of twistlock inter-layer stackers may well result from them being weakened by rough handling at discharge ports, e.g., by stevedores throwing down the twistlocks from third tier levels, for instance. Such rough handling could also cause defects in other components, which may then fail under operational stress. One solution is the provision of suitable bags or boxes, which can be used to collect components before lowering them to deck level to be retained in dedicated storage areas.

A combination of circumstances may result in the securing equipment of a container stack being subjected to the maximum design stress. In that event, if

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the recommended measures are not followed, loss of or damage to containers, cargo, or ship could well occur.

For example if:

- Upper height tension clamps (bridge fittings, screw-bridge fittings) are omitted in a system which requires their use.
- 'Handy-wire' is used in place of tension clamps.
- Damaged fittings are used.
- Marine personnel experiment by omitting parts of, or altering, the designed securing system.
- Containers are mixed with breakbulk general cargo without careful planning and adequate securing.
- Containers are distributed vertically without taking into account their respective and relative weights.
- Officers new to a ship assume, without checking, that the same securing system used on their previous ship can be used.
- Ships' officers are not given sufficient time to check that all approved securing measures have been carried out.
- Ships' officers are not given the information and time necessary to calculate the vessel's stability condition, including fluid GM and GZ curves for the port of destination, or to check sheer stress and bending moments.

The United Kingdom Department of Trade Merchant Shipping Notice no. 624, October 1971 (now superseded but containing sound guidelines) states, *inter alia*:

"3. Except where there is provision enabling twistlock, or other similar device, to be inserted in the bottom corner fittings of the container and into suitably designed recesses in the hatchcovers of fabricated deck stools of appropriate strength, containers carried on deck should be stowed one high only. In such cases, the containers should preferably be stowed fore and aft, prevented from sliding athwartships and securely lashed against tipping. Containers should be stowed on deck two or more high only on

> *those ships that have securing arrangements specially provided. At no time should the deck loaded containers overstress the hatchcover or the hatchway structure; in cases of doubt details of stress limitations should be obtained from the classification society."*

While it is recognised that containers are carried more than one high in non-purpose built ships, experience has shown that the foregoing advice is sound commonsense and good seamanship and that adequate provision must be made for positive corner-casting securing at base tier level, whether stowed on the weather-deck, the hatchcovers, the tween decks or hold tank-tops. If fittings are being welded to hatchcovers, decks or tank top plating, full consideration must be given to the downward-acting forces which the ship's structure will be required to withstand when fully laden containers are in position. Bear in mind that a single stack of two 20ft x 20 tonne units will exert a downloading of 40 tonnes, such that the point-loading beneath each corner casting will be about 345 tonnes/m^2.

Containers are designed and constructed to stand on the four bottom corner castings alone. The bottom side rails, the front and rear sills and the under-floor cross bearers should remain free of bottom contact at all times.

Never stow ISO containers on their bottom rails or skirts. *Always* stow ISO containers on their corner castings only

When stowed like this, skirts and bottom rails collapse, and general slackness develops in the stow

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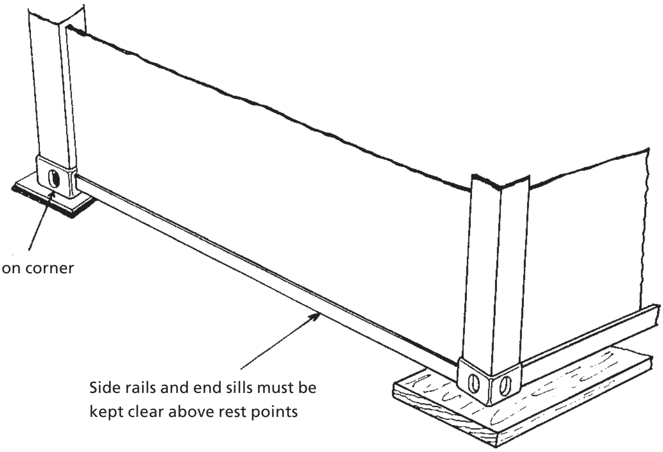

Between the upper corner castings of one container and the bottom corner castings of the next adjacent container, inter-layer stackers (frequently referred to as 'cones' or 'intermediate stacking fittings') must be fitted. The pattern and causes of container damages aboard ships indicate that lockable inter-layer stackers or twistlocks should be used between all container tiers and, where possible, double form stackers or twistlocks should be used to bridge-lock the units one to another, transversely and/or longitudinally. It is appreciated that in some lashing systems, lockable inter-layer stackers or twistlocks are not obligatory except to attach the first tier of containers to the hatchcover or deck. Where this is the case it is important to ensure that the full lashing requirements of the particular system are complied with.

Where containers of 8ft end section only are being used, the adjacent corners will be on the same level. Containers of 4ft, 4ft 3ins, 8ft 6ins and 9ft 6ins height are frequently intermingled and thus a six inch step or more can occur between adjacent heights in the same transverse stack. In systems where tension clamps/bridge-fittings are required between corner castings at the upper level, the uneven step should be compensated for by using spacer-fittings beneath a container to bring the upper surface of the stack completely level or, by using variable-height clamps. Handy-wire is not an acceptable alternative, as it cannot be made either taut or rigid.

Where two 20ft units are placed in what would normally be a 40ft container position, it is difficult, or even impossible, to apply wires, chains or bar lashings to the adjacent corners. Their absence is not fully compensated for by using double inter-layer stackers or similar components, because the container stack as a whole, and particularly those units in the bottom tier, may be subjected to excessive racking stresses should the ship start rolling heavily in heavy seas. Some compensation can be applied by the use of anti-rack bands (two tensioned metal straps fitted diagonally across the corners of the ends of the base tier containers) but a permanent alternative full lashing system properly planned for the particular ship is to be preferred.

Most containers are designed to stack nine high when empty, but there is always a trade-off for height against weight when units carrying cargo are to be stacked, and it is rare for a sound container to suffer a structural collapse where height and weight criteria are properly balanced. Occasionally, however, container stows collapse when the weight of containers and their contents placed in the upper layers of a stack exceeds the permissible limit and produces

Above. Collapse of stow.
Nine containers were damaged in this incident. Note the damaged container at the base of the stow

Right. The same incident viewed from a different angle

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unacceptable loads on the containers in the bottom tier, a situation which has given rise to catastrophic collapse and losses even in purpose-built ships. Care should therefore be taken to ensure that the safe weight load of the individual container is not exceeded and that the gross and tare weights are accurately recorded and declared. Shipmasters should be alert to charterers insisting on stacks of full-weight units where this is both dangerous and contrary to any approved conditions for the particular ship.

When circumstances require a mixture of general breakbulk cargo together with containers, whether above or below deck, great care must be taken with the stowage. Damage resulting from cargo shifting continues to occur in these situations and appears to result from an unrealistic reliance upon the containers acting as 'restraining walls' instead of the cargo being secured in accordance with normal sound stowage practices. Great care should also be taken when loading general cargo on top of containers.

Simplicity of design does not always produce efficient systems. Nevertheless, the simplifying of container securing systems by avoiding a variety of fittings is a trend to be encouraged. The safety of the entire operation is likely to be enhanced if one or two proven types of fitting are always properly used.

Reliable statistics for the incidence of collapses in container stows during ocean voyages are not available, but the reported reasons for container stowage collapse appear to be basically ones of scale. That is to say, that the omissions, makeshifts and mistakes are mostly associated with relatively large container stowages and quick turnrounds. The trend for the future is a continuing rise in the frequency of the carriage of containers in non-purpose built ships; with port turnround times being reduced still further by more sophisticated terminal handling techniques. Everyone engaged in construction, testing, inspection repairing, packing, handling, stowage and securing of containers should appreciate the potential danger if there is one 'weak link' in the system. It requires the co-operation and watchfulness of all concerned to assist the ship's master in fulfilling his duty to ensure the safety of the ship and its cargo before proceeding to sea.

Don't overload the stack. A container constructed to accept, say, eight empty units above it (a total weight of 20 tonnes) is unlikely to withstand the

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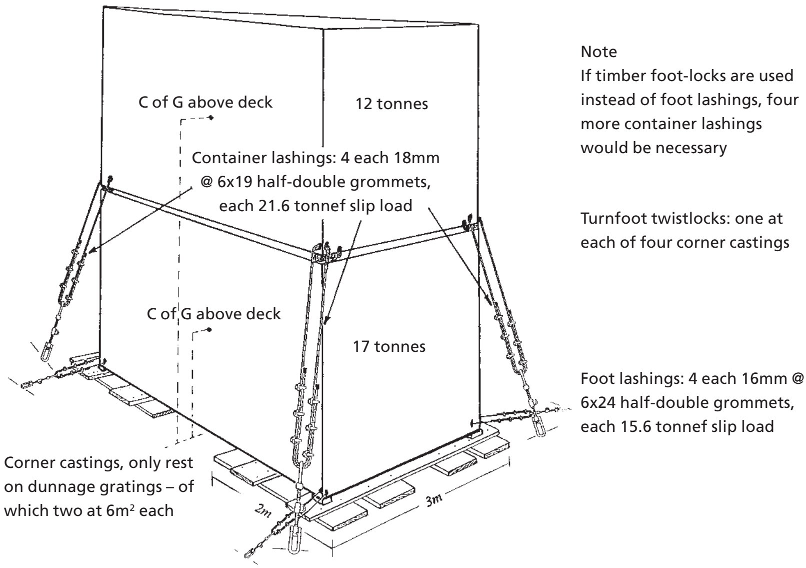
superincumbent weight of 160 tonnes – even when static; and, when subjected to vertical acceleration/deceleration stresses at sea, collapse and/or loss are almost certain to occur.



A safe and secure method of stowing and lashing a container twin-stack

Where applicable, shipmasters, owners and charterers should be conversant with the *International Code for the Safe Carriage of Packaged Irradiated Nuclear Fuel, Plutonium and High-Level Radioactive Wastes On Board Ships* (the INF Code) – IMO 2000 Edition, of which paragraph 6.1 says, *inter alia*:

> *"In designing permanent devices, due consideration shall be given to the orientation of the packages and the following ship acceleration levels shall be taken into account: 1.5g longitudinally; 1.5g transversely; 1.0g vertically up; 2.0g vertically down."*

This would seem to indicate that any lashing strength answers arrived at by using the 3-times rule would need to be doubled to satisfy the INF Code. Hopefully, guidance on this point will be provided by the IMO at the time any vessel applies for an international certificate of fitness for the carriage of INF cargo.

Containers in the holds of conventional ships and bulk carriers

While the securing of weather-deck stowages should follow the 3-times rule, the aggregate lashing strength of one to two times the static weight of the load has been found sufficient below decks, provided all foot-lock, vertical, and transverse interlocking arrangements are in place. The continuing incidence of catastrophic collapse of unsecured container stacks in non-purpose built holds and the financial losses arising there from provide ample evidence that such stacks will not stay in place on the basis of their total weight, alone.

Firm securing of the stacks to the ship's structure as a block is essential. If slackness develops during adverse weather conditions the containers will chafe and rack leading to overall distortion and possible collapse, especially if heavy units have been placed in upper tiers.

As indicated earlier herein, ISO containers are designed and constructed to be carried by stacking them one above the other in slots or cells below deck and on the weather-decks in purpose-built ships, or ships converted for such carriage. The design of bulk carriers appears to provide large, unobstructed spaces for the safe stowage of containers. They are however prone to the severe stresses arising in a heavy seaway in the same manner as other ships of similar size, and containers carried in block stowages below decks can create special problems if adequate securing measures are not adopted. It is not infrequent that an entire stow of containers collapses, with serious damage to the boxes and to the cargo within them.

Generally the cargo compartments of bulk carriers are not of the right dimensions to enable the container stow to be a perfect fit. For instance, in those vessels fitted with sloping hopper side tanks there will be a large area of unusable space between a block of containers and the ship's sides. Adequate measures must be adopted to ensure that the containers, as a result of rolling stresses, will not move or collapse into these spaces.

Experience has indicated that to ensure the safe carriage of blocks of containers in a bulk carrier certain basic requirements must be fulfilled. Importantly, whenever possible the containers should be formed into one solid rigid block so that there will be no movement whatsoever. The bottom

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containers in the stacks should be secured to the ship's tank top plating by twistlocks or lockable locator cones and, in addition, twistlocks or lockable inter-layer stackers should be used between each container in the stack. All the containers in a block may not be loaded or discharged at a single port, and in consequence there may be parts of a voyage when the block will be irregular rather than cuboid in shape. Do not neglect to fully resecure the stow. Omissions of this nature have been the prime cause of a number of casualties.

In the absence of these precautionary measures the stacking of containers two high or more will produce racking stresses, which tend to distort them laterally. This problem will be aggravated during heavy weather when the weight of the containers in the upper part of the stow may cause the corner posts of the lower containers to buckle, with the inevitable result that the stow collapses. This is more likely to happen in the forward holds where the effects of pounding are more pronounced. Ideally, all ships converting to the carriage of containers in stacks two or more high should have the securing system and the strengthening requirements for the tank tops approved by the classification society.

In some systems the spaces between the containers and the sides of the holds are taken up with portable or hinged steel girder chocks which insert precisely into the corner castings of the various heights of containers. Alternatively, and in addition to the provision of any form of inter-layer stackers or twistlocks, solid bar or wire lashings may be required, tautened on turnbuckles hooked into securing points at the tank-top and at higher levels adjacent to the ship's shell plating.

There are some bulk carriers that have cargo spaces of suitable dimensions without upper or lower sloping wing tanks. Although alternative methods, when carefully implemented, have been used with success in such spaces, it is still recommended that the principles set out above be followed.

If all else fails – read the instructions!

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Container crime

Estimates in 2000 put the annual cost of cargo crime worldwide at between US$30-50 billion, so how safe is container cargo whilst in transit?

The favourite locations for this type of crime are at ports, terminals or during road or rail transport.

Whilst onboard a vessel, container cargo poses less of a risk and yet all too often the vessel operators find that they are the focal point of a claim. The reason for this is due to the fact that the operator:

- Constantly accepts containers onboard without actually checking the seal.
- The contractual terms of their bill of lading provides coverage from door-to-door.
- Their assets are often more easily accessible than that of other parties.

Question

"What control does the issuer of a bill of lading have as to the safety of a laden container whilst in transit and storage?"

or

"How reliable are their agents in complying with the release terms of a container's cargo?"

Whatever type of container is used, its safety relies on its own security safeguards and those in place throughout its journey.

The introduction of containers was a technological advancement in the safe movement of cargo that has had a major impact on the reduction of cargo pilferage. However, this type of transport has become the notable asset to the organised criminal, primarily due to the cargo involved, which offers substantial profits with minimal chance of detection.

Cargo in transit has and always will be the subject of crime. The distance involved in this type of movement, combined with the various handling procedures in place during its journey, presents a major obstacle. Without an investigation it is extremely difficult to identify where a loss occurred and who

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carried it out. This is obviously very important when a bill of lading provides a door-to-door service.

If a container is correctly stuffed and its doors secured, there are only three ways that an unlawful entry can be gained:

- The removal of a section of the container's body.
- Interference to the seal or seals on the outer container door.
- Interference to the container doors. The weakest links tend to be the pivot rivet connecting the door handle to the handle hub, the rivet to the swivel seal bracket and the rivets on the door hinges.

The presence of a seal on a container may provide evidence that its cargo has remained secure throughout its journey, but it is not an anti-theft device. Fortunately, there have been significant advancements in the design of seals which act as an additional deterrent against the loss of cargo from containers whilst in transit.

These improvements alone will not prevent an attack on a container, because if given the time, situation and the tools, the criminal can remove virtually any seal or section of a container's door. As with a container, the extent to which a seal offers protection is only as good as the system into which it is introduced.

Above. Assorted door seals

Left. Main photo and inset show part removed pin on sealed door handle

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For this reason it is imperative that issuers of bills of lading are satisfied that the procedures in place throughout a container's movement meet their requirements. If they do not, take heed, for resourceful criminals know what containers to attack and the weaknesses in the operational system to enable them to carry out the crime.

In many instances, where improved security procedures have reduced the opportunity of a loss occurring at a port or terminal, they have not prevented the criminal from identifying a suitable cargo to steal once it has left that location.

There is therefore a need to constantly review procedures. For instance:

- Are you satisfied that a container was correctly secured before departure from the shipper's premises?
- Are you satisfied with the haulier contracted to move a laden container on your behalf?
- Do they use sub-contractors? If so, are they suitable to undertake this work?
- Are transport instructions issued to the haulier?
- How efficient is the checking procedure of a container on its arrival at a port?
- Is there a physical check prior to a container being loaded onto a vessel? Accepting the operational and financial aspects that are involved when discharge and loading takes place, it is this weakness in the system which is constantly exploited by criminals, who remove cargo prior to loading.
- Is the seal physically checked when the container is offloaded at the destination port?
- Is the seal checked when the container leaves the port?
- Is there a procedure in place should there be an alleged irregularity on delivery?

It is important whenever there is a potential loss that:

- The seal sections are retained.

- Special attention is given to the container's doors, in particular as to whether there are any different shaped rivet heads or signs of repainting.

Any irregularity should be noted, with consideration being given to a surveyor's examination.

It is imperative that a carrier's agent complies with the cargo release terms, which generally requires the presentation of the original bill of lading.

The case of *Motis Exports v Dampskibsselkabet AF 1912 and Another* emphasised this point.

On occasions agents show a lack of judgement in not complying with the release terms, but take an alternative approach without first obtaining the required authority. Such action usually relates to:

- A consignee's letter of credit.
- A consignee's letter exonerating the agent from their action.
- A bank guarantee confirming that sufficient funds exist in an account on a specific date.
- Agreement between agent and receiving party.
- Shipper's extended credit facility, minus the authority to release the cargo.

Container top safety

The subject of container top safety has been discussed in detail by various maritime organisations. The conclusions have brought about numerous changes in the applicable laws in a number of countries, most notably the United States of America and Japan. Both of these countries require all ships calling at their ports to comply with their legislation relating to the safety of dockworkers in the operation of loading and unloading containers.

Each of these countries has a requirement that dockworkers are able to secure containers without going on to the top of containers that are stacked more than one high, whether on the quayside or on the ship. For ships to comply with the applicable law means that the equipment for fitting and securing containers onboard the ship is operated from the deck, or possibly a safe walkway, level.

In order that containers can be safely secured, automatic or semi-automatic twistlocks need to be used and lashing rods need to be constructed such that they can be handled easily and safely and secured properly without the dockworkers having to be raised above the deck, or safe walkway, level.

The top tier of a stack of containers needs to be secured at the top of the container and the positioning of bridge-pieces normally does this. Dockworkers do need to be positioned on the top of containers on the top tier to fit these bridge-pieces. The port or terminal normally has specialised cages fitted with fall-arrester systems to facilitate this particular operation.

All of the above arrangements for loading and unloading ships are based on the ship being alongside a pier, quay or wharf and properly secured against unwarranted movement.

These arrangements do not mean that the ship's crew can be ignorant of these operations and the special nature of the equipment as they will need to be able to operate these items of equipment in an emergency whilst the ship is at sea (SOLAS). Training in the safe operation of these pieces of equipment is an essential part of the management and running of the ship. Initial training can be carried out on shore based facilities, providing a sufficient 'mock-up' of

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the arrangement for stacked containers onboard can be arranged, but training in the ship environment is likely to be more instructive.

All training should be frequently practiced, in a safe environment, and the training should be reviewed after each practice session. This is essential as the requirement for automatic and semi-automatic equipment becomes more widespread in ports and terminals throughout the world.

The fact that the USA and Japan has put such legislation in place means that any ship operator trading with them must follow their rules and regulations. This does not, however, mean that every port or terminal in the world will have the same requirements. Many countries are examining their specific practices regarding dockworker safety and may not arrive at the same conclusions as the USA or Japan, so ship operators need to be aware of the varying regulations in each port.

Because national legislators are keen to ensure that none of their countrymen are injured during the loading or unloading of a ship, does not mean that the ship's crew should consider doing any part of the job that would normally be done by dockworkers. The correct fixing and lashing of containers, irrespective of whether they are on or under deck, is a specialised job and should always be left for the specialists to do. Ship's personnel, who ultimately have the responsibility for the safe carriage of the cargo, should oversee the fixing and lashing onboard.

Any ship that does not have the particular equipment in use for a specific country's requirements should never consider trying to undertake releasing or lashing work whilst at sea, in coastal waters or manoeuvring in port limits as this would be very dangerous both for the crew and the cargo.

Despite various countries operating 'safe dockworker' principles, there should still be facilities to handle all ships that call at their ports. There should be other methods of ensuring that their dockworkers operate in a safe way, even if this means going on the tops of containers to release twistlocks (assuming that the ship has not been re-stocked with automatic or semi-automatic units). How they do this work is not the direct concern of the ship, as long as the ship is loaded or unloaded effectively.

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As dockworkers are provided with appropriate safety equipment, such as fall-arrester harnesses and ancillary equipment, there is every reason to ensure that similar safety equipment is provided for ships' crews, even though this may only need to be used in an emergency. If it is considered dangerous for a dockworker to go on the top of a container stack whilst the ship is moored against a wharf without safety equipment, then it is far more dangerous for a ship's crew to do this whilst at sea, and life threatening to do so without proper safety equipment. Safety equipment is often available onboard but its use, at every opportunity is not always enforced.

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Stuffing and stacking containers

Losses continue

The Club is concerned at the continuing incidence of damage to containers and cargo from within containers, and of damage to containers and contents from the collapse of containers in stack.

Reference should be made to such booklets as *Stuffing & Stowage* by ScanDutch, and to similar publications by Atlantic Container Lines and Hapag Lloyd, for example, with their excellent descriptive line drawings and practical advice, and to the catalogues of container securing components and securing systems available from all reputable manufacturers such as Coubro & Scrutton, Conver and Peck & Hale.

Stuffing

The stuffing of containers is not just a ship operator's problem. Containers are often packed at places which may be many miles, and sometimes even several days' journey, from the marine loading terminal. It is therefore important that everyone involved with the packing of containers, at whatever stage in transit, should be fully aware of the stresses that can be generated in the structure of the container itself and in and around the cargo within it, during transportation by road, rail or ship. It is also, of course, essential that containers are in sound structural condition each time they are put into service, and that the containers themselves are suitable for the cargo to be carried.

It should always be borne in mind that the side panels, the end panels, and the roof panels of an ISO container are not normally strength members. Beneath the floor timbers there are metal cross-bearers and it is generally those bearers which provide the floor's strength. Additionally, the corner posts, front and rear headers and front and rear sills provide the internal strength members. (See Fig A). Whenever bracing is to be used in vertical, horizontal or diagonal form, it must act against those members and the floor bearers, and no others. Bracing and/or end chocking against side, end, and roof panels will surely result in disaster (Photos 3 and 4).

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The great problem is that, unlike breakbulk cargo, the ship's master and his

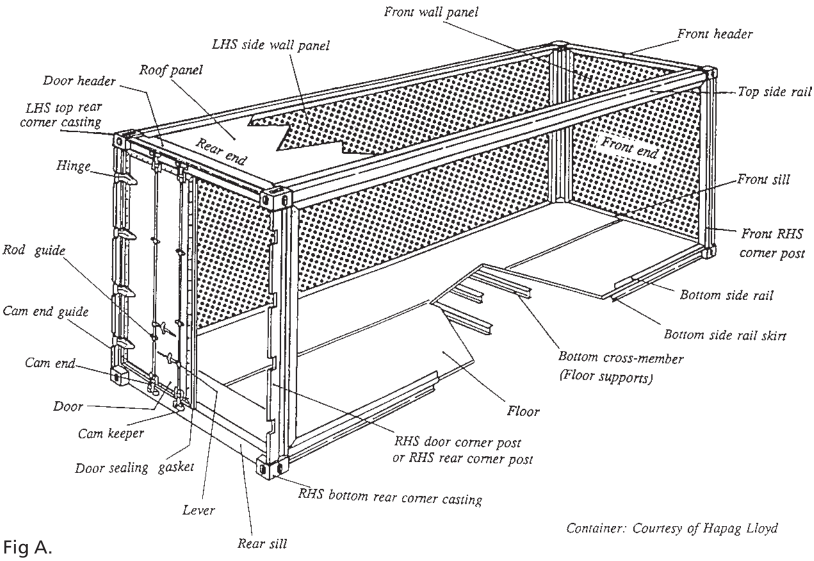

Fig A.

officers do not sight, nor do they have any control over, the contents of containers or the methods by which the contents have been packed and secured. Hence, whenever and wherever containers are being packed, management and supervisory personnel should be properly trained and be

Photo 1. Poorly stuffed container – note the damaged packages, the pallet on top of cartons and the apparent lack of securing arrangements

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provided with copies of the many relevant excellent handbooks and leaflets available from shipping companies engaged and specialising in container carriage by sea.

Photo 2. Nothing but straw to 'secure' these statuettes

If the contents of just one container are improperly packed or lack adequate securing arrangements or are inappropriate for container carriage and, as a result, break adrift when the ship encounters heavy weather, the safety of many other containers, their contents, and the safety of the ship itself could be at risk. For instance, round steel bars, inadequately secured, broke adrift within a container third in stack on deck, pierced and went through the container's side panels, shattered a corner post of the next adjacent container creating a domino collapse of other units. A single block of granite lacking securing arrangements within the lower tier of a below decks stack, broke through the container's side panel and fell corner down piercing the double-bottom fuel oil tank below. The consequential fuel oil flooding of the hold and lower level

Photo 3. Inspection of goods in container terminal

Photo 4. Note the damage caused to the container by the poorly secured coils

damage to base containers was a costly business. As has been said elsewhere: Only the foolhardy believe that a heavy cargo unit's inertia, alone, will restrain its movement during a sea voyage!

Of the casualties investigated it is often the case that horizontal spaces – that is fore-and-aft and longitudinally – are, more-or-less, adequately chocked, but the vertical component is entirely neglected. When a ship is pitching and scending in a seaway, vertical acceleration and deceleration forces acting on cargo components can attain values of 2g. That is, as it goes up and comes down the load upon the securing arrangements will be equal to twice the static weight of the cargo item. If there is no arrangement to **hold down** the cargo securely to the container's floor the cargo will lift, and once it lifts it will start to shift, and once it starts to shift it will go on shifting!

Where relatively lightweight cartons or good timber cases can be afforded tight block stowage, there will be little need for additional securing arrangements. However, where lightweight cartons with frail contents, or plastic jars, bottles and barrels, are to be stowed to the full internal height it may be necessary to provide a mid-height flooring so that the lowermost items do not suffer damaging compression and collapse. (Figs B & C).

Where bags, cartons or cases do not occupy the full internal space, then chocking and bracing with timbers and/or air bags is necessary. (Fig D).

And where heavy items are involved, securing with downward-leading wire lashings and/or strapping to 'D' rings attached to the upper parts of the floor bearers will be required.

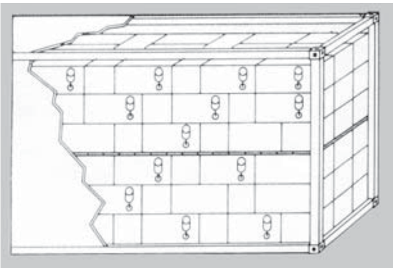

Fig B.

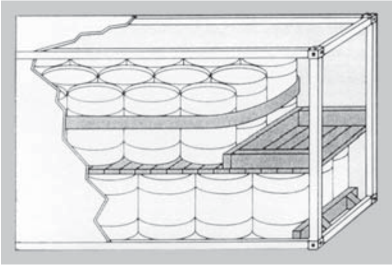

Fig C.

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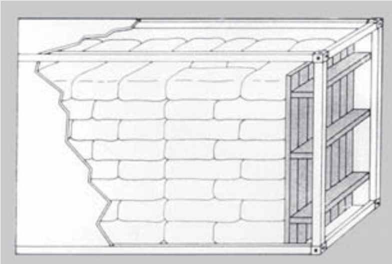

Fig D.

So it is important that the correct form of container is used, because not all have provision for mid-height flooring to be fitted, and not all are provided with 'D' rings.

Steel coils, steel pipes and bars, and heavy machinery items should be shipped on specially designed 'flat racks', 'flats' or 'sledges'. (Fig E).

These units are strengthened for such loads, and adequate securing terminal points are provided. (Figs F, G & H, for instance.)

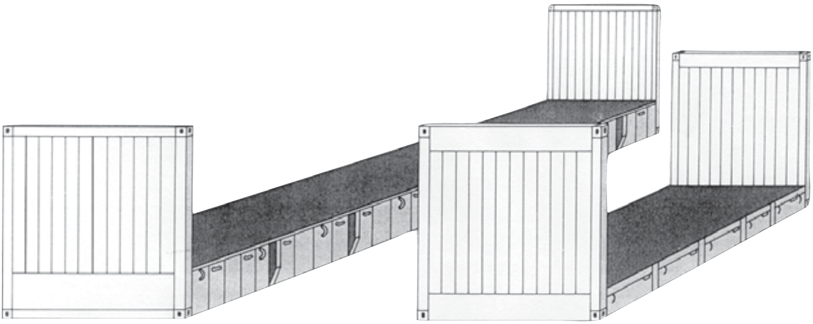

Fig E.

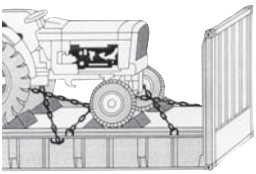

Fig F.

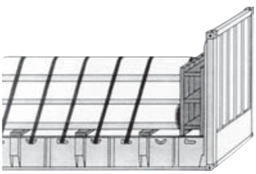

Fig G.

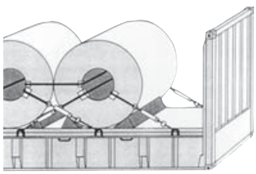

Fig H.

Source: ScanDutch.

It is when such items are packed into ordinary cargo containers that disasters occur.

As the Atlantic Container Lines booklet says to shippers:

> *"When you have finally packed your cargo into the container, sealed the doors and dispatched the unit, it is extremely difficult to correct an inadequate stow. If your load has not been properly secured or if the packaging is unsuitable the risks of damage to your cargo will increase during transit."*

Containers in stack

Most ISO containers are designed and constructed to allow nine-high stacking **when empty**. They should be placed and must stand on the four lower and four upper corner castings, alone, with the appropriate stacking/locking components between. The bottom and top side rails, the front and rear sills and headers, and the underside floor bearers should remain free of vertical stacking contact at all times if transient wracking stresses are to be avoided.

A variety of securing systems sometimes create problems where ships' officers/charterers' superintendents familiar with one specific system fail to update themselves when faced with something different. It is not possible within the scope of this article to examine the many different fully-approved and highly-efficient systems in current use, but the Club cannot stress firmly enough the need to comply with, and to fully implement the requirements of, the stowage and securing system formally approved and planned for a

Photo 5. The ultimate lashing failure

particular vessel. All too often, container stack wracking failures occur in non-purpose built vessels because charterers insist on stacking containers in the holds and on the weather-deck in a manner which would not be approved even in a purpose-built ship. Unfortunately, stack collapses within the holds, and within weather-deck stacks, occur just as frequently in purpose-built vessels.

Independent of casualties arising from lack of securing arrangements and use of inappropriate containers as indicated earlier, container stack failures seem to arise from three prime causes, all of which involve unacceptable wracking stresses in one form or another.

Firstly, it is found that container stacks have failed because a fully-approved and fully-adequate securing system has become downgraded with time. That is to say, after the casualty all concerned aboard the vessel insist that "*we always secure them that way*" when what proves to be the case is that, over time, one small recommended aspect after another has been omitted incrementally and successively without casualty until the day that circumstances conspire to subject the stacks to the maximum stress which the system was designed to withstand. Damage and loss result. A chain is only as strong as its weakest link, and a container stack securing system is only as effective as its least efficient component. **Do not omit from a container stack securing system any single component which comprises the full and approved arrangement.**

Secondly, and with disturbing frequency, it is found that container structural collapse has occurred due to excessive superincumbent weight in stack. This occurs mostly in chartered vessels where charterers neglect to consult, or deliberately ignore, the stack weight restrictions set out in the approved stacking plans. **It is most unusual for ships to be approved for on-deck and under-deck stacks of 4, 5 or 6 units high in the absence of very rigorous unit-weight restrictions. In other words, an approved stacking plan for 5 or 6 units high may well specify a sliding decrease in weight per unit up to 4 high, with tiers 5 and 6 required to be empty.** Time and again, casualty investigation reveals a blatant disregard for these restrictions.

A very large, purpose-built, container vessel was slot-chartered on her maiden voyage to a number of container carrying interests. The Classification-approved plans allowed 6-high stacks in the holds, so 6-high stacks were used throughout. Not a single charterers' superintendent bothered to check the stack plans, so many heavier units were placed in the upper three tiers because of the port discharge rotation. A week before arriving at the first discharge port the base tier containers in Nos. 2 & 6 holds suffered widespread collapse and crushing and tank tops were pierced. Investigation revealed that the approved stacking plans provided a sliding scale, in which unit height increase should have been traded off against unit weight decrease: 20ft base and second tier units should not have exceeded 20 tonnes; third tier units should not have exceeded 10 tonnes, fourth tier units should not have exceeded 6 tonnes, and the two top tiers should have been empty. Sad to say, anything learnt from that loss appears to have been quickly forgotten bearing in mind that a similar train of events occurred in the same vessel some twelve months later.

The records of all the P&I Clubs combined would reveal the unwelcome frequency with which a similar sequence of events has created widespread damage and loss to containers carried on the weather-decks, and continues to occur. **Don't overload the stack. Consult the stacking plans. A container constructed to accept 8 empty units above it (a total of 20 tonnes) is unlikely to withstand a superincumbent weight of 160 tonnes even when static; when subjected to vertical acceleration/deceleration forces at sea, collapse is almost certain to occur.**

Thirdly, where two 20ft units are stowed on the weather deck in what would otherwise be a 40ft unit position, it is very difficult – in many instances, impossible – to apply wires, chains or bar-lashings to the adjacent end-butting corners. Their absence is not compensated for by using double or four-way inter-layer stackers (spades) or longitudinally positioned screw-bridge fittings, tie-wire, or the like. (Fig I).

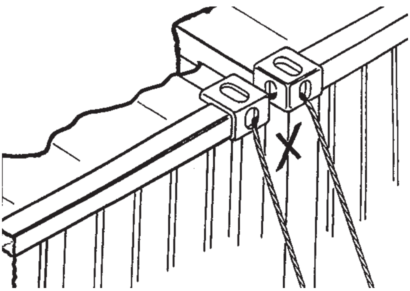

Fig I.
A recipe for disaster. Adjacent corner castings should never be loop-lashed like this, or similar

Source: Lashing & Securing of Deck Cargoes

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The problem is that the container stack as a whole, and particularly those units in the base tier, will be subject to excessive wracking stresses should the ship start rolling in heavy seas or pronounced swell conditions. Some compensation can be applied by the use of anti-wrack bands (two tensioned metal straps fitted diagonally across the corners of the 'free' ends of the base tier containers) but they suffer from the same inability to secure the 'butting' ends. A full lashing system, properly planned for the dual carriage of 20ft and 40ft units is to be preferred if container losses from this cause are to be prevented.

When all else fails – read the instructions!

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Substandard components and cargoworthiness

A vessel's container stowage and securing arrangement can be easily undermined if substandard and/or incorrect components are utilised. To maintain securing equipment in good order, both fixed and portable, requires considerable time and effort.

Whatever regulations, standards or codes of practice are issued the integrity of a vessel's container stowage and securing arrangement can only be made by regular inspection of the securing equipment. The securing arrangement can amongst other things be undermined by one or more of the following:

- 'Rogue' securing equipment.
- Improperly maintained securing equipment.
- Insufficient supply of correct securing equipment.
- Overloading of the securing equipment.

Portable securing equipment

The human nature of stevedores means that they will often use the first item of equipment which comes to hand, be it 'rogue' or damaged, without due consideration to its suitability. If substandard equipment is used it can fail at a lower load than its design rating, thereby resulting in a failure of the overall securing system and the possible collapse of the container stow.

The aspects which should be considered during periodic inspection of container securing equipment should include the following:

- Inspection of the twistlock complement to ensure that 'rogue' twistlocks, i.e. ones with an opposite locking action to the ship's standard complement, have not made their way onboard. When left-hand and right-hand locking twistlocks are fitted with similar shaped handles, which can be the case, it is not always possible to differentiate between them once used in the same stow. Even if the stevedores are aware of the difference, any subsequent checks by other people could allow disengagement if the handles were all actuated in the same direction on the premise that some twistlocks had not been properly locked in the first instance. ISO TC104 has been considering for some time amendments to ISO Standard 3874 that will include the physical and functional requirements for various items of portable securing equipment. For manual twistlocks it is proposed that the unified direction of handling will be clockwise when viewed from above, i.e. left-hand locking.

Mixed twistlocks

Uniform twistlocks

- Checks to ensure that the spring holding the twistlock in the closed position is in a resilient condition. If a spring loses its resiliency the cone(s) will not be held in position in a positive manner. The moving and flexing of a vessel in a seaway has been found sufficient to allow twistlocks to unlock themselves if their spring action is failing or has failed.

- No structural defects which would compromise the proper use of the equipment, for example:
  - Twistlocks with missing handles.
  - Twistlocks with fractured housings.
  - Double cones with fractured base plates.
  - Seized/buckled turnbuckles, bridge fittings.

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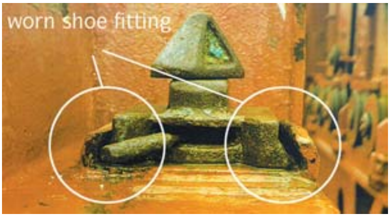

Fixed fittings

Regular inspection of fixed fittings is also essential to establish whether progressive wear has undermined their integrity. Areas requiring particular attention include:

- Reduction in the thickness of securing points where for example a turnbuckle may have chafed.
- Wastage in the way of the key holes of deck foundations.
- Wastage and cracking of the plating to which fittings are welded.
- Dovetail deck foundations distorted.

If a dovetail type fitting and its associated part are compatible and in good working order, it should only be possible to slide a dovetail type twistlock or locating in a horizontal direction into the deck fitting. However, if the deck fitting is damaged or its associated part is incompatible, it may be possible to lift a dovetail type twistlock or locating cone out vertically. In such an event no vertical restraint will be provided to secure a column of containers to the deck.

To ensure as far as possible that containers can be safely carried can be summarised as follows:

- Providing and maintaining an adequate supply of container securing equipment.
- Ensuring that they are of the required strength.
- Ensuring that they are properly maintained.
- Warranting the adequacy of the design of the securing arrangement.
- Provision of a comprehensive stowage and securing manual, and ensuring that the ship's staff understand the manual.

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Section 4

Miscellaneous

Part 1

page

Cargoes

Agricultural produce – insect infestation and fumigation

Insects and mites of plant products may be found within cargo spaces as:

- Introduced infestation (carried onboard with the produce).
- Cross infestation (moved across from one product parcel to another).
- Residual infestation (remaining onboard from a prior infested cargo to attack subsequent cargo(es).

Leaving aside localised spraying with contact insecticides in liquid or powder form the principal method of treating cargo spaces or their contents for the control of insects is by fumigation, which is the application of an insecticidal chemical in its gas phase.

The fumigants in common use are:

- Methyl bromide ($CH_3 Br$).
- Phosphine (PH_3) generated from solid phosphide preparations.

Both chemicals are extremely toxic and hazardous to humans.

The effective and safe use of fumigants requires the space being treated to be rendered gas-tight for the period of exposure, which may vary from a few hours to several days, depending on the type of fumigant and concentration used, the pests, the commodities treated and the ambient temperature.

Fumigant gases are poisonous to humans and require special equipment and skill in application. They should only be used by specialists, not by the ship's crew.

Evacuation of the space under gas treatment is essential and in some cases it will be necessary for the whole ship to be evacuated.

The master should require written instructions to be provided by the fumigator-in-charge on the type of fumigant used, the hazards involved, the threshold limit values (TLV) and the precautions to be taken.

Methyl bromide is supplied as a liquefied gas in metal containers. The holds into which it is to be applied should be reasonably gas tight. Delivery is made into the holds via a flexible pipe attached to the cylinder. As the valve of the cylinder is opened the liquefied gas begins to evaporate and enter and disperse within the hold and the cargo therein.

It should be noted that methyl bromide deposits a small residue of inorganic bromide in the cargo each time a fumigation is carried out. Many countries have legal restrictions on the maximum tolerable level of inorganic bromide in imported produce and there is therefore a limit to the number of fumigations that can safely be carried out on particular goods before the levels of inorganic bromide exceed the maximum tolerable values. It is an advantage of fumigation with phosphine that no measurable residues are deposited on the goods even after repeated fumigation.

The fumigation of cargoes with phosphine gas is effected using tablets, pellets or solid preparations in other physical forms which are supplied by the manufacturers in hermetically sealed containers. The active ingredient of these preparations is either aluminium phosphide or magnesium phosphide. These substances are highly reactive with water, and as the preparations are removed from their sealed containers the active ingredient comes into contact with atmospheric water vapour and yields phosphine gas into the cargo space under fumigation. The same 'crew evacuation' procedure that applies to methyl bromide fumigation ought equally to apply to phosphine fumigation because phosphine has a similar level of potentially severe human toxicity as methyl bromide. However, shippers or charterers frequently supply phosphine releasing preparations onboard and request the master to arrange for the fumigant to be applied to the cargo by the ship's crew during the course (often towards the end) of the voyage. Such requests flagrantly contradict IMO recommendations.

As well as noting this serious contradiction (applying apparently different procedural standards to the fumigation of goods according to which fumigant is employed) two further important points ought to be made in relation to requests to apply fumigant to goods whilst on passage:

- In order to fulfill such a request it would be necessary to open the weather-deck hatchcovers whilst at sea in order to apply the phosphine releasing preparation and then to release and secure them. This may involve considerable risk and is contrary to good practice.

- A basic requirement of the fumigation process (reasonably gas-tight holds) is, during the exposure time of the fumigant gas, incompatible with the need to be able to ventilate the cargo as may be required by prevailing climatic conditions. The inability to ventilate the cargo during this time (usually between five to seven days) will exacerbate ship's sweat if the prevailing conditions are conducive to its formation during this period. This can lead to an adverse effect upon the cargo.

Experience indicates that many masters and officers are unaware of the IMO publication *Recommendations on the Safe Use of Pesticides in Ships*. This forms a part of the supplement to the IMDG Code; the section last amended in 1996 is now contained in the more recent 2001 edition of the Code. The relevant section of this booklet should be studied very carefully by masters but a few points derived from the booklet are mentioned below:

- In transit fumigation should only be carried out at the discretion of the master.
- In transit fumigation with methyl bromide should not be carried out. Fumigation with this gas is only permitted when the ship is in the confines of a port (either at anchorage or alongside) once crew members have disembarked.

The IMO recommendations only specifically forbid in-transit fumigation with methyl bromide; they admit a discretionary usage of phosphine in transit. It is possible that this has led to a common misconception that phosphine gas is less toxic to humans than methyl bromide and that consequently non-specialists such as ships' crew may distribute phosphine-releasing preparations prior to or during a sea voyage. It should be clear from the points noted above that such a misunderstanding is incorrect and potentially dangerous. Therefore masters should never agree to requests for the ship's crew to apply phosphine-releasing preparations in cargo spaces at any time, whether or not at sea.

Fumigation continued in transit

If it is contemplated that a fumigation begun in port should be continued in transit, it is strongly recommended that the master should possess and familiarise himself with all the relevant passages in the IMDG supplement

Recommendations on the Safe Use of Pesticides in Ships. This will enable him to make suitably informed decisions whether or not to allow fumigation to be continued in transit and, if such fumigation is allowed, to be aware of and to implement the appropriate safety precautions that ought to be taken before the ship leaves port and during the course of the voyage.

When specialists apply phosphine in port, with a view to the fumigation being continued in transit, they usually install flexible pipework in stows in order to circulate the phosphine gas better throughout the stow. This provides more effective fumigation of deep stows than would be achieved by the fumigant being applied only to the surface of the stow with reliance being placed upon diffusion alone to deliver the gas reaching to lower regions of the stow.

Compatibility between fumigant and cargo

It should be borne in mind that compatibility between the fumigant and the particular cargo being carried needs to be determined. Decisions on this point should be left to specialists; however, it should be noted that whilst both fumigants are suitable for many different cargoes, they each separately bear notable exceptions to this general suitability.

Charterparties

Charterparties, on occasions, provide the charterer with an option to fumigate cargoes (usually cereal grains and oil seeds or similar agricultural produce) onboard ship after loading has been completed. Whilst it is convenient for the charterer or the shipper to fumigate cargoes onboard instead of ashore, problems may well be experienced as a result of this practice. Before considering the most significant problems encountered it is worth remembering that although the goods may have been fumigated prior to loading, this will not mean they are therefore free of all live insects. Insects in one or other of their metamorphic stages of development may still be present in the products because there is no permanence in any treatment against insects.

A standard sale contract (e.g. GAFTA 120) usually requires cargoes such as cereal grains to be free from 'live infestation' at the time of shipment. However, rarely, if ever, will such a cargo be absolutely free from insects.

Although the terms of the contract of sale may only affect the relationship between the buyer and the seller, it makes little sense to expect a master to adopt a standard which is at odds with the standards anticipated in standard forms of contract. If the expectation of the standard contract of sale is that the goods should be 'free' of live infestation at the time of shipment but infestation is clearly apparent to the master at that time he is bound to conclude that the goods are not in apparent good order and condition. If clearly infested goods are loaded onboard, even though there is an intention to fumigate the goods upon completion of loading, it is advisable to clause the relevant mate's receipts and bills of lading in terms similar to the following:

> *"Some live insects detected at the time of shipment onboard; cargo to be fumigated by shippers/charterers at their risk and expense upon completion of loading"*

If the charterer intends to have the goods fumigated onboard it is also advisable to make a suitable provision in the charterparty in terms similar to the following:

> *"Charterers shall indemnify the owners in respect of any and all claims of whatsoever nature howsoever arising as a consequence of any infestation of the cargo at the time of shipment onboard the vessel and/or the presence of dead insects in the cargo following the fumigation thereof."*

Regulations applying in some countries will only allow the presence of limited numbers of dead insects in imported goods. In such circumstances sale contracts will be drafted to reflect these limitations. However, the fumigation of goods onboard clearly anticipates a residue of dead insects remaining within the cargo following the fumigation and it is therefore doubtful whether the issuance of clean bills of lading in such circumstances can be justified.

Clean bills of lading

A shipper usually requires clean bills of lading and charterers usually arrange for their charterparties to reflect this requirement. But when insects (whether alive or dead and whatever their stage of development) are seen to be present in bulk cargoes or on the packing of bagged cargoes at the time of loading, it is

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questionable whether clean bills of lading can justifiably be issued. This reservation applies regardless of whether or not the cargo will be fumigated subsequently onboard.

The master may be told by a representative of the shipper or charterer that the presence of live insects in agricultural produce is quite normal, and that any insects present will be killed during the fumigation process onboard after the completion of loading. This is usually the basis of the request for clean bills of lading notwithstanding the visible presence of insects at the time of shipment. It is therefore important to consider this point further.

Recommendations on the safe use of pesticides in ships

The IMO has issued a booklet entitled *Recommendations on the Safe Use of Pesticides in Ships* and also include this information in the *IMDG Code Supplement 2000* Edition. This is a very helpful and comprehensive publication which it is recommended is carried on all dry cargo ships.The publication covers the use of insecticide sprays, smokes and gaseous fumigants. The former two can be used effectively on clean empty holds. However, the eradication of either insect infestation or rodents in loaded holds can only be effected with fumigant gas treatment.

Owners' and masters' attention is drawn specifically to the following entries:

3.1.1.2

> *"The success of chemical treatments does not tie wholly in the pesticidal activity of the agents used. In addition, an appreciation of the requirements and limitations of the different available methods is required. Crew members can carry out small-scale or 'spot' treatments if they adhere to the manufacturer's instructions and take care to cover the whole area of infestation. However, extensive or hazardous treatments including fumigation and spraying near human and animal food should be placed in the hands of professional operators, who should inform the master of the identity of the active ingredients used, the hazards involved and the precautions to be taken."*

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When a cargo or empty vessel is to be treated with gaseous fumigation the following requirement must be observed :

3.1.3.4

> *"A 'fumigator-in-charge' should be designated by the fumigation company, government agency or appropriate authority. The master should be provided with written instructions by the fumigator-in-charge on the type of fumigant used, the hazards involved, the threshold unit values (TLV) and the precautions to be taken, and in view of the highly toxic nature of all commonly used fumigants these should be followed carefully. Such instructions should be written in a language readily understood by the master or his representative."*

Fumigation in port is covered in Section 3.4.2. Especially important sections are:

3.4.2.1

> *"Fumigation and aeration (ventilation) of empty cargo spaces should always be carried out in port. Ships should not be permitted to leave port until gas-free certification has been received from the fumigator-in-charge."*

3.4.2.2

> *"Prior to the application of fumigants to cargo spaces, the crew should be landed and remain ashore until the ship is certified 'gas-free', in writing, by the fumigator-in-charge or other authorised person. During this period a watchman should be posted to prevent unauthorised boarding or entry, and warning notices should be prominently displayed at gangways and at entrances to accommodation."*

3.4.2.3

> *"The fumigator-in-charge should be retained throughout the fumigation period and until such time as the ship is declared gas-free."*

3.4.2.5

> *"The fumigator-in-charge should notify the master in writing of any spaces determined to be safe for re-occupancy by essential crew members prior to the aeration of the ship."*

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The Committee would draw the attention of owners and masters to 3.4.2.2 on the previous page. It is common practice these days to fumigate ships, both empty and loaded, with crew still onboard. In some instances this requirement is incorporated in charter parties. Conversely in some ports the authorities will not allow fumigation with the crew onboard. Whilst it is the Committee's view that evacuation of the crew provides the safest option, if a master is prepared or required to allow fumigation with the crew onboard it is imperative that he is satisfied that the fumigator-in-charge is equipped with proper gas detection and measuring equipment for the fumigant gas being employed. When Draeger tubes are used the master should ensure that adequate tubes are available bearing in mind that each measurement requires the use of a separate tube. The master should also insist that the fumigator-in-charge remains onboard throughout the whole operation, i.e. from initial closing to completion of ventilation and the issue of a gas-free certificate. The master should also be satisfied that the fumigator-in-charge regularly checks for gas leakages in areas where the crew may be working or resting.

Section 3.4.3. covers in-transit fumigation which is now a fairly common practice, especially for bulk cargoes of agricultural products. With this type of operation the master is responsible for the safety of all onboard his ship.

The Committee wishes to draw attention to the following paragraphs:

3.4.3 *Fumigation continued in transit*

3.4.3.1

"Fumigation in transit should only be carried out at the discretion of the master. This should be clearly understood by owners, charterers, and all other parties involved when considering the transport of cargoes that may be infested. Due consideration should be taken of this when assessing the options of fumigation. The master should be aware of the regulations of the flag State Administration with regard to in-transit fumigation. The application of the process should be with the agreement of the port State Administration.

The process may be considered under two headings:

1 fumigation in which treatment is intentionally continued in a sealed

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space during a voyage and in which no aeration has taken place before sailing; and

2 *in-port cargo fumigation where some aeration is carried out before sailing, but where a clearance certificate for the cargo space(s) cannot be issued because of residual gas and the cargo space(s) has been re-sealed before sailing."*

3.4.3.2

"Before a decision on sailing with a fumigated cargo is made it should be taken into account that, due to operational conditions, the circumstances outlined in 3.4.3.1.2 may arise unintentionally, e.g. a ship may be required to sail at a time earlier than anticipated when the fumigation was started. In such circumstances the potential hazards may be as great as with a planned in-transit fumigation and all the precautions in the following paragraphs should be observed."

3.4.3.3

"Before a decision is made as to whether a fumigation treatment planned to be commenced in port and continued at sea should be carried out, special precautions are necessary. These include the following:

1 *at least two members of the crew (including one officer) who have received appropriate training (see 3.4.3.6) should be designated as the trained representatives of the master responsible for ensuring that safe conditions in accommodation, engine-room and other working spaces are maintained after the fumigator-in-charge has handed over that responsibility to the master (see 3.4.3.12); and*

2 *the trained representatives of the master should brief the crew before a fumigation takes place and satisfy the fumigator-in-charge that this has been done."*

3.4.3.4

"Empty cargo spaces are to be inspected and/or tested for leakage with instruments so that proper sealing can be done before or after loading. The fumigator-in-charge, accompanied by a trained representative of the master or a competent person, should determine whether the cargo spaces

to be treated are or can be made sufficiently gastight to prevent leakage of the fumigant to the accommodation, engine-rooms and other working spaces in the ship. Special attention should be paid to potential problem areas such as bilge and cargo line systems. On completion of such inspection and/or test, the fumigator-in-charge should supply to the master for his retention a signed statement that the inspection and/or test has been performed, what provisions have been made and that the cargo spaces are or can be made satisfactory for fumigation. Whenever a cargo space is found not to be sufficiently gastight, the fumigator-in-charge should issue a signed statement to the master and the other parties involved."

3.4.3.5

"Accommodation, engine-rooms, areas designated for use in navigation of the ship, frequently visited working areas and stores, such as the forecastle head spaces adjacent to cargo spaces being subject to fumigation in transit should be treated in accordance with the provisions 3.4.3.13. Special attention should be paid to gas concentration safety checks in problem areas referred to in 3.4.3.4."

3.4.3.6

"The trained representatives of the master designated in 3.4.3.3 should be provided and be familiar with:

1 the information in the relevant Material Safety Data Sheet, if available; and

2 the instructions on the fumigant label or package itself, such as the recommendations of the fumigant manufacturer concerning methods of detection of the fumigant in air, its behaviour and hazardous properties, symptoms of poisoning, relevant first aid and special medical treatment and emergency procedures."

3.4.3.7

"The ship should carry:

1 gas detection equipment and adequate fresh supplies of service items for the fumigant(s) concerned as required by 3.4.3.13 together with

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instructions for its use and the threshold limit values for safe working conditions;

2 *instructions on disposal of residual fumigant material;*

3 *at least four sets of adequate protective equipment appropriate for the fumigant used;*

4 *the necessary medicines and medical equipment; and*

5 *a copy of the latest version of the* Medical First Aid Guide for Use in Accidents Involving Dangerous Goods *(MFAG). Particular attention is drawn to table 550."*

3.4.3.12

"Upon discharging his agreed responsibilities, the fumigator-in-charge should formally hand over to the master in writing responsibility for maintaining safe conditions in all occupied spaces. The fumigator-in-charge should ensure that gas detection and respiratory protection equipment carried on the ship is in good order, and that adequate fresh supplies of consumable items are available to allow sampling as required in 3.4.3.13."

3.4.3.13

"Gas concentration safety checks at all appropriate locations, which should at least include the spaces as indicated in 3.4.3.5, should be continued throughout the voyage, at least at eight-hour intervals or more frequently if so advised by the fumigator-in-charge. These readings should be recorded in the ship's log-book."

Conclusion

It has been noted in recent years that some fumigations have been unsatisfactory due basically to three causes:

- Excessively heavy infestation or infestation with fumigant resistant strains of various insect species
- Inadequate initial dosing
- Insufficient time allowed for total penetration of the fumigant gas

It is of course possible for masters to have sufficient expertise to be able to decide whether a proposed fumigation operation should prove satisfactory. Although it is possible for the Association to obtain expert advice on this matter, it is difficult for any experts to advise other than in general terms when they have not seen either the ship or the cargo. It is the fumigators' duty to perform a proper fumigation and if they are employed by shippers or charterers it is the latters' duty to ensure that fumigators are competent. However, to safeguard the shipowners' position the master must insist on receiving a certificate of fumigation from the fumigators which states:

- The fumigant used
- The dose level in terms of weight of fumigant per volume of hold e.g. $lb/1000ft^3$.
- The dates and times when fumigation commenced and ceased (i.e. when either ventilation fans were turned on or hatches were opened, whichever was the earlier)

If insects are observed in or on any cargo it could be helpful if specimens are taken and placed in a small bottle with a secure closure, such as an aspirin bottle and placed in a refrigerator. These can be supplied to experts at a later date if there are complaints at the time of discharge.

If heavy infestation is observed surveyors should be instructed to draw substantial samples of affected cargo (1kg lots) which should be sealed and kept refrigerated pending expert examination to determine the level and nature of the infestation.

Shipowners are particularly warned that receivers in certain countries, especially in the Middle East, may reject cargo, with the backing of their government authorities, if minimal live infestation is detected or even if the cargo is contaminated with a very small quantity of dead insect residues. It follows that if a master detects any insect infestation when cargoes are being loaded for Syria, Egypt and some other eastern Mediterranean countries, shipowners should be informed immediately and they should seek advice from the Association.

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Fishmeal cargoes – self heating and fires

Fishmeal products manufactured from oily fish, principally anchovies and sardines, normally contain about 8-10% fish oil unless specially defatted. The standard products are classified as hazardous cargoes and are covered by entries in the IMDG Code, 2000 edition. The relevant entries are in Class 4.2 (Spontaneously Combustible) or Class 9 (Miscellaneous) UN Nos. 1374 and 2216.

The original fishmeal trade involved products now falling into the Class 4.2 category. The basic requirements for the carriage of cargo of this type were that it was bagged and aged for a period of not less than 28 days between production and loading on the carrying ship. Stowage was by the double strip stow method, that is, the bags were stowed longitudinally in the cargo spaces with transverse channels every two bags. Cargo stowed in this way was to be ventilated throughout a voyage, weather permitting. There were also requirements in terms of maximum oil content, maximum and minimum moisture contents and temperature at the time of loading. Strict adherence to these conditions permitted generally uneventful carriage of fishmeal over protracted voyages. It will be appreciated, however, that the stowage requirements resulted in a high stowage factor and were expensive in both labour and materials (dunnage).

It has been known for many years that heating of fishmeal to the point of fire is due to aerial oxidation of reactive chemical sites on fish oil molecules. All oxidation reactions are associated with the product of heat. Thus, the rationale behind the practice discussed briefly above was that the most reactive material was oxidised during the aging process and the residual oxidisable material reacted with atmospheric oxygen at a rate at which the heat produced could be removed by ventilating air under the conditions of stowage stipulated. It followed that if some procedure could be found which would either eliminate or drastically reduce the rate of oxidation it would be possible to carry oily fishmeal products as bulk cargo, or as bagged cargo in block stow.

Certain shipowners approached the problem by the use of inert gas. Special

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ships were built which were equipped with onboard inert gas producing equipment, similar to that used on tankers, and had hatchcover systems which were substantially airtight. This system works satisfactorily provided the number of loading and discharging ports served on a single voyage is limited. It will be appreciated that each time a hatchcover is opened the inert atmosphere is replaced by air and the inerting operation must be repeated again when the hatches are closed.

The fishmeal industry sought to resolve the problem by modifying the product to render it inert or less susceptible to oxidation. This was achieved by the addition of antioxidant during the production of the meal. Fishmeal suitably treated with antioxidant was included under Class 9 (Miscellaneous Dangerous Substances) in the IMDG Code. Antioxidant-treated oily fishmeal, conforming to the requirements of the Code, can be carried either as a bulk cargo or in bags in block stow. This permitted relaxation of both stowage and ventilation requirements during ocean carriage. Introduction of antioxidant-treated fishmeal on a large scale roughly coincided with drastic fall in the annual production of fishmeal on the west coast of South America. However, sufficient cargo was shipped for it to be apparent that the process could give a stable product for carriage in bulk or block stow.

In 1982 there was a series of incidents involving serious heating, sometimes to the point of fire, in fishmeal cargoes shipped from Chile on various long ocean voyages. In 1987 similar problems were encountered with fishmeal loaded at Peruvian ports. A number of cases involving Peruvian cargoes are currently the subject of litigation and cannot be discussed in this article. However, some facts of general interest have emerged during investigations.

Fishmeal is produced by cooking the fish and extracting oil and aqueous fluids mechanically. The cake which is produced is then dried and milled. The milled meal is cooled and treated with antioxidant (ethoxyquin), usually by spraying the meal as it passes through a trough.

As indicated earlier, heating of fishmeal is due to atmospheric oxidation. The chemical process is complex and involves a series of reactions. The amount of heat produced by these reactions varies. The reactions producing most energy are those towards the end of the series. Antioxidant stops the reaction chain before these later reactions can occur.

Antioxidant is used up as treated fishmeal ages. If an insufficient quantity is added at the time of production, it will be used up before the condition of the fishmeal has been stabilised. As a result, at some stage after production, oxidation will start, producing substantial quantities of heat and the risk of a serious rise in temperature in the affected meal. However, this will not be evident for some time after loading. This was the case in shipments from both Chile and Peru mentioned earlier in this article.

When serious heating occurs, this can result in carbonisation and/or fire. Many small isolated pockets of bags may be involved. During investigations, these pockets were found in regions of maximum ventilation and also in the interiors of large block stows. It follows that the primary cause was the intrinsic reactivity of the contents of a few bags rather than unsuitable stowage or ventilation.

Bagged fishmeal

Bagged fishmeal presents the majority of problems.

Documentation

The master should have onboard a copy of the latest IMDG Code, 2000 edition. Entries for fishmeal are on pages 58, UN No.1374 for unstabilised fishmeal and pages 103, UN No. 2216 for stabilised (i.e. anti-oxidant treated) fishmeal. He should also have a copy of the IMO *Code of Safe Practice for Solid Bulk Cargoes* (IMO BC Code) 1998 edition, where the entry for stabilized fishmeal can be found at pages 80 and 81.

The master must ensure that he obtains and retains certificates for anti-oxidant treated fishmeal as required by the Code, covering all the cargo loaded; that these certificates give all the information required; and figures given conform with the requirements set out in the special provisions at page 189, Section No 907, Volume 2 of the Code.

Since de-regulation of the fishmeal trade in Peru, certificates may be issued by a person or company recognized by the Government of Peru, the competent authority. Certificates for Chilean fishmeal, which very rarely gives problems, are issued by IFOP.

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Action to be taken by the ship or surveyors acting for the ship during loading

The temperature of the contents of as many bags as possible should be measured. Where these do not comply with the requirements under special provision 300, page 188 of the Code, the relevant bags must be rejected. If high temperatures are being observed it may be necessary to stop the loading of the relevant parcel to allow more extensive temperature checking.

Any wet or water-stained or caked bags should be rejected. It must be appreciated that fishmeal cargoes packed in black woven polypropylene bags with staining are not readily detectable. Thus again it may be necessary when such staining is observed that loading of the relevant parcel is suspended or slowed to allow a proper examination. Torn bags should also be rejected.

Stowage

Standard stowage practice for bagged cargoes should be adopted, i.e. use of double dunnage on decks and tank tops and provision of a spar ceiling or adequate dunnage to prevent the cargo coming into contact with the ship's sides, pipes and bulkheads especially those which are liable to become heated.

Details of stowage precautions for fishmeal can be found at pages 321 and 322, Section 7.1.10.3, of Volume 1 of the 2000 edition of the IMDG Code. For UN 1374 fishmeal, where loose bags are carried, double strip stowage is recommended, provided there is good surface and through ventilation. For UN 2216 fishmeal,where loose bags are carried, no special ventilation is required for block stowages – IMDG Code, Volume 2, page 103. Flammable materials such as paint should be removed from storerooms immediately above or adjacent to cargo spaces loaded with bagged fishmeal.

Installation and operation of temperature sensors

The IMO requires that the temperature of cargo in each hold is monitored. This can only be satisfactorily performed by installation of remote reading sensors. The Committee specially recommends that installation is not performed by the ship's crew as they should be solely engaged observing loading operations.

The BC Code requires that the temperature of cargo in each hold is monitored throughout the voyage. This can only be satisfactorily performed by the installation of remote reading sensors which are normally connected to a switch box which also has a connection for a read-out meter. The installation is normally carried out by a specialist survey organisation who are employed by the shippers or charterers. The Committee specifically recommends that installation is not performed by the ship's crew as they should be solely engaged observing loading operations. It is common to install sensors at two or three levels in a lower hold and one or two levels in a tween deck depending on the depths of the relevant spaces. Between four and eight sensors are distributed at each level depending on the cross sectional area of the cargo spaces.

The master should obtain a drawing from the installation operator indicating the locations of sensors in each cargo space. At completion of loading, for preference, but in any event when all sensors have been installed, the master or chief officer should check the temperature as indicated by each sensor in the presence of the installing operator. This will ensure that the ship's command is conversant with the equipment. It will also show whether each sensor is functioning correctly. Abnormally high or low figures will indicate malfunction from the outset of the voyage. At this stage it is impractical to replace sensors and such an operation should not be attempted. The installing operator should be asked to sign the entry covering the first set of recordings which should be entered, as read, in a bound book. Subsequently, the figures for each sensor should be read and recorded in the book each watch for the first few days of the voyage. If they are more or less stable they may subsequently be read at eight-hourly intervals as required under *Special requirements (2)* in the BC Code entry. If some temperatures in a space start to rise, temperature reading should revert to four-hourly intervals for all sensors in the space.

From experience, it is known that there can be some increase in temperature (possibly up to 34°C) as recorded from some sensors, at the outset of a voyage after which the temperature stabilises. This situation need not give rise to concern. If, however, the temperature of one or more sensors exceeds 40°C and continues to rise, the master should take timely steps to seal the relevant hatchcovers using sealing tape and if necessary plastic or foam sealant or

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cement. Consideration should be given at this stage to sealing ventilation openings; owners and charterers should be informed of the temperature figures and their advice / instructions sought. Members of the Committee are on occasions requested to advise owners or charterers when this situation arises and advice is normally given on the temperature trends over a time period. Hence when a master is forwarding information he should ensure it is clear and the temperature figures for each cargo space are always reported in the same sequence.

In any event, the instructions in the BC Code entry *Special requirements (3)* should be followed, i.e. if any temperature sensors indicate a cargo temperature in excess of 55°C, the cargo space and any interconnecting cargo space should be sealed effectively and ventilation restricted. If self-heating continues, then CO_2 or inert gas should be injected as stipulated in the fire fighting manual provided by the installers of the system. The injection should take place slowly over a 24-hour period. It is basically undesirable to inject less gas than is recommended in the manual, even though this means that only a few cargo spaces can be so treated.

It should be appreciated that any cargo heating results from an oxidation process. This means that the oxygen concentration in a hold is depleted and the concentration of nitrogen (an inert gas) increases. Hence, in a sealed hold, cargo heating tends to be self-quenching. It is therefore of paramount importance that the master has all necessary materials onboard to allow very efficient sealing of cargo spaces in order to minimise atmospheric interchange. Very efficient sealing may be a time-consuming operation, but should never be skimped.

Technically, provided that hold sealing is adequate, it would be possible for a ship with cargo heating in all her holds, to sail safely across the Pacific Ocean with her CO_2 supply exhausted (assuming a sufficient reserve for the engine room). However, such action would only be recommended if sealing efficiency could be guaranteed. Under normal circumstances, where there is obvious progressive heating, a ship would be recommended to go to a port of refuge to obtain adequate CO_2 supplies. This often involves fitting a bulk tank containing several tonnes of CO_2. If considered necessary, further sealing should be performed whilst the ship remains in port.

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Unless special circumstances prevail, sealed hatchcovers should not be opened until the first discharge port for that hold is reached. An accurate assessment of the situation in any cargo space can be obtained by measuring the oxygen concentration via a pipe connected to an oxygen meter which is introduced ideally via dedicated points of access or alternatively by slightly opening an access manhole. The manhole should be closed and secured immediately after measurements have been taken. Although some ships have oxygen meters onboard and have crew conversant with their use, it is generally recommended that, where possible, measurements of oxygen levels are made by surveyors. If they are made by the ship, the instrument should be checked immediately before use by checking the oxygen concentration of the external atmosphere (20.8%). When oxygen levels are below 10% heating is greatly restricted. Even without use of CO_2, this situation may be achieved in a few days where hatches are effectively sealed and there is a substantial quantity of cargo heating in a hold.

Discharge

Heating cargoes (if any) should be discharged first. However, where this is not practicable, the rate of spread of heating in a cargo space can drastically be reduced by maintaining a low oxygen concentration. This is done for preference by the use of CO_2 or when supplies are not available by keeping the holds sealed. It must be appreciated, however, that once the holds are opened for discharge and the oxygen concentration is allowed to rise to at least 20%, which is necessary for safe working in the hold, heating will resume at an accelerating rate. Hence attempts should be made to discharge pockets of heating cargo a soon as possible. On some occasions this can be achieved without difficulty. However, on occasions smoke generation becomes excessive, preventing manual operations. There are then several options for dealing with this problem and the choice depends on the circumstances prevailing.

The first option is to reseal the hold and inject CO_2, the minimum quantity injected being that recommended by the installers of the ship's CO_2 system. Again this operation should take place over a 24-hour period. The hold should then be left sealed for at least four days. The oxygen concentration must again be allowed to rise to 20% before labour is allowed into the space to resume discharge. This option, when successful, results in the minimum amount of cargo damage but extends the discharging period. It may be considered impractical if it has to be repeated several times.

The second option is to control smoke evolution by the use of water sprayed through a fine spray directly onto the smoking cargo, whilst discharge proceeds. This procedure, if properly used, results in limited water damage to part of the cargo. However, excessive water is often applied, particularly when the local fire service intervenes, and the amount of cargo wetted can be substantial.

Very occasionally, the cargo will actually ignite. Flames should be extinguished with a water spray.

The third and last option which should only be used when other methods have failed is to use a water spray to control smoke evolution or fire and discharge heating pockets by grab. The procedure obviously results in more cargo damage.

Members of the Committee have had experience of fires in fishmeal igniting flammable cargo in adjacent spaces with disastrous results. Hence the earlier advice that flammable materials should not be stored in storerooms adjacent to or above holds loaded with fishmeal.

Damaged and apparently sound cargo should always be separated at the time of discharge. However, even badly heated cargo has feed value and can be incorporated in cattle feed. Hence, cargo should never be left onboard to be dumped at sea.

Bagged fishmeal carried in containers

Bagged stabilised (i.e. UN 2216, Class 9) fishmeal may be carried in freight containers as indicated in Volume 1 of the IMDG Code at page 322. It is probable that containers will be delivered alongside already sealed. However, if the master is in a position to see the containers being stuffed he should ensure they are clean and that the maximum quantity of bags are placed in each container. In any event he should ensure that the container doors and other openings are properly tape-sealed to minimise possible air ingress.

On the voyage, the temperature of the outsides of containers, if stowed in accessible positions should, if possible, be checked regularly by feeling them (in any event, as indicated in Volume 1 of the IMDG Code at page 322, 7.1.10.3.2.2 *"Temperature readings in the hold should be taken once a day early in the morning during the voyage and recorded"*. If any container becomes hot they should be cooled using water; *"...consequent risk to the stability of the ship should be considered."* 7.1.10.3.2.3. If smoke is seen issuing from a container, a hole should be punched in the side at the top of the container, a hose nozzle fitted and the container flooded.

It is self-evident that masters must ensure there is reasonable access to any containers stowed under deck.

Fishmeal carried in bulk

This matter is covered in the IMO BC Code pages 80 and 81.

Documentation

The required documents are the same as those for bagged fishmeal.

Action taken by the ship or surveyors during loading

The temperature of cargo at the time of loading should be checked in the most practical manner bearing in mind the loading procedure adopted. Hence if bags are being used to deliver cargo alongside, the simplest procedure is to check the temperature of cargo in such bags. Measuring temperatures in cargo loaded by spout is more difficult. However, there is also a requirement that cargo temperatures are measured during a voyage which means that temperatures can be measured as the sensors are placed, in various locations in the cargo. It is important that such temperatures are measured by personnel in the holds and not left until all sensors have been put into position and connected to a read-out meter. The reason for this is the IMO requirement that the maximum allowable loading temperature is 5°C above ambient or 35°C whichever is the higher. It follows that if excessively warm cargo is loaded early in the loading operations and the temperature is not observed until the hold is fully loaded, discharge of all the cargo may be required in order to comply with IMO requirements. Such a proposal would undoubtedly give rise to problems with shippers and charterers.

Installation of sensors

These should be positioned as described for bagged fishmeal. Temperatures measured by each sensor should be recorded at eight-hour intervals throughout the voyage. Data from such readings should be considered as discussed previously in this article.

Discharge

This should be conducted on the basis that heating cargo should be discharged at the earliest opportunity. However, if pneumatic elevators are normally employed, these are unsuitable for discharging significantly hot cargo and it may be necessary to employ a grab especially for this purpose. Problems involving carriage of bulk fishmeal are much more infrequent than those with bagged fishmeal cargoes.

Palletised cargoes

Wooden pallets are extensively used for the transportation of cargo both in containers and in conventional breakbulk sea-going ships. Palletising of cargo helps to speed up cargo handling operations by consolidating merchandise into units, which can be easily and rapidly handled. Both the efficiency and the reliability of the system depend upon the quality of the construction of the pallet and upon the measures taken to protect the goods and to secure them in place.

When pallets were first introduced into the trade, they were invariably of robust construction. As experience was gained, it was found necessary to secure the goods adequately to the pallet by means of metal strapping bands and to protect them by providing a covering. Nearly all palletised cargoes are received directly from the producers/manufacturers of the goods and it is most desirable that shippers as well as shipowners should appreciate that whilst pallets may appear to be adequate when stacked ashore in a warehouse, they must then be strong enough to be transported to the docks, unloaded, picked up by fork trucks, carried over uneven surfaces and finally loaded onboard ship.

There are formal recommendations which deal with the design, construction and strength of pallets; certain freight conferences specify the standards which they require. The philosophy behind these specifications is that a pallet so constructed will be capable of handling its proper load adequately and it will also be capable of supporting four tiers of similar pallets. It is incorrect to stack in tiers pallets which are not of adequate construction; the result is likely to be widespread collapse of the stow and damage to the cargo.

In the British Standards Institute Publication No. BS2629, Part I 1986, Paragraph C2 of Appendix C states :

> *"Pallet loading and stacking. Lading patterns should be established for the palletising of each type of merchandise. The pattern should be designed to achieve maximum safety and stability of the goods handled and it should be ensured that it does not entail the safe working load being exceeded and the load should, as far as possible, be uniformly distributed on the pallet deck.*

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> *Heavier packages should be placed at the bottom of the pallet load where mixed goods are being carried.*
>
> *The top of the pallet should be levelled off to allow other goods to be safely over-stowed where necessary. Pallets should not be over-stowed more than four high if they are loaded to their safe working capacity. Where pallets are to be loaded to less than their safe working capacity, the height of stacking should not result in a total stack weight exceeding four times the sum of the weight of one pallet and its safe working load. Further factors to be considered in deciding stacking height are the compressibility of the merchandise or its packing and the stability of the stack and the type of pallet."*

The quality and standard of pallets should not be allowed to deteriorate in an effort to reduce costs: if pallets are to be used for sea transport they must be of a consistently high standard. Flimsy pallets constructed from soft wood and designed for storage of lightweight cargo in warehouses, are not uncommonly presented for loading on to ships. Sometimes they are dangerously overloaded and able to withstand neither the rigours of an ocean voyage, nor the stevedoring operations which are entailed. In many cases where the design may be adequate, the materials used and the standards of workmanship are poor.

Experience has revealed that little consideration is given to whether the strength of the pallet matches the weight of the goods it is to carry. Often the dimensions do not match, with the result that bags or cartons project beyond the edges of the platform. Frequently the merchandise is badly stacked or badly secured and is in danger of shifting.

Other inadequacies which have been noted when pallets are presented for sea carriage relate to the methods of securing goods to the pallets. A fairly recent innovation is the shrink plastic cover. This is applied by placing a large piece of plastic over the stack of cartons or bags on the pallet and thereafter applying heat at the folds, in order to shrink the plastic on to the load. Many shippers mistakenly consider that this affords adequate packing and protection. Frequently when a shrink plastic cover has been applied and extended downwards to embrace the pallet, a load of substantial weight may be mistakenly considered to be secured to the pallet. If the load is secured to

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the pallet by any other means, this is often in the form of weak, flimsy plastic strapping which stretches easily. Subsequently, during the various stages of transportation and as a result of the jolts, jars and tilting which are experienced, pallets quite commonly break or even fall to pieces, loads become lopsided and unstable and sometimes fall off, ending as damaged break bulk cargo.

The method of handling pallets within dock areas may also sometimes leave something to be desired. Where forklift trucks are utilised the forks may be misdirected, so that instead of the forks penetrating beneath the platform of the pallet, they penetrate above it causing damage to the goods. If the cargo is in bags or containers and consists of a liquid or some form of granular material which sifts or runs easily, the entire stability of the load then becomes endangered to such as extent that it may in due course disintegrate. When bagged cargo bulges through the gaps of the planks forming the platform, or where in weak pallets the planks in the platform break, damage can occur when the pallet is picked up. The forks of the lift truck pierce the bulging part of the sack, the contents pour out and the stack or load is rendered unstable.

The photographs on the following pages show palletised goods which are typical of those regularly being presented for shipment.

Handling of pallets

The following recommendations have been put forward for the benefit of those handling pallets:

- Where slings are utilised, particularly wire slings, they should be of adequate strength. At the very least, wide nylon belts and spreaders should be utilised.
- Where fork lift trucks are utilised in the handling of pallets, care should be taken to ensure that the forks are not pointing parallel with the base boards of the pallets, otherwise there is a danger of tearing from below.
- Where it is necessary to load pallets in twos, this should if possible be done by utilizing special lifting equipment.
- Where pallets are being handled singly, perhaps because of the low safe

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working load of the crane, then they should be handled on solid pallets with suitable pallet-lifting gear attached.

- The use of C-hooks, originally developed for the handling of fruit cargoes, is now widespread on palletised goods and has proved very successful.
- Where holds are completely filled with pallets, the incorporation of 'key pallets' in the stowage will assist at the time of discharge. This may be achieved by pre-slinging the pallets with strops or other similar suitable appliances in order to gain access to the remainder of the stow.

Photos 1 & 2.
Note the platforms which have to be used in order to load damaged pallets onboard the ship

In Photo 1, above, it can be seen that the pallet is already breaking up. The stack, even, though cross-tier stowed, consists of polypropylene woven sacks which slide easily upon each other with the result that the stack becomes unstable and leans over. Each stack is covered with shrink plastic and secured with plastic straps which are not suitable for the purpose intended

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Photos 3 & 4.
The view of the goods in stow, if closely examined, shows many defects such as leaning stacks and pallets which are broken, bending or bulging

Photo 4, right, shows a method of slinging which causes extensive damage to such pallets

Stacking of pallets

When stacking goods on pallets there are a number of steps that can be taken to prevent or reduce some of the more obvious problems.

- The platform of the pallet should be covered with a sheet of cardboard, in order to prevent bulging bags or damage by contact with the sharp edges of the timber platform.
- Where polypropylene bags or paper bags are stowed on pallets, they tend to slide readily because of their smooth surface. In such cases, a square of strong kraft paper can be inserted between each horizontal tier in order to bind the layers of bags together.
- Where multiple paper bags are concerned, the bags can be attached to each other by a patch of glue on the centre surface of each bag.

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- In order to prevent the secure strapping from damaging the bags when tightened, a thin square plywood sheet or a sheet of strong cardboard should be placed on the outer perimeter edge of the pallet platform and inserted between the securing bands and the bags. This will also provide protection against the fork ends of the lifting trucks.

In summary, the pallet should be strong enough to support its load and able to withstand handling by stevedores at the several stages of transport. The stacks of the load should be properly built up with interlocking tiers to bind the goods together on the pallets, taking precautions against toppling and instability. The load should fit the pallet and not project over the sides. Preferably it should be firmly secured to the pallet with flat metal bands, or nylon straps, or nylon nets and may incorporate vertical fibre-board/plastic corner angles.

Radioactive cargoes

The transport of radioactive materials is a well-regulated international activity and it may be surprising to many people to know that over ten million radioactive packages are transported around the world each year with up to four million of these by sea. Records show that radioactive material transport is a highly safe activity in terms of people and the environment. This is attributable to the regulatory standards to which the carriage is subject internationally and the careful application of them by industry and transporters. As with the transport of all hazardous materials the carrier places great reliance on the consignor to declare the materials correctly. In the case of the liability insurance there is the additional question of whether the consignment is or is not 'excepted matter'. If it is not 'excepted matter' then the consignment is NOT covered by P&I Club Rules and the consignor must arrange nuclear liability insurance and produce a certificate of financial security from his government before the consignment can be moved.

The following case involving an international shipment has highlighted the fact that, whilst Members may think they know that a certain shipment is probably 'excepted matter' they should always consult the Club for their nuclear consultant's confirmation.

Two consignments of uranium – one of uranium trioxide and one of uranium metal ingots – were shown on the Dangerous Goods Note as being "*Radioactive Material, Low Specific Activity (LSA-11), N.O.S.*" and as being "*fissile excepted*". However the Dangerous Goods Note also showed that from the weights of uranium and of the U235 fissile isotope, the uranium trioxide was 5.55% fissile and the uranium ingots were 1.23% fissile. In each case the limit for the quantity involved to be fissile excepted was 1.0%. Upon the Member refusing these consignments, the consignor reverted with revised weights for the U235 fissile isotope which brought both consignments within the 1.0% limit. The Club's nuclear consultant was able to confirm that the revised figures were correct by obtaining the relevant data independently from the consignee (who he knew) by asking them what they were expecting to receive.

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In this case the outcome was satisfactory, but if the U235 fissile isotope weights in the first Dangerous Goods Note had been correct and the packages had been stowed on a vessel in the proximity of other fissile material, there would have been a real risk of a 'criticality excursion' (chain reaction).

The Association's Rule 5, Exclusion of Nuclear Risks, applies.

Part 2

Steel hatchcovers

Introduction

The steady increase in the size of ships especially bulk carriers during the past thirty years has been accompanied by a steady increase in the cost of manning and running them. As a partial counter to this escalation in costs, equipment, such as steel hatchcovers were developed and introduced onboard ship shortening the turnround time in a port, and enabling larger ships to be manned by smaller crews. As is so often the case, however, new developments create new problems, and steel hatchcovers were no exception to this rule.

This report considered steel hatchcovers in general and MacGregor-Navire hatchcovers in particular. We are indebted to the original MacGregor-Navire Organisation for their assistance in providing the earlier technical information required in preparation of this article.

The aim of the report is to consider claims for sea water damage to cargo carried in ships fitted with steel hatchcovers to analyse the causes of the leakage and to suggest ways and means whereby the incidence of such claims might be decreased. The fitting of steel hatchcovers on the weather-deck of seagoing ships is now the rule rather than the exception, and it thus essential to eliminate the underlying causes of cargo damage from ingress of sea water through steel hatchcovers.

Claims statistics

That the problem is worthy of study is shown by the following figures compiled during two studies of claims for damage to cargo by leakage of sea water through steel hatchcovers.

The first set of figures appeared in the 5th *Carefully to Carry* report published in 1965 and covered 15 cases handled by the Club:

Largest claim	US$240,000
Lowest claim	US$2,200
Total claimed	US$903,422
Average claim	US$60,200

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More recently, during the period 1987-2001, the Club handled 236 large claims (gross value in excess of US$100,000), paying out approximately US$57M. The average value for the period was US$243,000.

Advantages of steel hatches

The advantages of the installation of steel hatchcovers on a ship are several, greater strength which contributes to the safety of the vessel, the ease and speed with which they can be moved to open and close the hatches and the minimal number of persons required to operate them in comparison with the crew needed for traditional hatchcovers This last point may be easier to appreciate in the context of large modern bulk carrier of, say 9 cargo holds, with twin hatches at each hold and a deck crew of only 12 men in total. Against these advantages must be placed the high costs of initial purchase and routine maintenance.

The development of the automatic steel hatchcover

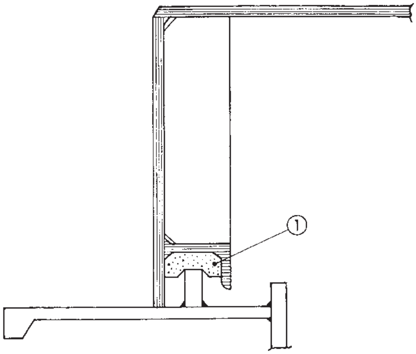
History

In the 1930s, the hatch openings of ships were covered with beams, wooden boards and tarpaulins very much as they had been for centuries past. Metal had been used for slab type pontoons but the MacGregor-Navire Organisation had the idea of using an eccentric wheel, to lower and raise these pontoons and, in the raised position, to move them to one end of the coamings, lifting them at that point into a vertical position. In the lowered position they would rest on a rubber gasket and, by the use of cleats, become weather tight. This revolutionary but simple modification was still in operation in the mid 1940s.

Development

In the late 1940s, coupled with an international marketing development programme, these simple individually moved panels were linked together and counter balanced in such a way that one wire could be used to move them to one end of the hatch where they would automatically assume a vertical position and stow in a small area. This principle became internationally known as the 'single pull hatchcover' and on the weather-deck, is still the most widely used means of cargo protection. Refinements and modifications have been incorporated, basically in the fields of automation techniques and, of course, folding hatchcovers motivated by hydraulic or electrical means, piggy back covers, stacking covers, coiling covers and more recently the sequential or non sequential multi panel covers of the modern container vessels have also been in wide use throughout the maritime world, However for illustrative purposes, we will restrict our comments to the single pull type of operation.

Fig A.
Section through side or end of hatchcover.



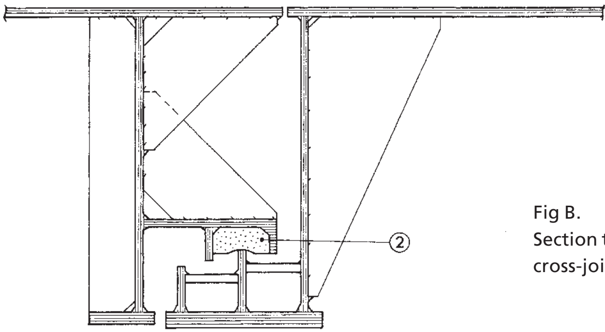


Fig B.
Section through cross-joint.

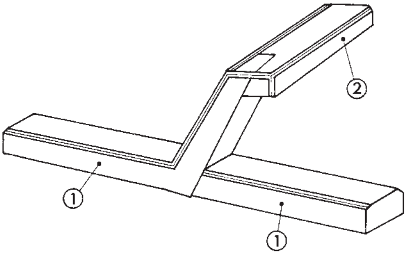


Fig C.
Details of cross-joint rubber inserts.

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Coamings

The sealing round the edge of the hatch to prevent the ingress of water consists of hard rubber gasket strip retained on three sides in a channel bar within the hatchcover framework and resting on the compression bar which is a square section steel bar welded onto the coaming bars (see Fig A). The maintenance of this type of installation is dealt with later but it is worth mentioning at this stage why a 'double drainage' trough is designed inboard of this compression bar. Should anything be trapped on the coaming during the closing operation, or a local deformation in the compression bar be caused by for example a derrick runner wire or cargo handling damage, then in this local area there is a small access for the possible entry of water, which whilst not being dangerous, could damage a fairly large amount of cargo. Incorporation of double drainage allows any such water to be taken away and is a wise safeguard against such minor localised sealing problems.

Moving parts

Maintenance necessary for the continuance of original weather tightness is essential and it will be obvious that correct maintenance of moving parts, i.e. wheels, chains, gypsies etc., will alleviate the possibility of the assembly being subjected unnecessarily to rough treatment because of undue wear taking place on these parts.

What the claims have to tell us

Strength

Each automated steel hatchcover panel consisting of steel plate, sections, beams etc., all designed and assembled to the strict requirements of a classification society is, in comparison with the hatch beams, boards and tarpaulins which preceded it, immensely strong. However, this can be a disadvantage under certain circumstances, especially when the vessel is labouring in a seaway.

Although ships give the impression of great strength, such is the power of the sea, when the weather is adverse, that any ship which does not yield to the force of the waves would quickly founder. In fact, the ship must act, rather as a boxer does, by riding those blows which cannot be avoided so as to absorb the greater part of the energy directed at it. In so doing, the ship 'works' along its length and across its width all the time.

In these conditions, the very strength and rigidity of the steel hatchcovers as compared with the greater flexibility of the ship, can cause the weather-tight joints between the vessel's structure (hatch) and the covers to move as the ship works in a seaway. Yet it is at just such a time that hatchcovers no matter what their type need to be most resistant to water in order to protect the cargo beneath them.

Analysis of claims

In carrying out the research necessary to compile the statistics mentioned in the earlier study, it was found that in only one instance was general cargo damaged. All other ships were carrying bulk cargoes with maximum dead-weight and minimum permissible freeboard. In many cases the log extracts for the voyage state that seas and waves were continually washing over the decks and hatches. How high then are the waves which are met in the open sea? The height depends mainly on the strength of the wind and the length of time during which it has been blowing, but reproduced below is part of the international Beaufort Scale of Wind which gives the average wave height likely to be experienced for various wind strengths from gale to hurricane.

Beaufort Scale

Wind force	Limits of speed in knots	Descriptive terms	Probable mean height of waves
7	28-33	Near Gale	4.0
8	34-40	Gale	5.5
9	41-47	Strong Gale	7.0
10	48-55	Storm	9.0
11	56-63	Violent Storm	11.0
12	64-71	Hurricane	Over 14.0

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Freeboard

As the average freeboard of the ships considered in the earlier survey was 2.75 metres it can safely be said that, from these figures for wave heights, most ships carrying a dead-weight cargo, which also encounter strong winds while on passage, will have the decks and hatches awash at frequent intervals.

Conclusions from claims

From further study, other factors emerged which were present in many of the cases. With very few exceptions, the voyages had taken place in the northern hemisphere, and three quarters of all the voyages had taken place during the winter months between October and April. Indeed, one third of all the voyages took place during the months of December and January. Not surprisingly, bad weather was experienced on every voyage, but in no case was it of such severity as to offer certain defence of 'perils of the sea' under the Hague rules. Neither was it severe enough to justify penetrations of the rubber seals of the hatch joints, provided that the seals were in good condition. However, in very many cases, survey reports from the discharge port criticised the condition of the hatchcovers and coamings indicating a poor standard of maintenance.

The results of the research can, therefore, be summarised as follows:

- Usually, the only vessels involved were those carrying bulk and dead-weight cargoes.
- Their freeboard was not very large.
- All voyages included a period of heavy weather.
- The majority of the sample voyages were confined to the northern hemisphere.
- 75% of the sample voyages took place during the winter months.
- Hatch survey reports indicated that some hatches and coamings were in poor condition.

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Suggested remedies

Proper securing

Can anything be done in the future to eliminate or reduce the leaking of this type of hatchcover? Of the six points previously listed, it is the last on which, in our view, attention should be concentrated. However, while it is true that in most cases an adverse survey report has been presented, this is by no means so in every case. Some survey reports have stressed the very good condition of the seating of the seals and equipment of the hatches and in one case, the ship was actually on her maiden voyage.

What then is the reason for the hatch leakage in these cases? Is it the extra rigidity of the covers which was mentioned earlier, or is there some other reason? Considering the nature of the weather experienced on the voyages in question, it is likely that the working of the ship was a contributory factor. But can the leakage be explained in other ways? The answer may be that the covers were improperly or carelessly secured.

In the past, when hatches were secured with boards and tarpaulins, the need for care in their securing was very obvious. The ships were also much smaller and there were more seamen to perform the tasks connected with leaving port, such as the lowering and securing of derricks and the battening down of hatches. The crew had to work as a team because the various jobs could not be done by one or two men alone and with teamwork there is less risk that the job will be improperly done. Lastly a poorly secured hatch was immediately apparent to the ships officers and steps could be taken to remedy the situation.

Nowadays however, on modern bulk carriers, there are fewer crew members, and with the likelihood of no cranes or derricks to stow to relieve the monotony of securing the 6 to 9 hatches. For the one or two men concerned, the prospect of securing a long line of hatchcovers stretching away along the weather-deck is not an inviting one, and when there are added discomforts of wind and rain, it is not surprising if the securing is not always carried out as conscientiously as perhaps it ought to be. Steel cleats and wedges are not as interesting as canvas tarpaulins and wooden wedges even if they are stronger and more efficient and therefore safer. There are also a great many of them; hatches of say 40ft x 30ft will probably have 6 panels secured around the edges by about 40 cleats and further secured by about 50 cross seam wedges.

The essential points to remember in securing hatchcovers are firstly that the joints cannot be effective if insufficient pressure is applied, and secondly, but by no means less important, that the pressure must be evenly distributed along the whole length of the joint.

Type of cargo stresses

The type and distribution of cargo carried can affect the stresses experienced by a ship in a seaway and thus the degree of bending and twisting she suffers. In this respect homogeneous cargoes of low density, such as bulk grain, are better than high density cargoes such as ore concentrates or steel products. Bulk carriers are designed as single deck vessels which means that high density cargoes will be stowed at the bottom of the holds, causing severe racking strains of hogging and sagging. These racking strains may well cause the hatchcovers to leak if the cleats and wedges are not secured properly. In these conditions, it is important to ensure that the cleats remain tight.

Leakage despite proper securing

However, in spite of these comments, it is a fact that in conditions of severe weather, leakages can and will occur through steel hatchcovers which are properly secured. This was illustrated by the decision of the US Court of Appeal in the case of the *Sabine Howaldt* 1971 AMC539.

The *Sabine Howaldt* was a vessel of 2,300 gross tons, 306 feet in length with a beam of 40 feet. Her bridge amidships and her engines aft, and the four cargo holds were served by two hatches only, one forward and one abaft the bridge. The fore deck hatch was about 60ft x 18ft and had the protection of solid bulwarks at the ships side, while the after deck with open rails at the ships side was 3 feet higher than the fore deck and had a hatch of about 68ft x 18ft The holds were separated by bulkheads with the forward hatch serving Nos. 1 and 2 and the after hatch serving Nos. 3 and 4.

At the time the *Sabine Howaldt* was seven years old and her classification, which was the highest in Germanischer Lloyd, had been maintained at her

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annual survey in April, 1965. The charter voyage during the following December was from Europe to the USA with a full cargo of steel products, which were loaded in good condition but were rusted and pitted from contact with sea water when discharged from No. 4 hold and also but to a lesser extent, from No. 1 hold.

Before completion of loading, the surveyor for the charterer inspected the hatchcovers and found them in good condition with no dents, bending or other damage and no staining on the inside of the coamings to indicate previous leakage. His report found the ship seaworthy. After the hatches had been closed and tightened down they were inspected by the chief officer together with another officer and a log entry was made by the chief officer that the MacGregor-Navire hatchcovers were "closed and wedged".

The *Sabine Howaldt* sailed from Antwerp on the 15th December at a draught less than permitted as she was not down to her winter marks, and by midnight on the third day, the wind had risen to force 9 on the Beaufort Scale. The wind increased to force 10 by 09.00 on the 18th, blew with that force until about 17.00 and then began to ease. During the whole of this period the ship pitched and rolled heavily in the high seas which had been whipped up by the wind, and waves were continually breaking across the decks.

The respite offered by the easing of the wind during the evening of the 18th December was not to last for long. On the 20th the wind reached force 9/10, remained at 7/8 moderate to fresh gale – during the whole of the next day, gathering strength for the coming onslaught. On the 23rd December, the ship was hove-to for twelve hours trying to reduce the battering from hurricane force winds, heavy confused swells and the huge seas which were breaking over her forecastle deck hatches and upper works, bending, twisting and vibrating her continuously.

The violence of the weather was severe enough to cause structural damage for, after the worst of the storm was over, it was discovered that the pedestal holding the master switch control for the capstan had been torn loose leaving a hole in the deck, a galley port hole was smashed, the catwalk gangway from amidships to poop was torn loose and destroyed, denting a ventilator at the same time. Several parts of the ship's superstructure and fixtures were dented and the covers from two winches disappeared after being ripped off.

When the weather first deteriorated at the beginning of the voyage, the chief officer, in the company of another officer, made a second inspection of the hatches from inside the cargo holds. He found no leakage through the hatchway although waves were washing across the covers. He also examined the covers on arrival in the USA on 3rd January and found hatches, covers and gaskets all in good condition, as did the surveyors for both the owners and the charterers. Nevertheless, sea water had entered the hold and it was decided that the severe stresses to which the ship had been subjected had momentarily deformed the rectangular opening of the hatch thereby disturbing the seal between the gasket with the compression bar on the coming allowing sea water, which was pouring over the decks and hatches, to enter the hold.

After considering all the circumstances, including the fact that on both the previous and following voyages the hatchcovers had not leaked in spite of heavy weather, the Court of Appeal decided that the violence of the wind and the confused cross-swells that had wrenched and twisted the ship during the voyage were a 'peril of the sea' and that the owners were not liable for the damage to cargo resulting from the leaking of the hatchcovers.

While it is impossible to say what the effect of the storm would have been had the ship been equipped with wooden hatch boards and tarpaulins, the situation in which the *Sabine Howaldt* would then have found herself would have been far more dangerous: certainly for the safety of the cargo and possibly for the ship also. The collapsing of the amidships cat walk would undoubtedly have torn the tarpaulins covering the hatch over Nos. 3 and 4 holds, allowing a much larger volume of sea water to enter those holds to the certain detriment of the cargo and possibly to the ultimate danger of the ship itself.

Summary

This section can be summarised as follows:

- Hatches can leak in a seaway if they are not secured as tightly as possible, and checked as appropriate during the voyage.
- There is more likelihood of leaking if the ship is carrying high density cargoes.

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- Even though every care is taken as in the first item, above, it is possible for steel covers to leak if the ship becomes twisted in certain conditions of weather without any fault on the part of the shipowner at all.

Proper maintenance

Having considered the contents of numerous survey reports on the condition of hatchcovers, there can be no doubt whatsoever that maintenance lies at the heart of the problem. It is absolutely crucial for hatchcovers to be maintained at the highest standard if cargo damage is to be avoided.

To achieve this standard is less easy than to state its requirements, because the modern bulk carrier has a smaller crew for its size than the older type general cargo ship, and spends little time in port. Adequate maintenance is therefore difficult to carry out in port because of cargo being worked, or at sea because the hatches are then secured for the passage whether the vessel be fully laden or in ballast.

Working parts

The marine environment is an extremely corrosive one and every opportunity must be taken to minimise its effect, particularly in respect of the cleats which secure the pontoons. It is the shipowner's/operator's responsibility to undertake the required maintenance whatever the problems.

Rubber seals

Although routine maintenance must be carried out whenever opportunity arises, the most important factors determining the ability of the hatches to remain weather tight are firstly the rubber seals on the under-side of the panels and secondly the compression bars with which the seals make contact when the hatches are in a closed and secured position.

The effectiveness of the rubber seals can be reduced in several ways. Accidents while the hatches are being worked and during the opening and closing of the hatches can physically deform the seals. Careless painting of channels can cause 'hard spots' on the seals locally reducing its resilience. Rust scale can form underneath the seals in an uneven thickness causing 'high spots' and resulting in non-uniform compression of the rubber. Particles of cargoes such as grain or ore can become compressed between the seals and the compression bars. Finally, though every care and attention is given to the seals, age will cause them to perish or harden with the tendency for them to crack and break. Any of the above can result in the covers leaking when under stress.

Having isolated the dangers, the remedies and the safeguards suggest themselves. Good management and careful inspection at every opportunity will help to prevent all but the last. The ageing of the rubber cannot be prevented but it can and ought to be recognised and remedied before it has progressed too far. The only remedy is the replacement of the old seals with new, and the opportunity should be taken at the time of renewal to remove all traces of rust scale from the channels before preparing them and reseating the new seals.

Any seals more than two years old ought to be inspected regularly for signs of deterioration due to ageing.

Whenever packing is to be renewed, whether because of damage or old age, it is essential that the whole strip be replaced, otherwise there will be different compression strengths between the new and existing rubber.

Compression bars

Because the compression bars along the top of the hatch coamings are solid steel, there is a tendency to assume that no harm can come to them and that they need no maintenance. But in fact sound compression bars are as necessary as sound rubbers.

The most frequent way in which these bars are damaged is by impact from cargo moving into or out of the hold. This is especially so if the ship carries cargoes of constructional steel, when each lift will be awkward to handle and probably heavy as well. A load such as this striking the compression bar can easily dent, score or bend the bar.

The bars may also become damaged over a period of time by cargo wires continually passing across the same area, with the result that the original right-angled edge of the bar becomes rounded. If little or no care is taken to combat corrosion then the top surface of the bar will in time develop ‘high and low spots’ which will prevent the proper seating of the rubbers.

This corrosion is particularly likely to affect the compression bars of the cross-joints. Experience has shown that close attention should be paid to the cross-joints between the panels as in many instances, leakage has occurred at these joints or at some other position as a result of these joints being defective in some way. The cross-joints must be pressed firmly and evenly together. So far as the pressure on the cross-joint is concerned, the cross-wedges, whether manually or automatically operated, are of paramount importance as on these the tightness of the joint mainly depends. If the cross-wedges do not provide an effective seal, then either the seals have become too heavily compressed and require renewal; the compression bar on the adjacent panel has become bent or worn down; or there is a combination of both these defects. The situation is often rectified by welding a small plate onto the adjacent panel edge at a position where the manual wedge end rides up and over the panels to put pressure on the cross-joint. If the wedges become strained or bent, new wedges should be fitted.

Drainholes

The coamings and covers of steel hatches have been designed so that moisture is cleared away but the general cleanliness of drainholes, waterways and coamings is important, because any accumulation of cargo residues or dirt may trap condensation and rainwater resulting in possible sweat damage to the cargo and the steady deterioration of the covers by corrosion.

Ram-nek tape

From time to time, certain additional safeguards against leakage have been conducted. The usual proposal is the covering of cross-joints with some heavy adhesive tape; one proprietary brand is 'Ram-nek'. A more recent procedure is to use an expanding foam, which when sprayed onto the joints produces a hardened barrier to water. Some charterers, especially in the steel trades require the master to apply tape to the hatchcover joints and indeed supply the tape. However the very fact that tape or foam has been used has encouraged some cargo interests in the past to allege that the ships hatches must have been known to be leaking before the voyage began! Thus alleging 'lack of due diligence to make the vessel seaworthy'.

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Maintenance manuals

There are two final comments which ought to be made in this section on maintenance. Vessels fitted with steel hatchcovers should have supplied to them manuals giving detailed information relating to construction, operation and maintenance of the covers, together with lists of spare parts which can be carried onboard the vessel for remedial repairs. In addition, leading manufacturers may have representatives in major sea ports readily available both to advise and also to carry out repairs and maintenance should this be required.

It is strongly recommended that major overhauls and inspections should be carried out by manufacturers' representatives at the very least, each time the vessel dry-docks, in order that the high original standard of the covers is maintained throughout the life of the ship. It has already been emphasised that the trend is for ships to spend less time in port and for crews to be smaller now than they were when ships were generally smaller. It is therefore wholly reasonable to say that shore maintenance must be the standard with crew maintenance being used as 'remedial' as and when necessary. In this way, claims on the shipowner for damage to cargo should be reduced to a minimum.

Testing weather-tight integrity of dry cargo vessels' hatchcovers

In 1989 IACS introduced its guidance to owners concerning the care and survey of hatchcovers as follows:

> *"Loss of weather-tight integrity continues to be a constant factor leading to cargo damage which could result in a threat to the safety of the crew, the ship and its cargoes, despite advances in modern shipbuilding technology, construction, navigation and means of preventing ingress of water into hold spaces".*

Little appears to have changed over the intervening years.

Regulation 3.12 of the International Load Line Convention 1966 which states:

> *"Weather-tight. Weather-tight means that in any sea conditions water will not penetrate into the ship".*

Regulation 16 of the convention concerns *"hatches closed by weather-tight covers".*

The *"means for securing weather-tightness"* is defined in regulation 16.4 of the convention which states:

> *"The means for securing and maintaining weather-tightness shall be to the satisfaction of the Administration. The arrangements shall ensure that the tightness can be maintained in any sea conditions, and for this purpose tests for tightness shall be required at the initial survey, and may be required at periodical surveys and at annual inspections or at more frequent intervals."*

Traditionally the routine tightness testing of hatchcovers and which owners of dry cargo vessels will be familiar, has been conducted by:

- Chalk test.
- Light test.
- Hose test.

And more recently

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- Ultrasonic test.

Traditional methods

The chalk test

Chalk is applied to the compression bars of the coamings and the individual panel cross seams. The hatches are then battened down fully and in the proper manner after which they are immediately re-opened and the rubber packing (joints) carefully examined. Where a clean regular chalk mark is observed on the packaging it is assumed that sufficient pressure exists between the joint and the adjacent compression bar. If the chalk mark is found to be intermittent or less pronounced at some points than at others then it is assumed that weather-tight integrity does not exist over those areas. This dated method can only be considered as indicative of a possible problem with likely inconclusive results even after rectification of possible defects which may have been exposed by the test. IACS recommendations:

> *"Upon completion of installation of hatchcovers, a chalk test is to be carried out. This to be followed by a hose test with a pressure of water of not less than 200Kn/m^2."*

The light test

The simplest means of establishing if a defect exists and its location is by means of the light test. The hatches are battened down fully and properly for seagoing, the surveyor/observer entering the hold and viewing the underside of the covers from below. In strong sunlight defects will/should readily be visible with daylight shining through any gaps in the packaging. If the test is being undertaken during poor light conditions strong torchlight properly directed from above will serve the same purpose.

The hose test

The most commonly used of the traditional tests is the hose or water test whereby a strong jet of pressurised water is directed at the seams and joints of the hatchcovers. Hatchcovers are battened down fully in the proper manner and with the surveyor stationed in the hold a survey assistant must be stationed

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on deck/top of the hatchcovers to ensure that the water, usually supplied from the vessel's fire main is directed at a constant and sufficient pressure in the proper direction. Ideally the hose must be held at a distance no more than one metre from the joint under test with a pressure, as before noted, of not less than 200Kn/m^2. There are however a number of disadvantages, these include:

- Time-consuming method.
- Ensuring adequate water pressure.
- Excessive water draining from decks when vessel may be alongside wharf, pier or jetty.
- Test cannot be safely carried out when vessel is laden for fear of wet damage to the cargo.
- Two surveyors are required to undertake the test.
- Test cannot be carried out if weather conditions/air temperatures are at or below 0°C.

Ultrasonic test

There has been, over the past 12 to 15 years since the ultrasonic testing equipment became available, a great debate concerning the efficiency and acceptability of this type of equipment. However, the technique is now widely used throughout the industry to test and prove the weather-tightness of hatchcovers. The equipment, when properly used, gives the exact location and the extent of leakage, is relatively easy and quick to operate and does not require the assistance of crew members once the hatchcovers have been properly battened down.

Sound is generally produced by a vibrating body. Air surrounding the body forms waves and transmits sound. The frequency of the sound so produced is measured in cycles per second, hertz, which indicates the number of vibrations the sound wave makes over a period. The smaller the number of vibrations, the lower the frequency. Ultrasonic sound vibrations are similar to those of sound audible to the human ear whose upper and lower limits are 15 and 20Khz. The frequency of ultrasonic sound is above 20Khz, is propagated in a directional

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Ultrasonic testing of hatchcover

fashion and is somewhat similar to that of a beam of light whose intensity diminishes with distance.

Ultrasonic waves produced by a transmitter placed within an enclosed space will be released through the smallest of openings. Thus any leakage of the sound may then be detected by a receiver or detector between frequencies of 36.7 and 40.7Khz and convert them into aural frequencies or into digitally reproduced information.

Whereas originally no class approval of the equipment was sought by the manufacturers and no training of operators was considered necessary, class type approval and operator training is undertaken by some manufacturers of ultrasonic equipment used in the testing of hatchcovers.

The training courses include:

- Principles of the technique.
- The ultrasonic equipment.
- Hatchcover types.
- Typical defects identified.
- Testing and reporting procedures.

The basic procedure comprises placing the transmitter in the cargo hold, switching it on, properly closing and securing the hatchcovers or access equipment to seaworthy requirements.

The ultrasonic waves emitted by the transmitter within the enclosed space will leak through the smallest of apertures. Location of leaked emissions in way of hatchcovers can be precisely detected from outside the hold by moving the hand-held detector along the periphery and cross seams of the covers. Evaluation of the extent of leakage can be established from a reading of the digital scale.

During testing by any of the above noted methods a record of the location and extent of any leakages detected should be kept. The hatches then opened, the causes of leakages, if any, identified – the defects rectified, covers re-secured and subjected to a further test which should prove them to be fully weather-tight.

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Part 3

Cargo pre-loading surveys

A shipowner is under an obligation to care for the cargo he is contracted to carry and he should therefore determine, at the stage when he takes delivery of the cargo, that the cargo he receives is exactly as described in the shipping documentation and, if not, should either refuse to ship the cargo or document the anomalies.

In most contracts of carriage, the shipowners' responsibilities begin at the time of loading and it is therefore important to inspect the cargo at this stage. Pre-shipment inspection of cargo is intended to determine and document the condition of the cargo at this time. This inspection is commonly referred to as the pre-loading survey. This survey can be carried out by the ship's master and officers, owners' representatives, or surveyors instructed by the owners depending on the trade and nature of the cargo. It is at this time that decisions have to be made, if the cargo is not as described in the shipping documentation, whether to reject the cargo or accept the cargo and adequately describe any differences on the mates' receipts and bills of lading. Early notification of any deficiencies to the shippers is desirable together with owner's intentions on rejection of the cargo or clausing the mate's receipts and bills of lading. This notification can be given direct to the shippers but is more commonly given to the agents, stevedores or charterers, depending on the owners' contractual relations.

Masters and deck officers employed by owners who trade their ships in liner services are usually trained to take care of pre-shipment inspections. Liner companies usually employ cargo superintendents, so if there is a problem the cargo superintendent can be called upon to assist. They may also have their own network of contracted surveyors who can be called upon quickly if an unusual cargo is to be loaded. Ships employed in the main bulk trades, (oil, grain, ore etc.) or specialised ships such as gas carriers and ro-ro vessels usually have sufficient and adequately trained masters and officers onboard to take care of any pre-shipment inspections that are necessary. It is however, the tramp operator who is chartered to carry steel products, paper products or break bulk cargoes, where the master and the ship's officers have little or no experience of these products that problems are often encountered. In many

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instances loading operations commence immediately upon the ship's arrival and there is little time for the ship's personnel to inspect the cargo. The ship's personnel will be unfamiliar with the port and the system of loading; they will not know the agents, who almost always will be the charterer's agents, and they will be put under pressure by the charterers and possibly a cargo superintendent employed by the charterer to load their ship as quickly as possible. It is in these circumstances that the employment of a competent local surveyor can be most useful and cost effective.

If owners decide they require a surveyor to attend their ship to carry out a pre-loading survey then the instructions given should be comprehensive, precise and given as early as possible allowing sufficient time for the surveyor to conduct an efficient survey. This will avoid confusion and disagreement at a later date when the surveyor presents his report and invoice. An instruction that the surveyor should 'carry out a pre-loading survey' is inadequate and leaves the surveyor in doubt as to how far his duties extend. In these circumstances the surveyor would simply inspect the cargo on the quay, possibly prior to the ship's arrival if all the cargo had been delivered, and report to the master on its condition and present his written report. Most surveyors would take their duties a little further and advise the master on the clausing of the mate's receipts and give advice on loading and stowage, if requested by the master, but more precise instructions would avoid confusion. Instructing and informing the surveyor should therefore include:

Relevant details in the contracts of carriage (charterparties) including:

- Clauses relating to damaged cargo, e.g. sometimes clauses state that damaged cargo should not be loaded or that specific clausing only is permitted on the bills of lading.
- Clauses relating to the responsibility for loading and stowage.
- Clauses relating to the issue of the mate's receipts and bills of lading.

Precise instructions on the survey:

- Whether the cargo should be inspected on the quay just before loading or

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in the transit shed or elsewhere prior to the ship's arrival etc. The nature of the cargo and time factor will probably determine this. In many cases the owners, charterer or ship's agent will not know where the cargo is stored in the port or when it is to be delivered. In this case the surveyor should be instructed to survey all cargo to be loaded as near to the time of shipment as possible.

- Information to be given to the master before the signing of the mate's receipts and whether the surveyor should formulate suitable clauses relating to any damage. Usually the surveyor should be instructed to be present when the master signs the shipping documents. At this time the surveyor can assist with any language problems and any disputes with shippers, agents or charterers in the clausing of mate's receipts and/or bill of lading.

Other additional services connected with loading

- Inspection of ship's hatchcovers and ship's ventilation system. (The findings of this inspection should be reported in a separate report or confidential side letter. This is to avoid any adverse information being disclosed if the pre-loading report is used in a cargo dispute).
- Advising the master on loading, stowage and securing.
- Monitoring the loading, stowage and securing.
- Advising and reporting on handling damage caused by stevedores.
- Advising on the tallying of the cargo and the issue of cargo documentation.
- Advising if the cargo can be loaded in rain.

If early instructions are given, the surveyor will have time to contact the agents and stevedores to find out the exact nature of the cargo, when it is arriving at the loading berth, and the proposed stowage on the ship.

Most shipowners will be aware that the employment of a competent surveyor for a 'precautionary' pre-loading survey in certain circumstances can eliminate or reduce problems and claims and the money spent is well worthwhile. The UK P&I Club and correspondents can assist and advise owners in arranging these surveys and in some exceptional circumstances will pay for the survey. This is particularly the case with finished or semi-finished steel products when the Club will always pay for a pre-loading survey if notified by the owners but not any associated services.

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Lashing and securing deck cargoes

For the purposes of this article, the reader's attention is drawn to the requirements of the IMO *Cargo Securing Manual Regulations* and the IMO *Code of Safe Practice for Cargo Stowage and Securing*.

The IMO cargo securing manual

Regulations VI/5 and VII/6 of the 1974 SOLAS Convention require cargo units and cargo transport units to be loaded, stowed and secured throughout the voyage in accordance with the cargo securing manual (CSM) approved by the administration and drawn up to a standard at least equivalent to the guidelines developed by the International Maritime Organization (IMO).

The guidelines have been expanded to take into account the provisions of the *Code of Safe Practice for Cargo Stowage and Securing* (the CSS Code), the amendments to that Code, the *Code of Safe Practice for Ships Carrying Timber Deck Cargoes*, and the codes and guidelines for ro-ro vessels, grain cargoes, containers and container vessels, and ships carrying nuclear waste and similar radioactive products. Such individual publications are subject to amendments which need to be carried into the appropriate section of the cargo securing manual as they occur.

As from 1 January 1998, it is a mandatory regulation for all vessels, other than exempted vessels such as dedicated bulk solid, bulk liquid, and gas-carrying vessels, to have onboard an approved and up-to-date cargo securing manual. Some administrations may exempt certain cargo-carrying ships of less than 500 gross tons and certain very specialised ships, but such exemption should not be assumed in the absence of a formal exemption certificate.

It is a mandatory requirement for masters and ships' officers to be conversant with the CSS Code and the CSM Regulations, to understand their applications for the vessel in which they are serving, and to be capable of deploying correctly the hardware which goes with it. All securing of cargo units shall be completed before the ship leaves the berth. The CSM and its associated hardware are subject to port state control inspection. Violation of the CSM requirements may give rise to vessel detention and/or prosecution of the master and owners.

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The CSS Code and CSM Regulations and their amendments contain much sound and well-tried advice, and should not be treated lightly. There are, however, a number of anomalies, and in some instances the applied text is difficult to reconcile with safe practice and sound seamanship. It is hoped that these shortcomings may be rectified by future amendments. In the meantime, the following suggestions may be found useful by ships' officers, loading superintendents, supercargoes, surveyors, and the like.

What is a deck cargo

The phrase 'deck cargoes' refers to items and/or commodities carried on the weather-deck and/or hatchcovers of a ship and thereon exposed to sun, wind, rain, snow, ice and sea, so that the packaging must be fully resistant to, or the commodities themselves not be denatured by such exposure. Even in ro-ro vessels, many areas above the actual 'hold' space can reasonably be considered as 'on deck' even though not fully exposed to the onslaught of wind and sea. The combined effects of wind, sea and swell can be disastrous. Where damage and loss occur to cargo shipped on deck at anyone's risk and expense, the shipowners, the master and his officers, and the charterers, must be in a position to demonstrate there was no negligence or lack of due diligence on their part.

Deck cargoes, because of their very location and the means by which they are secured, will be subjected to velocity and acceleration stresses greater, in most instances, than cargo stowed below decks. When two or more wave forms add up algebraically a high wave preceded by a deep trough may occur; this may be referred to as an 'episodic wave': a random large wave – noticeably of greater height than its precursors or successors – which occurs when one or more wave trains fall into phase with another so that a wave, or waves, of large amplitude is/are produced giving rise to sudden steep and violent rolling and/or pitching of the ship. These are popularly – and incorrectly – referred to as 'freak' waves; they are not 'freak', however, because they can, and do, occur anywhere at any time in the open sea. The risk is widespread and prevalent. The stowage, lashing, and securing of cargoes therefore require special attention as to method and to detail if unnecessary risks are to be avoided.

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Causes of losses

Unfortunately, despite all the loss-prevention literature available, there is a continuing incidence of the collapse and/or loss overboard of deck cargo items. Losses continue of large vehicles, rail cars, cased machinery, steel pipes, structural steelwork, packaged timber, freight containers, hazardous chemicals, boats, launches, etc. When investigated fully, the causes of such losses fall into the following random categories which are neither exhaustive as to number nor mutually exclusive in occurrence:

- Severe adverse weather conditions.
- Lack of appreciation of the various forces involved.
- Ignorance of the relevant rules and guiding recommendations.
- Cost limitation pressures to the detriment of known safety requirements.
- Insufficient time and/or personnel to complete the necessary work before the vessel leaves port.
- Dunnage not utilised in an effective manner.
- Inadequate strength, balance and/or number of lashings.
- Wire attachment eyes and loops made up wrongly, including incorrect methods of using bulldog grips.
- Lack of strength continuity between the various securing components.
- Taking lashing materials around unprotected sharp edges.
- Incorrect/unbalanced stowage and inadequate weight distribution.
- The perversity of shore-based labour when required to do the job properly.
- Securing arrangements, both supplied and approved, not fully utilised on the voyage under consideration.

This last point is particularly true of ISO freight containers and timber cargoes carried on the weather-deck, and of large commercial vehicles carried in ro-ro vessels.

All interests involved in the lashing and securing of deck cargoes should bear

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in mind that high expense in the purchase of lashing materials is no substitute for a simple design and a few basic calculations before lashing operations commence. Other than in ro-ro and purpose-built container operations where standardisation of gear and rapid loading and turnround times pose different problems, ship masters should be encouraged – on completion of lashing operations – to make notes of the materials used, to produce a representative sketch of the lashing system, to insist upon being provided with the test/proof certificates of all lashing components involved, and to take illustrative photographs of the entire operation. These, at least, will be of great assistance to the vessel's interest in the event of related future litigation.

General guidelines

The *Merchant Shipping (Load Lines) (Deck Cargo) Regulations 1968* (United Kingdom Statutory Instrument No.1089 of 1968) set out some of the general ideas to be followed when securing deck cargoes. The list of requirements is not exhaustive but provides a realistic base from which to work, and reads, *inter alia*:

"2. *Deck cargo shall be so distributed and stowed:*

1) *as to avoid excessive loading having regard to the strength of the deck and integral supporting structure of the ship;*

2) *as to ensure that the ship will retain adequate stability at all stages of the voyage having regard in particular to:*

   a) *the vertical distribution of the deck cargo;*

   b) *wind moments which may normally be expected on the voyage;*

   c) *losses of weight in the ship, including in particular those due to the consumption of fuel and stores; and*

   d) *possible increases of weight of the ship or deck cargo, including in particular those due to the absorption of water and to icing;*

3) *as not to impair the weathertight or watertight integrity of any part of the ship or its fittings or appliances, and as to ensure the proper protection of ventilators and air pipes;*

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4) *that its height above the deck or any other part of the ship on which it stands will not interfere with the navigation or working of the ship;*

5) *that it will not interfere with or obstruct access to the ship's steering arrangements, including emergency steering arrangements;*

6) *that it will not interfere with or obstruct safe and efficient access by the crew to or between their quarters and any machinery space or other part of the ship used in the working of the ship, and will not in particular obstruct any opening giving access to those positions or impede its being readily secured weathertight."*

Dunnage

If all deck cargo items could be structurally welded to the weather-deck using components of acceptable strength this would remove the necessity to consider coefficients of friction between the base of the cargo and the deck or dunnage on which it rests. Such is the large range of deck cargoes which do not lend themselves to such securing, however, that an appreciation of the sliding effect naturally raises the subject of coefficients of friction.

The values given for the coefficient of friction between dry timber and dry steel vary from 0.3 (17°) to 0.7 (35°), and between steel and steel sliding can occur at angles of inclination as small as 6°; but until some years ago there appeared to be no published data relating to the coefficient of friction between timber dunnage and the painted surface of steel decks or steel hatchcovers. Carefully controlled experiments were carried out in Liverpool under the author's supervision, using 9in x 3in x 8ft sawn pine deals, some of which had earlier been allowed to float in water; others had been stored in covered conditions so as to conform to normal atmospheric moisture content. The experiments were carried out on hinge-opening hydraulic-powered steel MacGregor hatchcovers in clean painted condition free of any unusual roughness and/or obstruction.

The tests used dry timber on dry covers; wet timber on dry covers; dry timber on wet covers; and, lastly, wet timber on wet covers. The lowest value – 0.51 (27°) – occurred with wet timbers on wet covers; the highest value occurred with wet timber on dry covers – 0.645 (33°).

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On the basis of such results the lowest value of 0.51 (27°) should be accepted as relating to the most common condition likely to be found on the weather-deck of a sea-going ship, i.e., wet timber on wet decks. Hence, with inclination, only, and without any effects likely to be introduced by velocity and/or acceleration stresses due to rolling and pitching, **timber dunnage alone will start to slide of its own accord at angles of inclination of 27°**. Thereafter, sliding will continue at progressively smaller angles. It follows that, when the vessel is rolling and pitching and timber dunnage is unsecured, it will begin to slide at angles of inclination considerably less than 27°.

From such results it follows that the normal practice of utilising timber dunnage and of keeping downward-leading lashings as short and as tight as possible should be continued and encouraged. A near vertical lashing is of great benefit in resisting the cargo item's tendency to tip; a near horizontal lashing will greatly resist sliding forces. Do not overload lashing terminals and/or shackles. Think in terms of the 'effective strength' of a lashing – its 'holding power'. Balance the 'slip-load' of an eye in a wire with the strengths of a shackle, a bottle-screw and a chain. A lashing is no stronger than its weakest part.

Spread the load

Point-loading and uneven distribution of cargo weight can, and frequently does, cause unnecessary damage to decks and hatchcovers. Unless the weather-deck has been specially strengthened, it is unlikely to have a maximum permissible weight-loading of more than 3 tonnes/m^2. Similarly, unless hatchcovers have been specially strengthened, it is unlikely they will have a maximum permissible weight-loading of more than 1.8 tonnes/m^2. The ship's capacity plan and/or general arrangement plan should always be consulted. If the information is not there, try the ship's stability booklet. In the event that specific values are not available onboard the ship, allow no more than 2.5 tonnes/m^2 for weather-deck areas; and no more than 0.75 tonnes/m^2 for hatchcovers in small vessels; 1.30 tonnes/m^2 in vessels over 100m in length. (The word *tonnef* used later in this article means *tonnes force.*)

The adverse effects of point-loading are not always fully appreciated. On the one hand, a 6 tonne machine with a flat-bed area of 3m^2 will exert a down-load of 2 tonnes/m^2 (Fig 1a).

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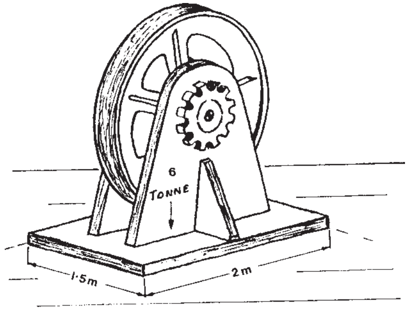
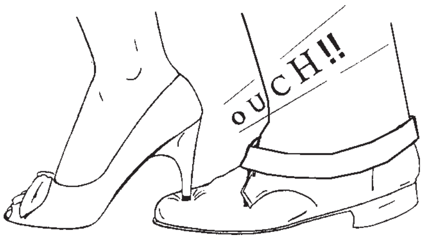
Fig 1a. The 6 tonne weight is exerting a down- loading of 2 tonnes/m^2



On the other hand, a lady of 60kg weight in evening-shoes with heel areas 50mm^2 (0.00005m^2) will exert a point-loading of 1200 tonnes/m^2 if, when dancing, she stands on your toe with all her weight on one heel (Fig 1b). Which is why our ladies are often more dangerous than machines!

Fig 1b. The heel of the lady's shoe is exerting a point-loading of 1200 tonnes/m^2.



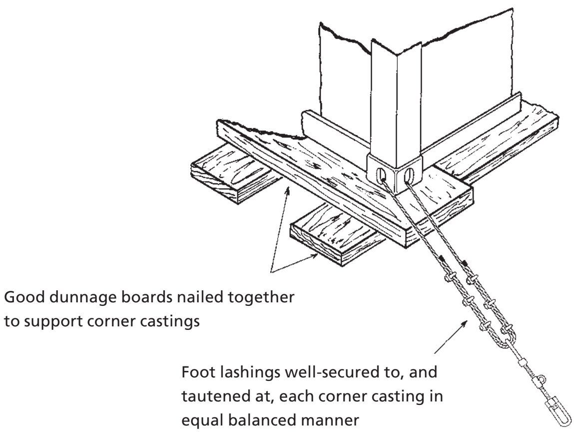
When exceptionally heavy weights are to be carried, it may be necessary to shore-up the weather-deck from below; but, again, care must be taken to spread the load on the tween deck so as not to overload that plating. In the not so dense range of cargoes, units of 20 to 40 tonnes weight are common today, and stacking of unit weights is widespread. If a piece of machinery weighing, say, 30 tonnes with a base area of 6m^2 is placed direct on the weather-deck the point-loading will be 30/6 = 5 tonnes/m^2. If, however, the deck plating has a maximum permissible loading of 2.5 tonnes/m^2 then the **minimum** area over which that 30 tonne load must be spread is 30/2.5 = 12m^2.

Good dunnage must be used to spread the load, and it is always good practice to add 5% to the weight to be loaded before working out the dunnage area. For the 30 tonne weight, for instance, 31.5 tonnes would be used and the dunnage area would go from $12m^2$ to $12.6m^2$.

Dunnage timber is often no more than 6"x1" (150 x 25mm) rough planking; but where weighty cargo items are involved dunnage should not be less than 50mm (2") thickness x 150mm (6") width, and preferably 75mm (3") x 225mm (9"). It is acceptable, however, to use two dunnage planks nailed together securely to make up the thickness. A dunnage width greater than 150mm is always acceptable – 225mm (9") to 305mm (12"), for instance; but where the thickness goes to 75mm (3") care must be taken to choose straight-grained timbers of as great a width as possible, and to ensure that they are laid with the grain horizontal and parallel with the deck. There have been incidents in the past where what appeared to have been a soundly-dunnaged and well-secured item of deck cargo broke adrift and was lost overboard due to a sequence of events commencing with the collapse of 3"x 3" dunnage timbers along the curved grain used on its edge, followed by consequential slackness in otherwise adequate lashing arrangements, followed by increasingly accelerated cargo movement and finally breakage of the lashings.

Because of the random nature of grain configurations in the thicker dunnage timbers it is acceptable to achieve thicknesses by nailing planks together. A 2" thick dunnage timber can be made up using 1" thick planks, and a 3" thick dunnage timber can be made up using 2" and 1" thick timber

Fig 2. The use of foot lashings with a twin-tier stack



planks, all securely nailed together. To a large degree, this will correct the tendency for separation in timber with a badly-aligned grain.

And remember, it will be as important to install good lower-level foot lashings as it will be to install downward-leading lashings if load-spreading dunnage is to remain fully effective.

Rolling periods

It is not the purpose of this article to deal with ship stability aspects, so far as those aspects may be avoided. However, it is worth repeating a few established and relevant stability facts. For instance, the roll period of a ship is the time taken to make one complete transverse oscillation; that is, from the upright position to starboard inclination, from starboard inclination back to upright and through to port inclination, thence back to upright. Hence, if the roll period is 15 seconds and if the roll to starboard is 10° and the roll to port is 11°, the total 'sweep' within the 15 second roll period will be 10°+10°+11°+11° = 42°.

When a ship rolls the axis about which the rolling takes place cannot generally be accurately determined, but it is accepted as being near to the longitudinal axis passing through the ship's centre of gravity. The time period of the roll is generally independent of the roll angle, provided that the roll angle is not large. Thus, a vessel with a 15 second roll period will take 15 seconds to make one full transverse oscillation when the roll angle (to port and to starboard) is anything from say 2° to 30°. The crux, from a cargo lashing viewpoint, lies in realising that a roll angle of 2° and a roll period of 15 seconds involves a 'sweep' of no more than 8°, whereas a roll angle of 20° and a roll period of 15 seconds involves a 'sweep' of 80° (ten times the arc) **in the same time**. The first will be barely noticeable; the second will be violent and will involve large transverse acceleration stresses particularly when returning to the upright.

Equally important is consideration of vertical acceleration as the ship pitches and scends. Calculation of this force is not so simple, but measured values give results varying from 0.5g amidships to 2g at the far forward end of the ship.

A 'stiff' ship is one with a large GM (metacentric height); difficult to incline and returns rapidly to the upright and beyond, sometimes with whiplash effect.

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This imposes excessive acceleration stresses on cargo lashings. A 'tender' ship is one with a small GM; easy to incline and returns slowly to the upright, sometimes even sluggishly. Although acceleration stresses are small the inclined angles may attain 30º, and the simple gravitational effects of such angles and slow returns may impose equally excessive stresses on cargo lashings. Try to avoid the extremes of either condition. And it is worthwhile working on the assumption that, if deck cargo is to remain safely in place during severe adverse weather conditions, the lashing arrangements should be sufficient to sustain 30º roll angles associated with 13 second roll periods, and 5° pitch angles associated with not less than 1g vertical acceleration.

Rule-of-thumb for lashing strength

The seaman's basic rule-of-thumb for securing cargoes with a tendency to move during a moderate weather voyage is simply that the sum of the minimum breaking-loads of **all** the lashings should be not less than twice the static weight of the item of cargo to be secured. That is, a single item of 10 tonnes weight requires the lashings used to have a total breaking-load of not less than 20 tonnes – on the positive assumption that the lashings are all positioned in a balanced, efficient, and non-abrasive manner. This rule may be adequate, or even too much, below decks – though not necessarily so in all instances – **but it will not be adequate on the weather-deck in instances where calm seas and a fair weather passage cannot be guaranteed.**

In circumstances where, for **any time** during a voyage, winds of Force 6 and upwards together with associated wave heights are more likely to be encountered, the increased stresses arising therefrom are those here considered, allowing for 30º roll angles with not less than 13 second roll periods. (And see Tables 3 and 4, herein, taken from the CSS Code and the CSM Regulations.)

In such cases, the sailor's rule-of-thumb – the **'3-times rule'** – tends to be that the sum of the **safe working load** of all the lashings shall equal the static weight of the cargo item to be secured; **the safe working load** being arrived at **by dividing by 3** the minimum breaking-load/slip-load/holding power of the lashings. In other words, if the breaking-load/slip-load/holding power of **all** the lashings is 30 tonnes, then they can safely hold an item whose static weight is

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10 tonnes – **again on the assumption that all securing arrangements are deployed in a balanced, efficient, and non-abrasive manner.** The author is not aware of any failures of lashings/securing arrangements or loss of deck cargo where this **'3-times'** rule-of-thumb has been applied in a sensible manner.

It is not arbitrary, however, because it is derived from the International Load Line Rules within which framework the United Kingdom Department of Transport, in earlier Instructions to surveyors, gave the following guidance, *inter alia*:

"When severe weather conditions (i.e. sea state conditions equal to or worse than those associated with Beaufort Scale 6) are likely to be experienced in service the following principles should be observed in the design of the deck cargo securing arrangements:

(iv) Lashings used to secure cargo or vehicles should have a breaking load of at least 3 times the design load, the design load being the total weight of the cargo or cargo plus vehicle subjected to acceleration of:

0.7 'g' athwartships,

1.0 'g' vertically and

0.3 'g' longitudinally,

relative to the principal axis of the ship.

"When sea state conditions worse than those associated with Beaufort Scale 6 are unlikely to be experienced in service, a lesser standard of securing such items of cargo might be acceptable to approval by the Chief Ship Surveyor.

"The equipment and fittings used to secure the deck cargoes should be regularly maintained and inspected."

To condense those recommendations into a form simple to apply, reference should be made to the paragraph enclosed within the horizontal lines above. Put into practical and approximate terms, and using the phrase **'holding** power' to indicate 'breaking-load/slip-load/holding power', this means:

- The total holding power, in tonnes, of all lashings holding the cargo item vertically downward to the deck should be equivalent to three times the ordinary static weight of the cargo item in tonnes: i.e. a 10 tonne cargo item requires total lashings having a holding-down potential of 30 tonnes.
- The holding power, in tonnes, of all lashings preventing the cargo item moving to port and to starboard should be equivalent to seven-tenths of the holding-down potential of item 1, above: i.e. a 10 tonne item requires lashings with holding power preventing transverse movement of 21 tonnes.
- The holding power, in tonnes, of all lashings preventing the cargo moving forward or aft should be equivalent to three-tenths of the holding-down potential of item 1, above: i.e. a 10 tonne item requires lashings with holding power preventing longitudinal movement of 9 tonnes.

The IMO 1994/1995 amendments to the CSS Code (now carried forward into the requirements for the preparation of the CSM) changes the emphases of the foregoing paragraphs as discussed hereunder:

The CSM 'rule-of-thumb' varies as the MSL of the different lashing components, as listed in its *(Table 1)* – shown on the next page – giving rise to five different answers to the one problem. For the most part, vertical acceleration is replaced by a 1g transverse acceleration, and vertical and longitudinal accelerations are not quantified except, that is, in the instance of containers of radioactive wastes, and the like, when accelerations shall be considered to be 1.5g longitudinally, 1.5g transversely, 1.0g vertically up, and 2.0g vertically down. To date, the IMO have not offered an explanation as to why a tonne of radioactive waste should be considered to 'weigh' twice as much as, say, a tonne of tetraethyl lead or some other equally noxious substance.

The rule-of-thumb method given in Section 6 of the current CSS Code amendments indicates that the MSL values of the securing devices on each side of a cargo unit (port as well as starboard) should equal the weight of the unit, and a proposed amendment to Table 1 in Section 4 of the Code now provides MSLs as follows:

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Table 1. Determination of MSL from breaking strength

Material	MSL
Shackles, rings, deckeyes, turnbuckles of mild steel	50% of breaking strength
Fibre rope	33% of breaking strength
Wire rope (single use)	80% of breaking strength
Web lashing	50% of breaking strength (was 70%)
Wire rope (re-useable)	30% of breaking strength
Steel band (single use)	70% of breaking strength
Chains	50% of breaking strength

"For particular securing devices (e.g. fibre straps with tensioners or special equipment for securing containers), a permissible working load may be prescribed and marked by authority. This should be taken as the MSL. When the components of a lashing device are connected in series (for example, a wire to a shackle to a deckeye), the minimum MSL in the series shall apply to that device."

Say that a cargo unit of 18 tonnes mass is to be secured using only shackles, web lashings, chains and turnbuckles – all MSLs of 50% breaking strength (BS). The unit will require 18 tonnef MSL on each side, namely, 36 tonnef total MSL (72 tonnef BS for these items), representing a **total lashing breaking strength to cargo mass** ratio of 72/18 =4.

Secure the same cargo unit with steel band, only. Total MSL required will still be 36 tonnef (72 tonnef BS) but the MSL of steel band is nominated as 70% of its breaking strength – so this gives a total lashing breaking strength of (36x100)/70 = 51.42 tonnef, representing a **a total lashing breaking strength** to **cargo mass** ratio of 51.42/18 = **2.86**.

Do the calculation using wire rope, re-useable, and the answer is (36x100)/30 = 120 tonnef: ratio 120/18 = **6.67.** For wire rope, single use, the answer is (36x100)/80 = 45 tonnef: ratio 45/18 = **2.5**, and for fibre rope the ratio is **6**. And these ratios (or multipliers) remain constant for equal cargo mass. (If you do the same calculations using, say, 27 tonnes and 264 tonnes cargo mass, you will finish up with the same **4, 2.86, 6.67, 2.5** and **6** ratios (or multipliers). If a

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component was assigned a 66.67% MSL the result would be a ratio of **3** – the *three-times rule* multiplier.

The CSS Code is here changing the seaman's commonly-held understanding of the term 'rule-of-thumb' – a single multiplier easy to use and general in application – by inserting the MSL percentages to produce a range of rule-of-thumb multipliers.

Just to labour the point. If the cargo mass to be secured was 18 tonnes, and we use the five results obtained by using Sections 4 and 6 of the Code, the total lashing breaking strength required in each instance would be: 72 tonnef, or 51.48 tonnef, or 120.06 tonnef or 45 tonnef or 108 tonnef – and that seems to be an enigma at odds with commonsense!

One way of partly rationalising this 'enigma' is to create an additional column on the right-hand side of the MSL Table 1, as follows:

Table 2. Determination of MSL from breaking strength, including rule-of-thumb multipliers

Material	**MSL**	**ROT multiplier**
Shackles, rings, deckeyes, turnbuckles of mild steel	50% of breaking strength	4.00
Fibre rope	33% of breaking strength	6.06
Wire rope (single use)	80% of breaking strength	2.50
Web lashing	50% of breaking strength (was 70%)	4.00
Wire rope (re-useable)	30% of breaking strength	6.67
Steel band (single use)	70% of breaking strength	2.86
Chains	50% of breaking strength	4.00
(Compare with overall general component)	*(60.67% of breaking strength)*	*(3.00)*

By looking at Table 2 – and in respect of any cargo mass – you can use the multipliers without going through all the calculations required by the Sections 4 and 6 route and, more importantly, you will be able to see clearly the extent to

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which the MSL multipliers degrade or upgrade the generally accepted **three-times rule**.

In the instance of the 18 tonne cargo unit given above, the lashings total breaking strength would be 54 tonnef when the three-times rule is applied. Simply 18x3=54 tonnef total BS, that is:

Cargo mass x Rule number = Lashings total breaking strength

Correction factors

While the **three-times rule** rule-of-thumb may be considered adequate for the general conditions considered above, Section 7 of the CSS Code Amendments provides Tables 3 and 4 where GMs are large and roll-periods are less than 13 seconds, and those Tables, reproduced below, provide a measured way of applying that extra strength.

Table 3. Correction factors for length and speed

Length (m)	50	60	70	80	90	100	120	140	160	180	200
Speed (kn)											
9	1.20	1.09	1.00	0.92	0.85	0.79	0.70	0.63	0.57	0.53	0.49
12	1.34	1.22	1.12	1.03	0.96	0.90	0.79	0.72	0.65	0.60	0.56
15	1.49	1.36	1.24	1.15	1.07	1.00	0.89	0.80	0.73	0.68	0.63
18	1.64	1.49	1.37	1.27	1.18	1.10	0.98	0.89	0.82	0.76	0.71
21	1.78	1.62	1.49	1.38	1.29	1.21	1.08	0.98	0.90	0.83	0.78
24	1.93	1.76	1.62	1.50	1.40	1.31	1.17	1.07	0.98	0.91	0.85

Table 4. Correction factors for B/GM <13

B/GM	7	8	9	10	11	12	13 or above
on deck, high	1.56	1.40	1.27	1.19	1.11	1.05	1.00
on deck, low	1.42	1.30	1.21	1.14	1.09	1.04	1.00
‘tween deck	1.26	1.19	1.14	1.09	1.06	1.03	1.00
lower hold	1.15	1.12	1.09	1.06	1.04	1.02	1.00

NOTE: The datum point in Table 3 is length of ship 100m, speed of ship 15 knots and, in Table 4, B/GM = 13.

A word of caution. Ships’ officers may care to ignore in Table 3 any correction factor less than 1, as shown shaded. For all those values less than 1 let the rule-of-thumb calculation stand on its own and only apply the Table 3 factors

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when the values are greater than 1. This way the safety of the **three-times rule** or any other rule-of-thumb you may care to use will not be compromised.

Section 5 of the current CSS Code Amendments says:

"5 Safety Factor

Within the assessment of a securing arrangement by a calculated balance of forces and moments, the calculated strength (CS) of securing devices should be reduced against MSL, using a safety factor of 1.5, as follows:

$$CS = \frac{MSL}{1.5}$$

The reasons for this reduction are the possibility of uneven distribution of forces among the devices, strength reduction due to poor assembly and others.

Notwithstanding the introduction of such safety factor, care should be taken to use securing elements of similar material and length in order to provide a uniform elastic behaviour within the arrangement."

Many people were puzzled by that expression CS=MSL/1.5 appearing where it did in the text, because the phrase **calculated strength** appeared to have no direct relationship to the Sections 1, 2, 3 and 4 preceding it, nor did it sit easily with any attempt to apply it to Section 6 which followed it. It can now be stated with some authority that Section 5 (other than the third paragraph thereof) and its CS=MSL/1.5 expression **does not relate to, nor should any attempt ever be made to apply it to, Section 6 or any other rule-of-thumb,** other than the admonition in the third paragraph relating to securing elements of similar material and length.

Section 5 and its CS=MSL/1.5 are wrongly placed in the text. They relate to the **Advanced Calculation Method** illustrated in Section 7. To make sense of Section 5 there is currently a proposed amendment to Annex 13 indicating that the expression should be re-sited under paragraph **7.2.1.** In Section 7 **calculated strength** is used within a set calculation method, and it is in that sense and in that context that **calculated strength (CS)** should be applied. So, unless you are involved with a full **advanced calculation method,** just ignore

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CS=MSL/1.5; and note that the **advanced calculation method** itself, is also under review. Readers should be alert to the likely soon promulgation of formal amendments to these aspects**;** act accordingly and avoid using the advanced calculation method for the time being.

Breaking strengths

Within the CSS Code and the CSM Regulations the phrase *breaking strength* is not defined. Within the context of those two documents, however, the phrase *breaking strength* could reasonably be taken to mean *the point at which the component, material or element can no longer support or sustain the load,* pending some possible amendments by the IMO.

The CSS Code defines the values of maximum securing loads (MSL) of mild steel components for **securing** purposes as 50% of breaking strength (see Table 1). The 1997 amendments to the CSM require such components *inter alia* to have '**identification marking**', '**strength test result or ultimate tensile strength result**' and '**maximum securing load* (MSL)**', all to be supplied by the manufacturer/supplier with information as to individual uses, and/ strengths/MSL values to be given in kN – kiloNewtons. (To convert kN to tonnes force (tonnef) – multiply by 0.1019761, or for a rough value, divide by 10).

* The CSS Code 1994/95 amendments say:

> *"**Maximum securing load** is to securing devices as **safe working load** is to lifting tackle."*

and Appendix 1 of the 1997 amendments to the CSM says:

> *"**Maximum securing load (MSL)** is a term used to define the allowable load capacity for a device used to secure cargo to a ship. **Safe working load (SWL)** may be substituted for MSL for securing purposes, provided this is equal to or exceeds the strength defined by MSL."*

This latter definition is included in the proposed amendment to Annex 13 of the CSS Code.

There are difficulties likely to result from this mix of terms which raise questions about the validity of the cargo securing manuals issued and/or approved to date by the various national administrations, and the other

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approved certifying organisations. If the components are not identifiable by at least their MSLs, they are not complying with the CSM Regulations. To overcome this problem it has been suggested in the relevant quarters that all aspects could be safely met by attaching, with suitable wire, small coloured metal tags stamped with the MSL of the component, much as is currently required for components approved for the securing of timber deck cargoes. Responses received from the industry to date would give positive support to this proposal.

The Committee's advice to ships' officers and others trying to apply the requirements of the CSM/CSS Code is this: if the chains, shackles, rings, and the like, available to you are not clearly identified as to their MSLs (**and remember, they should be so identified**) use the stamped SWL of a lifting shackle as required by the CSM/CSS Code, thereby using a component which may have a breaking strength two-times greater than is needed, but you will have complied with the letter of the Regulations. Alternatively, it is suggested that the best method may be to multiply the stamped SWL value by 4 to obtain the breaking strength, and apply the percentages given in Table 1 to obtain the MSL – **and then remove that component from any possibility of use for lifting purposes by tagging it.** This should then have fulfilled the spirit of the Regulation without resorting to the use of massively oversized lashing components.

Wire rope

It is recommended that for efficient lashing purposes wire ropes should be round-stranded, flexible and not so great in diameter as to make their use cumbersome. The most common of such general purpose wires is 16mm diameter (2" circumference) of 6x12 construction galvanised round strand with 7 fibre cores having a certificated minimum breaking load of 7.74 tonnef (tonnes force). This is the cheapest wire for its size, will turn easily around thimbles and lashing points, can be spliced or bulldog gripped without difficulty and is easily handled.

Other wires of different construction and of varying sizes or strength may be needed for particular lashing purposes and the certificated minimum breaking load should always be verified before taking such wires into use.

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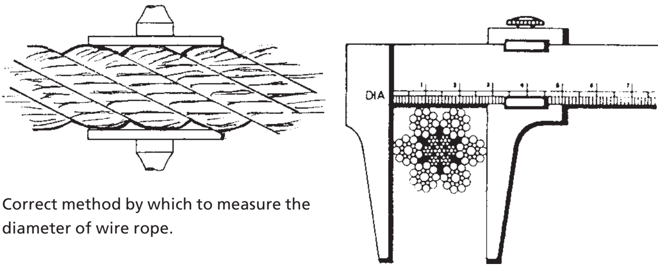
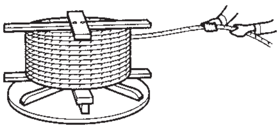
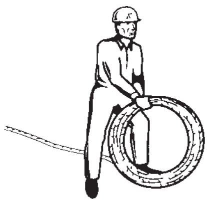
Fig 3. Wire rope



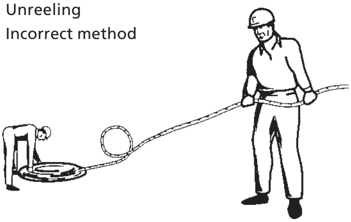
Correct method by which to measure the diameter of wire rope.

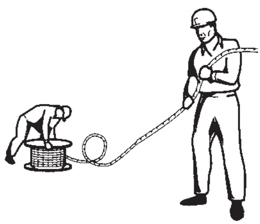
Uncoiling
Correct method





Unreeling
Incorrect method





In some instances wires intended for use as lashings are supplied pre-cut to precise length and with eyes or attachment devices already formed in one or both ends. Such purpose-made items are usually sold with certificates stating the test load and minimum break load applicable. If test certificates are not supplied then they should be requested. More commonly the wire is supplied in coils and must be cut to length onboard ship with eyes and attachment devices formed and fitted as required. Where this is the case, eyes formed by bulldog grips must be made up in accordance with the manufacturer's instructions otherwise the eye terminations will tend to slip under loads very much smaller than the certificated breaking load of the wire.

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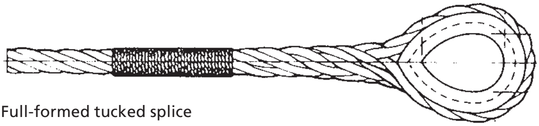
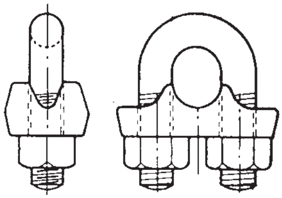
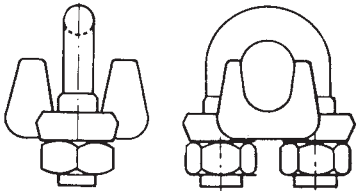
Fig 4. Grips and clips



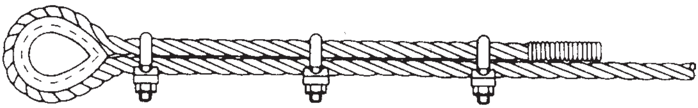
Full-formed tucked splice



Bulldog grip



Crosby clip



Bulldog grips applied correctly

The WRONG WAY to apply bulldog grips

The application of bulldog grips

Experience continues to show that the most common cause of lashing failure is the incorrect application of bulldog grips. Tests indicate that where an eye is formed around a thimble in the correct manner the lashing arrangement will hold secure with loads up to or even in excess of 90% of the nominal break-load (NBL) of the wire before slipping or fracturing, although it is usual and recommended to allow not more than 80%. Without a thimble, the eye when made-up correctly, can be expected to slip at loads of about 70% of the NBL. Where the correct procedures are not followed slippage is likely to occur at much reduced loads. Under strictly controlled conditions, more than 100 tests were applied on a licensed test bed on 16mm and 18mm wire rope lashing configurations. The configurations tested were as illustrated in Fig 5 a, b and c.

As a result of such tests the following recommendations are made:

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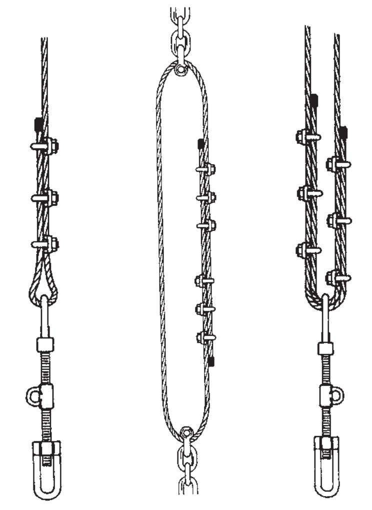
It should be stressed that these recommendations relate to cargo lashings only. Lifting gear and other statutory applications require a minimum of 4, 5 and 6 grips for 16mm diameter wire and upwards, respectively. It is also most important to ensure that the bulldog grips are of the correct size in order to correspond with the diameter of the lashing wire.

Recommended minimum number of bulldog grips for each eye – lashing purposes only:

Diameter of wire rope (mm)	Wire rope grips
Up to and including 19	3
Over 19, up to and including 32	4
Over 38, up to and including 44	6
Over 44, up to and including 56	7

An allowance of 150mm should be made between the last bulldog grip and the end of the 'dead' wire. It is important to ensure that the lashing wires

Fig 5. Configurations tested



5a. Single eye at each end | **5b.** Single loop | **5c.** ½ double grommet are not cut short immediately next to the bulldog grips. The end of the 'dead' wire should be tightly taped.

- Bulldog grips have a grooved surface in the bridge piece which is suitable for a standard wire of right-hand lay having six strands. The grips should not be used with ropes of left-hand lay or of different construction. Crosby grips have a smooth surface in the bridge piece. The first grip should be applied close to the thimble or at the neck of the eye if a thimble is not used. Other grips should be placed at intervals of approximately six rope diameters apart (i.e., 96mm with a 16mm diameter wire; 108mm with an 18mm diameter wire).

Fig 6. Correct application of Bulldog grips

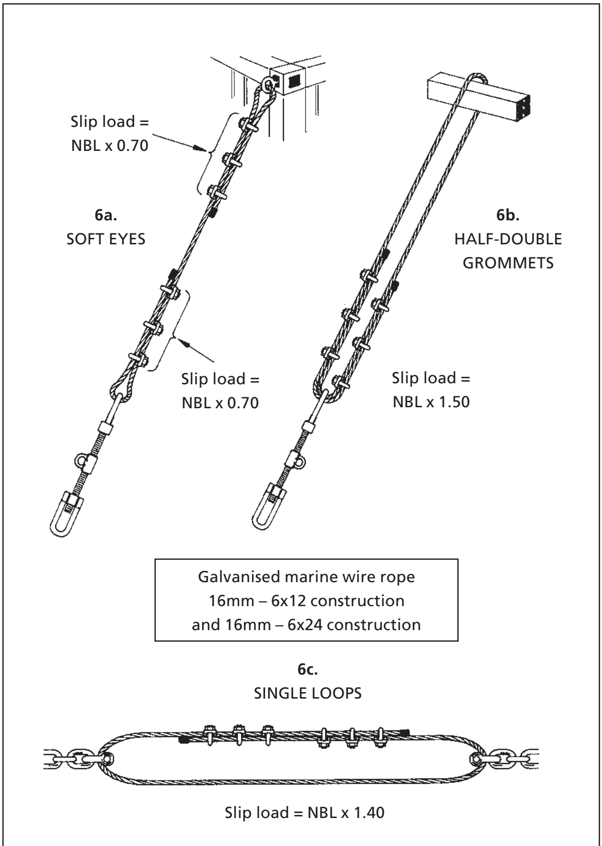
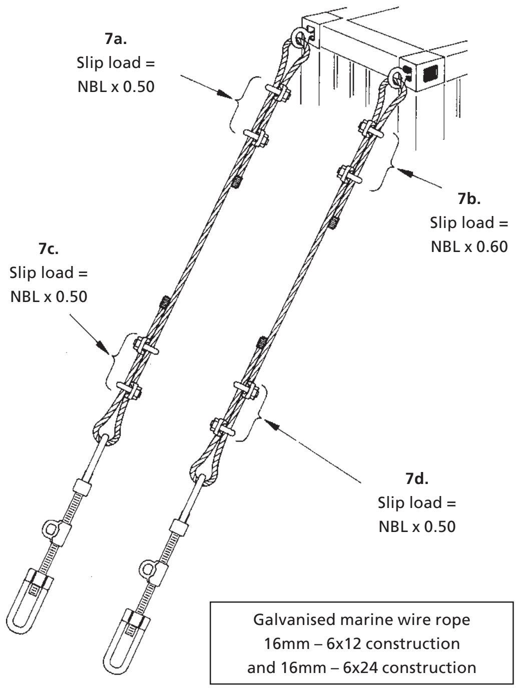


Fig 7. Soft eyes – some other representative slip loads



- The grips must all face in the same direction and must be fitted with the saddle or bridge applied to the working or hauling part of the rope. The U-bolt must be applied to the tail or dead-end of the rope as illustrated in Fig 6a. If the grips are not applied as indicated, the effectiveness of the eye can be seriously affected.
- Ideally, all the nuts on the grips should be tightened using a torque wrench so that they may be set in accordance with the manufacturers' instructions. In practice it may be sufficient to use a ring spanner although thereafter all the nuts should be checked periodically and adjusted as necessary.
- Should a connection slip under load, it is likely that initially the rate of slip will be accelerated. The rate may then decrease, but until the load is removed the slip will not be completely arrested.

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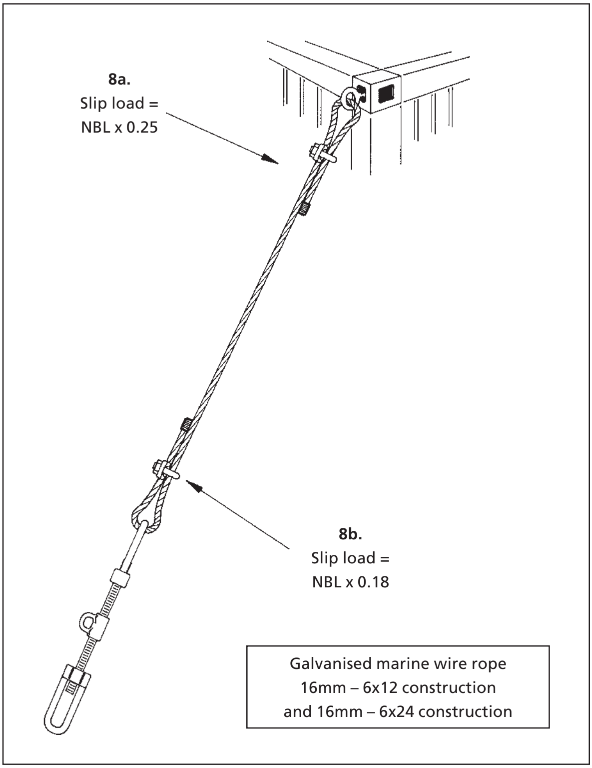
Lashing and securing deck cargoes

Fig 8. Soft eyes – UNSAFE application of Bulldog clips



- As mentioned earlier, if three grips are applied in the correct manner and with an eye formed around a thimble (a hard eye) the eye will not fail or slip at loads of less than 80-90% of the NBL. Without a thimble the eye (a soft eye) made-up correctly can be expected to slip at loads in excess of about 70% of the NBL. See Fig 6a. This is referred to below as the 'slip-load' or 'holding power' of the eye.
- The use of half-double grommets is widespread and it is sometimes wrongly assumed that the holding power will be twice the NBL of the wire. In fact, tests show that the slip-load will be only 1.5 times the NBL. See Fig 6b. The holding power also decreases as the number of grips is reduced. See Fig 9 and Fig 11b.
- The use of bulldog grips to join two ends of wire rope is to be avoided:

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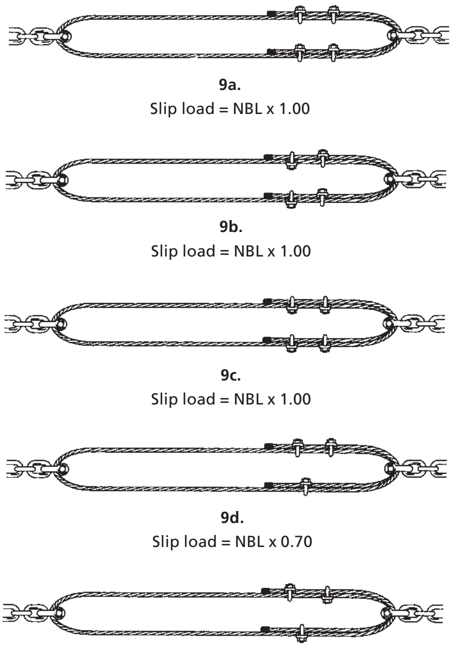
again, it is sometimes wrongly assumed that this will provide a holding power of twice the NBL. In a single loop with six grips being used, (see Fig 6c) the slip-load will be about 1.4 times the NBL. The holding power decreases as the number of grips is reduced. (See Figs 10 and 11).

- In a soft eye, with 2 grips, and with one or both used in the reverse manner (see Fig 7 a, b and c) the eye can be expected to slip at loads of about 50% NBL. These configurations are the least efficient and, as indicated, the holding power is at most half the nominal break load of the wire.
- With a soft eye using only one grip the slip-load was found to be 0.25 NBL with the grip positioned correctly (Fig 8a) and 0.18 NBL with grip reversed (Fig 8b).

Fig 9. Half-double grommets –
some other representative slip loads



9a.
Slip load = NBL x 1.00

9b.
Slip load = NBL x 1.00

9c.
Slip load = NBL x 1.00

9d.
Slip load = NBL x 0.70

9e.
Slip load = NBL x 0.70

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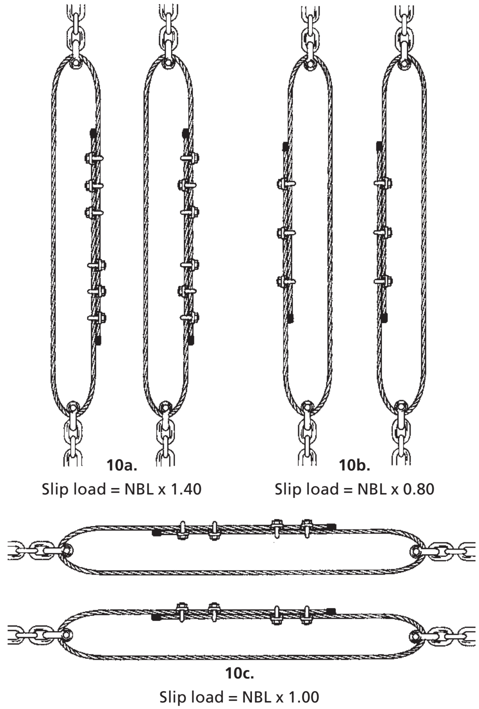
Fig 10. Single loops –
some other representative slip loads



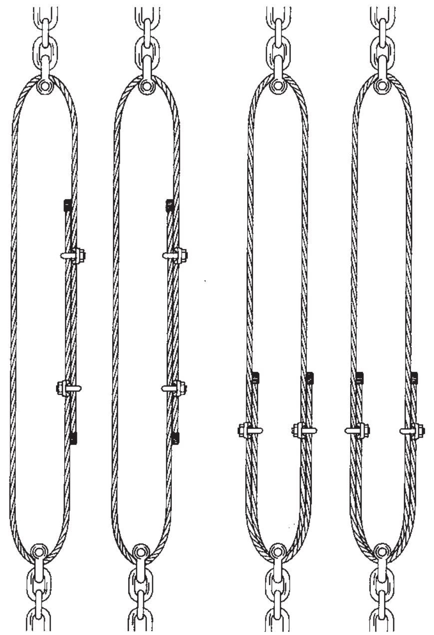
- A turnbuckle with a thread diameter of 24mm or more can be adjusted to set up a pre-tension of about 2 tonnes. If such a turnbuckle were attached to an eye made up in 16mm wire as shown in Fig 8 a and b, full tension in the wire would not be attained and the eye would slip at the grip under the pull of the turnbuckle, alone.

A word of caution before deciding to use half-double grommets (at NBL x 1.5) and single loops (at NBL x 1.4) as opposed to single eyes (at NBL x 0.7). At one terminal end in the instance of a half-double grommet, and at each terminal end in the instance of a single loop, there is no more material than at the terminal end of a soft eye.

If a properly made-up single loop breaks adrift, you have immediately lost twice the holding power allowable for a soft eye; if a properly made-up half-double grommet breaks adrift, you have lost more than twice the holding power allowable for a soft eye; so it is most important to ensure that the terminal ends are connected by shackles or some other form of smooth, non-sharp-edged, component.

For instance: Instead of 25 single eyes, for convenience and time saving, you use 12 half-double grommets of 16mm 6 x 12 wire to secure a 46-tonne item of deck cargo. If one of the half-double grommets fractures at a poor terminal connection you lose 8.3% of the total holding power; if a soft eye had failed you would have lost only 4% of the total holding power. As remarked earlier, lashing and securing of deck cargoes is not an exact science: it's frequently a case of a balanced trade-off, but the trade-off should be based on information and a few quick calculations the basis for which this article hopefully provides.

Fig 11. NOT recommended



Slip load = NBL x 0.40

Eyes and similar terminal ends in wire lashings should never be formed by the use of round turns and half hitches. Experience shows that initial slackness is seldom taken up sufficiently and that, even when it is, the turns and hitches tend to slip and create sharp nips leading to failure of the wire at loads well below those to be expected for eyes properly formed by the use of bulldog grips.

When attaching wires to lashing terminals on the ship's structure or the cargo itself every means should be taken to avoid hard edges, rough chaffing points, and sharp nips at the eye. Even where thimbles are not used the attachment of the eyes of the wire to lashing terminals may best be accomplished by using shackles of the appropriate size and break load.

Plastic coated wires

Plastic (PVC) coated galvanised standard marine wire of 18mm diameter and 6x24 construction is commonly used for various purposes where there is a need to avoid the risk of cutting or chafing. Such wire should be used with caution. Tests have revealed that if plastic covered wire is used in conjunction with grips, slippage is likely to occur at much reduced loads than would be the case for unprotected wire of the same size and characteristics. The plastic coating should be stripped from the wire where the bulldog grips are to be applied and from the surface of any wires coming into contact with each other.

Fire and explosion hazards

If lashing terminals are to be welded while or after loading cargo, great care should be exercised. Before undertaking any hot-work it is important to obtain a hot-work certificate from the local port authority. The authority should also be in possession of all relevant information relating to ship and cargo. The welders themselves should be properly qualified and competent and, if welding is taking place either on deck or under decks, a proper fire watch should be mounted both at and below the welding site. Adequate fireproof sheeting should be spread below welding points. On deck, fire hoses should be rigged with full pressure on the fire line. A watchman should be posted for at least four hours after the completion of welding and a ship's officer should examine all spaces before they are finally battened down. **Do not neglect these precautions. If in doubt, do not weld.**

Positive action

When you see something being done badly or wrongly, stop the work and have it re-done correctly. When rigging foremen, stevedore superintendents and charterers' supercargoes insist on doing things wrongly and say they have always done it that way successfully, tell them they've just been lucky! Then make them do it correctly

One important aspect remains – ensure that the lashing points on the ship are sufficient in number and adequate in strength for the lashings they will hold.

Chain

The use of chain alone for the securing of general deck cargoes is not widespread. Where chain lashings are used they tend to be supplied in precise lengths already fitted with terminal points and tightening devices.

The advantage of using chain resides in the fact that under the normal load for which the chain is designed it will not stretch. Thus, if all chain lashings are set tight before the voyage and the cargo neither settles nor moves, nothing should cause the chain to lose its tautness. Hence it is widely used in the securing of freight containers, timber cargoes and vehicle trailers.

In general chain for non-specific uses is awkward to handle, tiresome to rig, difficult to cut to length, and does not render easily. For general purposes it is most effectively used in relatively short lengths in conjunction with or as a part of lashings otherwise composed of wire or webbing.

Webbing

The use of webbing slings and webbing lashings for cargo securing purposes has steadily increased over the past years. Operational results differ widely. There are instances where webbing is ideal for securing deck cargoes and there are other instances where it should be used with caution.

Special large bore pipes made of reinforced plastic or provided with contact sensitive outer coatings make webbing an ideal securing medium because its relatively broad flat surfaces and reduced cutting nature allow it to be turned

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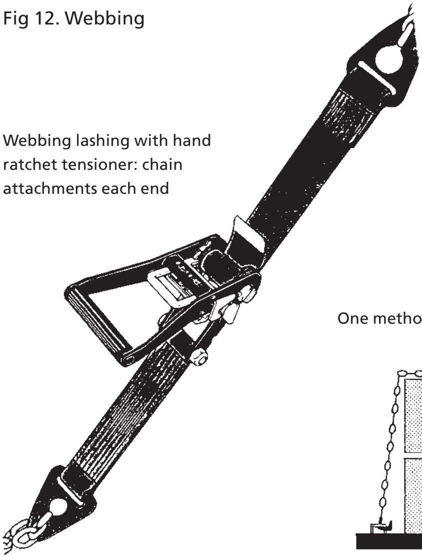
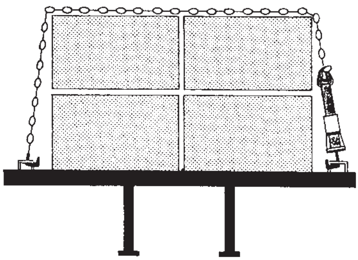
Fig 12. Webbing



Webbing lashing with hand ratchet tensioner: chain attachments each end

One method of using webbing and chain lashings



around and tightened against the pipes with short spans, producing a most acceptable stowage. On the other hand large, heavy, crated items or high standing heavy machinery where relatively long spans may be involved require wire or chain lashings, because sufficient unsupported tension is difficult to apply with webbing alone, although some of the ‘superlash’ systems now available can overcome this problem effectively.

Webbing in general is manufactured from impregnated woven polyester fibre and therefore will stretch more than wire rope. It is supplied in reels and may be easily cut and fashioned to any required length. Webbing should not be used without clearly confirming from the manufacturer’s literature its nature, breaking load and application. Recent independent tests confirm that good quality webbing will not fracture at loads less than those specified by the manufacturers. Tension on a hand ratchet can be obtained easily up to 0.54 tonnes and then with increasing difficulty up to a maximum of 0.60 tonnes. A spanner or bar must never be used to tighten a hand tension ratchet since recoil could seriously injure the user.

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Webbing should be kept away from acid and alkalis and care taken to ensure that it is never used to secure drums or packages of corrosive materials or chemicals which, if leaking, might affect it. All webbing should be inspected frequently and if re-used care taken to ensure that all lengths are free of defects. Protective sleeves should be used between webbing and abrasion points or areas. For securing ISO freight containers use only those webbing systems designed for such purpose.

Fibre rope

Ropes of up to 24mm in diameter are handy to use but are more likely to be found on cargoes that are stowed below decks. The use of fibre ropes for weather-deck cargoes should be restricted to light loads of limited volume in areas that are partly sheltered by the ship's structure. The reason for this is that where such ropes are used on deck difficulty is likely to be encountered in maintaining the tautness of the lashings when they are subjected to load stresses and the effects of wetting and drying out in exposed situations. The use of turnbuckles should be avoided: they may quite easily overload the rope lashing and create the very failure conditions, which they are designed to avoid. The tautening of rope lashings is best achieved by the use of bowsing ropes and frappings. At 24mm diameter, a sisal rope has a breaking strain of 7.5 tonnes, and a polyester rope 9 tonnes.

Composite rope, frequently referred to as 'lashing rope' is made up of wire fibres and sisal or polypropylene fibres which are interwoven thus adding to the flexibility of sisal and polypropylene some of the strength of steel. It is most frequently supplied in coils of 10mm diameter. The breaking strain of composite ropes should be considered as about 0.8 tonnes for sisal based and 1.8 tonnes for polypropylene based ropes.

Nylon fibre absorbs between 8% and 9% of water: the overall effect when under load is to reduce its effective strength by about 15%. Premature failure of nylon rope occurs under limited cyclic loading up to 70% of its effective strength. Therefore nylon rope is not recommended for deck cargo securing purposes.

The figures for breaking strain, which are quoted above, refer to new material and not to rope which has been in use for any length of time.

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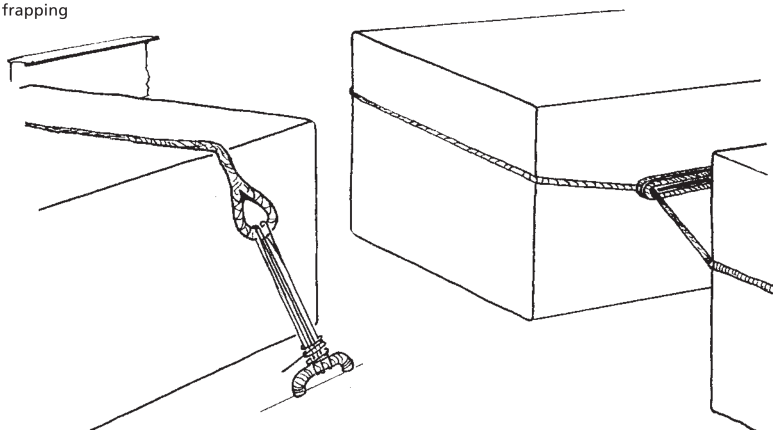
Shackles

Shackles are supplied in several shapes, sizes and strengths of material. The two shapes most commonly used for general cargo lashing purposes are the D-shackle and the Bow-shackle each with an eyed screw-pin. When using shackles it is correct to define their strength in terms of the safe working load although, as indicated earlier in this article at Table 1, *et al*, the CSS Code and the CSM Regulations define their maximum securing load (MSL) as 50% of the breaking strength; so when preparing combined cargo lashings always ensure that the MSL of the shackles selected is not less than the effective strength of the eyes or other configurations formed in the wire rope and similar materials.

Fig 13. Tightening rope lashings

Tightening rope lashings by means of frapping

Tightening rope lashings by means of bowsing



Turnbuckles

The same precautions apply to the use of turnbuckles. The word ‘turnbuckle’ is used collectively to include solid-cased bottle-screws and open-sided rigging screws or straining screws. These are most commonly used for general cargo lashing and are supplied in a range of sizes and strengths with a closed eye at each end. Open-sided rigging-screws and straining-screws tend to have noticeably lower strengths than solid bottle-screws of the same size. The suppliers or manufacturers should be asked to provide the relevant test data

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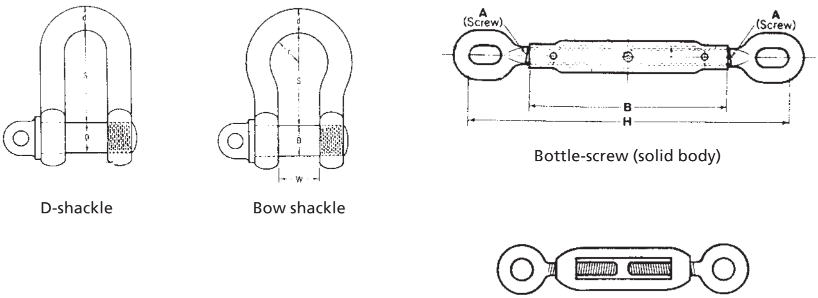
Fig 14. Shackles and screws



D-shackle

Bow shackle

Bottle-screw (solid body)

Stretching-screw (open body)

before those responsible for lashing cargoes assume a MSL or SWL which may be erroneous.

Solid bottle-screws are typically sold by size of screw-pin diameter. Those of 24mm diameter have a proof-load of 4 tonnes and those of 38mm have a proof-load of 10 tonnes. Special purpose turnbuckles are available with much greater strengths than those given above. These may have particular fittings and modifications such as those used in the container trade. Again it is important that the manufacturers' literature should be consulted before such equipment is brought into use.

Turnbuckles should always be used with the pulling forces acting in one straight line. They should never be allowed to become the fulcrum of angled forces no matter how slight. Care should always be taken to see that the screws are at adequate extension when the cargo is finally secured. In this way scope is provided for further tightening if this should prove necessary during the voyage as the cargo and lashing arrangements settle. Where high torque upon a main lashing is involved the eyes of the turnbuckle should be seized or stopped against its own body in order to prevent the screws working back under load during the voyage.

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Photography

It has long been the practice for surveyors acting for cargo receivers or underwriters to attend onboard vessels and request facilities for taking photographs. Members attention is often drawn to the Hague Rules, Article 3 (6) which reads:

> *"… In the case of any actual or apprehended loss or damage, the carrier and the receiver shall give all reasonable facilities to each other for inspecting and tallying the goods."*

Photographs are usually a reasonable form of evidence. Therefore, claimants' request to take photographs cannot normally be denied. However photographs can be inclined and indeed, often intended to provide a false picture of the overall state of cargo. This may be achieved by taking only selected views designed to support a claimant's case and give the impression that the whole/majority of the cargo was damaged to the same extent as the cargo actually photographed. Clearly, no such facilities should be granted to any persons acting on behalf of cargo interests unless and until there is present a surveyor acting on behalf of the ship. On some occasions it may be necessary for the ship to employ a professional photographer in order to combat the possible distortions of claimants' photographic evidence.

Since about 1996, digital cameras have regularly been used by surveyors, some ships' officers and other interested parties. Digital cameras continue to improve and the achieved quality of the photographs can be equal to the traditional SLR camera. When using digital cameras taking selective views of a subject cargo is no longer necessary as most – if not all – digital cameras are supplied with photo-editing programmes which permit manipulation and possible falsification of the picture(s).

Whereas digitally reproduced photographs may be acceptable when electronically transmitted to provide essential, initial and urgent details of damages many clients refuse to accept them as part of a formal and final report.

Until English Courts accept photographic evidence reproduced digitally the use of digital photography, at least for the time being, should be used for urgent advices only and not in the preparation of formal evidence suitable for litigation.

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Preparing cargo plans – structural limitations

Strength of tank tops, tween decks, hatchcovers and weather-decks

When preparing cargo loading plans, it is important that the ship should be loaded as close as possible to its maximum deadweight or capacity, but it is equally important to consider the implications of loading any high density cargo. In the early stages of planning, it is essential that not only should the physical dimensions of the cargo be established but also the maximum permissible weight which can be loaded into any compartment. The Committee believes that there is a common failure to fully understanding the strength limits of tank tops, tween decks, hatch covers and even weather-decks and that the knowledge of many ship masters in this matter is often superficial.

The strength limits which are to be applied to tank tops are calculated and approved by the classification societies. The maximum limits are expressed in tonnes per square metre and are included in the ship's technical manuals and capacity plans. To calculate the number of tonnes which can be loaded on the tank top without exceeding the limit, the area of the tank top in square metres is simply multiplied by the permissible number of tonnes per square metre. To ensure that the limits are not exceeded the cargo **must be spread evenly** over the area of the tank top. The volume of the space above the lower hopper tanks should also then be calculated and the figure obtained included in the total quantity to be loaded. A typical calculation might be as follows:

Maximum tonnage to be loaded:

(L)ength x **(B)**readth x **PL** (permissible load) = 27 x 21 x 12 tonnes/m^2 = 6,804 tonnes.

(Where L & B represent the dimensions of the tank top *excluding the hopper tanks.*

Maximum volume to load:

6,804 tonnes @ **3** tonnes/cubic metre = **2,268** cubic metres.

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Height of stow :

2,268/567 = 4.0 metres. (n.b. 567 = 27 x 21)

When discrete items are to be loaded such as billets, steel coils, slabs and the like, the committee recommend that the load should not exceed 6,804 tonnes as shown above.

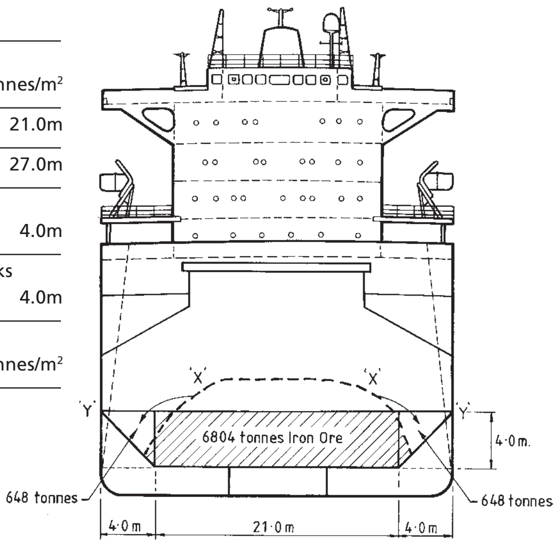
When other homogeneous cargoes are loaded, which may safely be stowed over the hopper tanks, then additional weight may be carried but always with the proviso that the overall height of stow should never exceed the original figure as arrived at above.

In such cases, the amount of weight which can be safely added to the 6,804 tonnes can be calculated by using the formula: 0.5 (***l*** **x** ***b*** **x PL)** tonnes, where ***l*** = the length of hopper tank and ***b*** = the horizontal width of tank and **PL** = permissible load.

Thus if ***l*** = 27m and ***b*** = 4m then 0.5 (27 x 4 x 12) = 648 tonnes at each side. At 3 tonnes/m^3 648 tonnes would occupy 216m^3. Over a base area of 108m^2

Fig 1.
X = level of surface of stow before trimming Y = level of surface of stow after trimming

Total cargo: 8,100 tonnes	
Cargo of iron ore stowing at	3 tonnes/m^2
Width of tank top	21.0m
Length of hold	27.0m
Peak of hopper tanks above tank top level	4.0m
Base width of hopper tanks above tank top level	4.0m
Classification Society permissable load	12 tonnes/m^2



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(27 x 4) this would take the height to 2 metres (216/108) or, allowing for the wedge of a 45 degree hopper tank, to 4 metres height. Thus the final result of the calculation would be that the total weight of cargo to load would be 8,100 tonnes at an overall height of 4 metres.

In any case the committee recommend that, when making these calculations, masters should consult the *Code of Safe Practice for Bulk Cargoes*, Section 2.1, pages 7 and 8, Cargo Distribution.

When bulk cargo is poured into a ship's hold, it tends to form a heap, thereby increasing the load on the tank top towards the centre of the hold. The result is a tendency for the double bottom to sag and for the ship's sides to be drawn in as indicated in Fig 1.

Such stresses can seriously weaken the ship's structure. It is possible that the effects of such stowage procedures over a number of years may have contributed to the losses of loaded bulk carriers. During loading, the aim should be to maintain an even distribution of weight both transversely and longitudinally so that the specified tank top limits are not exceeded.

The procedures outlined above are simple, but more complicated situations may arise if breakbulk cargoes are to be loaded where large, heavy pieces of cargo may be offered for shipment. Take for instance, a 200 tonne transformer with base dimensions of 5m x 3m (15 square metres) to be loaded into the hold illustrated in Fig 1. The spot load on the tank top would be 200/15 = 13.3 tonnes per square metre. This load would be excessive if the limit were 12 tonnes per square metre. To spread the load and reduce the pressure to within the specified limits, it is customary to build a grid-like timber frame on the tank top. The timber selected should have its grain running the length of the timber, and be of uniform quality. The area over which to apply the timber can be calculated by dividing the weight of the transformer by the tank top limitation: i.e. 200 tonnes/12 tonnes per square metre = 16.7 square metres. This would be the minimum area to be covered by the frame. 2"x 2" and 3"x 3" timber is commonly used with the loading of many cargoes, especially steel. Square timber of greater cross section is extensively used for supporting heavy lifts.

Ideally, a complete floor should be constructed with baulks of timber placed next to the steel surface of the tank top having no spaces between the timbers.

In practice this would be costly and uneconomical. Whatever procedure is finally adopted is likely to involve compromise, but it is in any case recommended that, with heavy lifts, the baulks used should be of substantial sized timber with cross sectional dimensions of not less than 9 inches (23cm) square. It should be appreciated that there is a possibility that the timber may compress under the applied weight. As an alternative, a steel frame may be used. Before deciding the exact stowage position for a heavy lift it is advisable to check the nature of the hull construction. A heavy lift should be placed with reference to the longitudinal re-inforced structure (longitudinal girders.) The placement of timber baulks should be considered with reference to the internal double bottom structure, always bearing in mind that an important function of dunnage is to spread the load to the primary structure of the hull.

Where steel cargoes are to be loaded, other complications are likely to arise. When loading steel coils it is usual to load not more than three tiers high with individual coils weighing up to 10 tonnes. If the unit weight is more than 10 tonnes, only two tiers are loaded and if more than 15 tonnes then only one tier is loaded. Usually two lines of double dunnage measuring 6"x 1" are laid athwartships beween the coil and the tanktop. Applying the formula above, the pressure exerted over the small bearing surface of the lowest coil is about 30 tonnes. Without due care, the customary dunnage may not be sufficient to effectively spread this weight and there is a risk that the tank top will be overloaded beneath each unit. Every possible precaution should be taken to ensure that the spot load does not exceed the limit, bearing in mind that the load spread is improved if the pitch of dunnage is reduced and that the dunnage must be laid across primary structures and must not terminate in between members (i.e. between double bottom longitudinal girders).

The stowage of steel slabs poses similar problems. A typical slab may measure 6 m x 1.25m x 0.25m and weigh 14.75 tonnes. The area of such a slab is 7.5m and when stacked 7 high, there would be 103 tonnes bearing down on the tank top. Assuming the slabs were **stowed flat**, this would indicate a load of 13.74 tonnes per square metre – 14.5% in excess of a 12 tonne permissible limit. However the lowest slab is likely to be supported by three or four baulks of timber in order to facilitate handling by forklift truck. This means that the entire stack is supported on a maximum of four points, resulting in a

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tremendous concentration of weight on a small area. Unless larger dunnage is utilised, thereby spreading the load to within satisfactory limits, the tank top is likely to be overloaded when such cargo is loaded in the manner described. Bearing in mind the manner in which steel billets and slabs are usually dunnaged and stowed, it should be realised that little or no weight of that stowage will be distributed to the sloping tank sides unless special dunnaging arrangements are constructed to do so. It is more likely that the flat tank top area alone, will be supporting the entire cargo weight, even though billet/slab ends/sides may be touching the plating of the sloping tanks.

Masters are again encouraged to consult the *Code of Safe Practice for Bulk Cargoes* with particular reference to Section 2.1.2.1 which commences as follows:

> *"When loading a high density bulk cargo having a stowage factor of about 0.56m³/t or lower, the loaded conditions are different from those found normally and it is important to pay particular attention to the distribution of weights so as to avoid excessive stresses. A general cargo ship is normally constructed to carry materials of about 1.39 to 1.67m³/t when loaded to full bale cubic and deadweight capacity. Because of the high density of some materials, it is possible by improper distribution of loading to stress very highly either the structure locally under the load or the entire hull."*

Within the data provided in that section of the Code, the very densest iron ore has a stowage factor of 0.29m³/t which is considerably lower than the guiding upper limit of 0.56m³/t. Using reported dimensions for billets, their stowage factor may be not greater than 0.25m³/t (allowing for dunnage, margin plate areas, interstitial spacing etc) and on the basis that a mild steel billet will have an inherent density of 7.86t/m³. If it were possible to stow billets without any interstitial spaces, the stowage factor would be 0.127m³/t: thus it can be seen that billets constitute a very heavy cargo which stows denser than the densest iron ore.

In purpose-built container ships the tank tops and double bottoms' structures are specially strengthened where container corner castings are to be positioned. Here, the guiding principle is the stack weight, where 4, 6 or even 9 units per stack are involved. When containers are carried in the holds of non-purpose built vessels, such as general cargo ships and bulk carriers, great care must be taken to use adequate dunnage to spread the point loading at the corner castings, generated by the stack load. For instance, a single stack of 2 x 20ft x 20 tonne units will exert a down loading of 40 tonnes. Beneath each corner casting, the point loading will be about 345t/m^2. Failure to appreciate the magnitude of such stresses has sometimes resulted in tank tops becoming pierced, followed by flooding of the hold by fuel oil or ballast water.

Summary

When loading high density cargoes there is a risk of overloading tank tops and proper precautions should be taken. Provided that the tank top is not overloaded, the pressure on the hopper tanks should be within acceptable limits, but in any case, if the density of the cargo is sufficiently high, the surface level of the stow will be below the upper limits of the sloping sides and no problems should arise. When high density bulk cargoes are loaded, the cargo should be levelled to ensure an even pressure over the tank top. Heavy lifts require plenty of strong, good quality dunnage, laying as much dunnage as feasible on the tank top, in order to spread the load evenly. The tank top limitations are laid down when the ship is built and provided that the structure remains within class specifications, remain unchanged throughout the life of the ship. If through damage or wastage, the structure is reduced, then reduced limitations may well have been imposed as a condition of class.

A collapsed tween deck

Masters should be aware that tween decks can collapse even when overloading is marginal. There are no safety factors and all cargo must be carefully trimmed. Where ships are fitted with twin hatchways, (port and starboard) the cargo should be loaded in equal quantities on each side, unless there are specific instructions in shipyard plans which dictate otherwise.

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Weather-decks and hatchcovers

Similar caution should be exercised when loading heavy cargo and containers on weather-decks and hatchcovers.

Unless the weather-deck has been specially strengthened, it is unlikely to have a loading limit in excess of 3 tonnes per square metre. Similarly, unless hatchcovers have been specially strengthened, it is unlikely that they would have a limit greater than 1.8 tonnes per square metre; maybe half that value in vessels less than 100m in length. Hence, it is of great importance to consult and confirm the relevant data from the ship's documentation. When exceptionally heavy cargoes are to be carried, it may be necessary to shore up the weather-deck from below, but in such cases care should be taken to ensure that the load on the tween deck plating is properly spread. It is always prudent not to load up to the maximum permissible limit on weather-decks but to err on the safe side, given that heavy seas may be shipped in these areas. It is good practice to add 5% to the weight to be loaded before calculating the dunnage area.

In line with earlier advice given elsewhere, the Committee is of the general view that containers should be stowed on deck two or more high only on those ships which have securing arrangements specially provided. At no time should the deck-loaded containers overstress the hatchcover or the hatchway structure. In cases of doubt, details of stress limitations should be obtained from the classification society. As mentioned above, where bulk carriers or dry cargo ships are being used for the carriage of containers on the weather-deck and/or the hatchcovers, it should be borne in mind that it is the **stack weight** and the resultant point loading beneath the corner castings which must be taken into consideration. This criterion addresses not only structural capability but also the ability of the lower tiers of containers to support the superincumbent weight.

Where containers are to be stacked two or more tiers high, on the hatchcovers or weather-deck, the base tier should be provided with permanent footlocks for the lower corner castings. The containers should be secured one above the other by means of twistlocks and/or lockable inter-layer stackers and the upper corner castings of a block of units should be locked into each other transversely by means of screw-bridge fittings and/or tension clamps.

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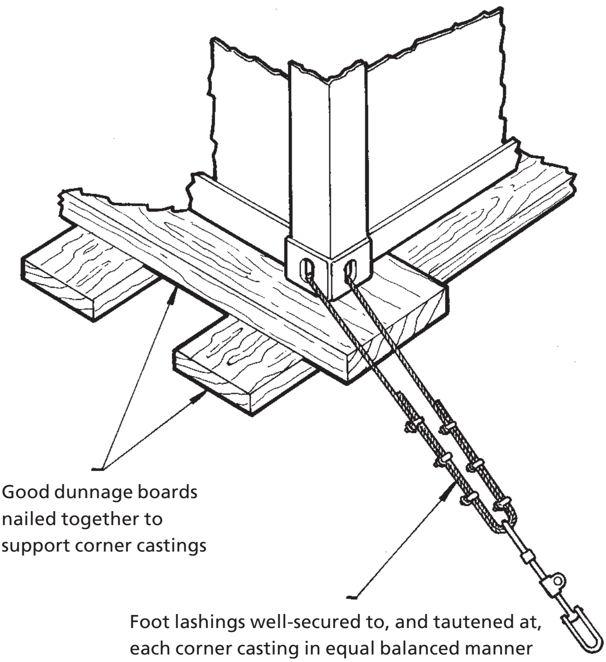
Containers so carried must be treated as 'deck cargo' and secured in accordance with the deck cargo rules and recommendations. In other words, the total holding power of the lashing arrangements, properly disposed and attached to appropriate terminal points, should be not less than three times the static gross weight of the containers and contents.

If circumstances demand a twin tier stack in the absence of footlocks or welded restraints, then properly rigged foot lashings should be used. The units must be twist locked together and lashed as indicated above. In such instances, the correct use of dunnage, both as to size and application, beneath the base corner castings, is of paramount importance, as illustrated in Fig 2 for instance.

Fig 2.



Stowage of breakbulk cargo (general cargo)

Many *Carefully to Carry* articles have mentioned, and given advice, on the stowage of different commodities which could loosely be described as breakbulk cargo. However, no article has yet dealt generally with the subject of stowage of breakbulk cargo. In recent years there appears to have been a general decline of standards in the stowage of breakbulk cargo resulting in cargo damage and claims.

The Committee considers there are various reasons for the decline of standards, namely:

- Use of bulk carriers for the carriage of breakbulk cargo.
- Improper dunnaging.
- Inadequate packing.
- Inadequate stowage skills of ships' officers.

Bulk carriers

The ideal ship to use for the stowage of breakbulk cargo, is a ship fitted with tween decks. This type of ship is designed for the carriage of breakbulk cargo. The many compartments facilitate the carriage of different commodities and make port rotation easier, usually avoiding overstows. Provided care is taken over the stowage, cargo damage, especially crushing damage, should be avoided. Unfortunately, tween deck ships are in short supply and cannot compete economically with the medium sized bulk carrier. Medium sized bulk carriers have therefore replaced, or are replacing, tween deck ships on trades that have not been containerised or where, because of the type of cargo, it is impossible to use containers.

The bulk carrier's two main disadvantages, as compared with the tween deck ship, are the height of holds (about twelve metres as compared with six metres for the lower hold of a tween decker), and the sloping lower wing ballast tanks. As most breakbulk cargo is stowed by the use of fork lift trucks, the sloping lower wing ballast tanks prevent the fork lift trucks manoeuvring

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close to the side of the holds, making stowage difficult. The height of the holds also prevents stowage from the tank top to the deck head using fork lift trucks. These problems are usually overcome by loading the cargo in horizontal tiers on top of which are placed steel plates on which fork lift trucks can manoeuvre to load the next tier. It can readily be seen that crushing damage may occur, not just because of the height of the stow, but due to the use of the steel plates and forklifts.

Dunnaging

It is apparent that it is of paramount importance to use proper and adequate dunnaging materials during the stowage of breakbulk cargo, and this is especially true in the case of bulk carriers.

Timber and timber products such as plywood, are still the main type of dunnage materials in use, even though timber products have risen in price over the past few years. Other cheaper materials are sometimes used as a substitute, but are generally found to be inadequate. Because of the price of timber, charterers, or whoever is paying for the dunnage, are often reluctant to provide dunnage which is adequate both in quality and quantity.

Dunnage is used for the following reasons:

- To spread the load over the surface area of the tank top, tween deck or deck and also between horizontal tiers of cargo.
- To increase friction between steel surfaces (tank top and cargo, etc.).
- To tie the cargo together to prevent any movement in the stow.
- To keep the cargo away from the tank top or deck and away from the steel structure at the ship’s sides, thereby preventing contact with moisture formed on, or running down or across steel surfaces and permitting the water to flow to the bilges.
- To block void spaces, brace and support cargo and block cargo to prevent movement.
- To create a divide, an auxiliary deck or level surface.

Dunnage is an absolute necessity for proper stowage of breakbulk cargo and, when cargo damage occurs, the failure to use adequate or good quality dunnage may result in allegations of bad stowage by cargo interests and liability for cargo claims being difficult to refute. Because of the difficulties in the stowage of breakbulk cargo in bulk carriers, proper and adequate use of dunnage is vital and although cost is a consideration, this is usually minor in proportion to potential claims.

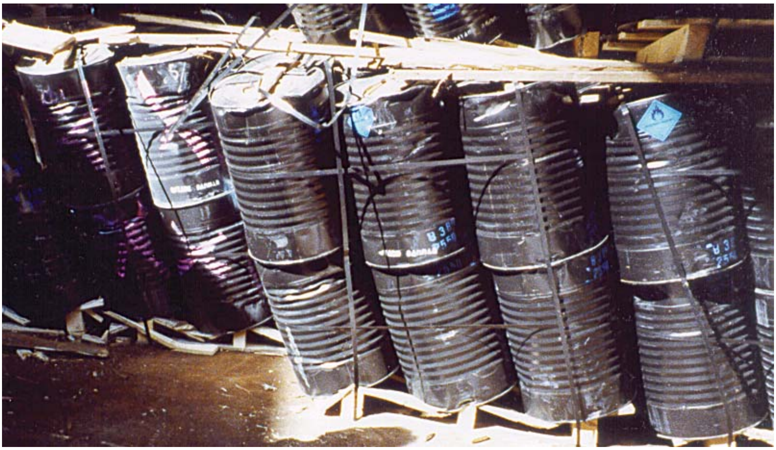
When timber dunnage is supplied, the master and the ship's officers should check that the timber is properly seasoned. Green or wet timber contains up to 35% of water. Shrinkage of green timber results in the loosening of nails and could mean that any blocking or bracing structure collapses. Timber should also be without dry rot, without infestation, without splits (split timbers cannot be fastened properly and lack strength) and of adequate scantling. Poor quality timber should be rejected and, as the ship's officers will probably have to sign for the timber supplied, they should check that the amount supplied corresponds to the receipt they sign.

Packing

One of the main causes of damage to breakbulk cargo is inadequate packing. Pallets, boxes, crates and other forms of packing are usually designed for a single transit. During the course of this transit the unit must survive initial storage, loading on to a road or rail vehicle, transit to a port, handling at the port into temporary storage, loading on to the ship and stowage, static and dynamic forces related to the ocean passage, breaking out of stow and unloading, handling into temporary storage, handling on to road or rail vehicle, transit to the receiver's premises and handling at the receiver's premises. There are probably a minimum of ten handling operations involved with every transit but, by far the most arduous, is the sea voyage. It is therefore very important that packaging is taken into account when planning the stowage of breakbulk cargo, particularly, when a stow could be as high as twelve metres on a bulk carrier. Packaging should be inspected prior to loading and if inadequate, the cargo should either be rejected or the bills of lading properly claused in regard to the inadequacy of the packing. It is difficult to generalise on what should be considered as inadequate packing, however, listed below are some examples:

- Flimsy pallets which bend and break when lifted.

- The cargo on the pallets is laterally greater than the surface area of the pallet platform which results in the cargo projecting over the sides and becoming torn or split on the pallet edges causing the load to become unstable.
- The load on the pallet is only secured with shrink-wrapped plastic sheeting, which is not acceptable as a securing material and leads to instability of the cargo on the pallets.
- Some of the bottom bags of the pallets leak their contents due to being pierced by the forks of fork lift trucks which impairs the stability of the stow on the pallet.
- Packages on pallets are not interlocked making the whole unit unstable. This is especially true when the goods on the pallet are slippery.
- Bundles of pipes secured with wire are wrongly arranged in the bundles causing slackness in the bundles resulting in bending and end damage.
- Heavy drums loaded on pallets which are only secured with flat metal strapping bands which eventually become slack and the load becomes loose.



Heavy drums that have broken loose from inadequate strapping

- Wooden cases which have a strong base but with weak covers which lack rigidity because they are not fitted with a frame. This can result in the cases

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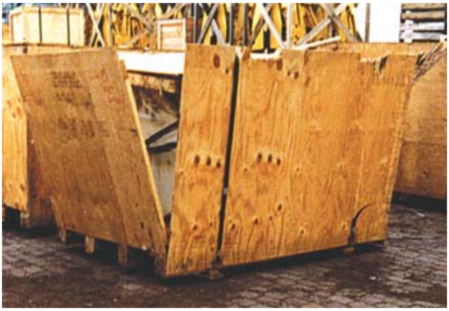

Wooden cases that lack structural rigidity

collapsing in stow and the stow collapsing. It is obviously difficult to see this weakness at the time of shipment.

- Plywood bundles that are packed in such a manner that the packing is too light for the weight of the bundle and the bearers.

Plywood bundles that have broken out of packing that is insufficient for the weight of the bundles and bearers

It should be realised that if the packing is inadequate and considered incapable of withstanding the rigours of an ocean voyage, good stowage may not prevent the cargo from sustaining damage. Furthermore, inadequate or weak packing can undermine the stability of a stow and in extreme cases, lead to its eventual collapse. Without proper supervision during loading, inadequate or weak packing is very often only discovered at the discharge port when the cargo is unloaded in a damaged condition. It is difficult to determine at the discharge port or ports, whether the cargo was damaged due to bad stowage or as a result of inadequate packing. Cargo claims will eventually be directed to the shipowner and may prove costly and impossible to defend.

Again, it should be pointed out that it is far more difficult to cater for stowage of cargo with weak or inadequate packing on a bulk carrier as compared to ships with tween decks. On a tween deck ship, top stowage either in the lower hold or tween deck can be arranged for suspect or weak packing. However, top stowage on a bulk carrier is far more limited, especially when there are many loading or discharge ports.

Even if packing is adequate, it is only designed to withstand certain pressures and usually, these pressures are determined for static conditions. Packing crates and cases of medium size should be able to withstand the superincumbent load of five similar items stowed above. Properly designed palletised units of l,500kg should be capable of supporting a 6,000kg load under static conditions, which would result in a five tier pallet stow of about six metres in height. Steel drums are designed to survive under a static load of three metres height of units of the same weight. Clearly, proper stowage of these types of commodities can be arranged on a tween deck ship, but the problem is far more difficult on a bulk carrier even if vast amounts of dunnage are used to spread the loads evenly.

Various international and national organisations such as the IMDG Code, British Standard, USA Packing Standard and the German Industry Standard (DIN), stipulate strength and construction of packing. For example under German Standard (DIN) cases have to withstand a static vertical pressure of 1.0mt/m^2 during sea transit. Ships' officers cannot be expected to test packaging to see if it complies with these standards, but they should be aware that standards do exist and that shippers are under an obligation to comply

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with the rules and regulations of national and international organisations. Also, packaging has to be properly marked especially if there are special requirements for lifting or stowage. Wordings or marks on the packages such as:

- Stow away from heat.
- Top stowage only.
- Position of weight point.
- Marks for lifting points.
- Marks for forklift handling.
- This way up arrows.

should all be complied with. If it is impossible to comply with the instructions on the package especially in regard to stowage then that particular package or parcel of cargo should not be loaded.

Stowage skills

Before the containerisation revolution, most ships' deck officers were properly trained during their career in the skills of loading and the proper stowage of breakbulk cargo. These skills were mainly obtained through practical experience, but some tuition was given in shore based colleges and institutions. Gradually these skills have been lost with older deck officers and masters retiring or taking shore employment. The result is that a master or chief officer on a medium sized bulk carrier may have never seen a general cargo loaded or stowed, and he also may have not received any tuition or training in a shore based establishment. If a bulk carrier is chartered to load general cargo, the master and chief officer will probably rely on the charterer's super cargo, if any, to advise on stowage or on the stevedores' expertise. The result may be a series of expensive cargo claims.

Recommendations

The Committee recommends that when owners know that their masters and deck officers do not have the necessary expertise available to properly load and stow general cargo, particularly on bulk carriers, then expert advice should be obtained. Club correspondents have the local knowledge to advise Members on experts and surveyors in their areas. Even if the master and deck officers have some skills in the loading of breakbulk cargoes, expert advice should be sought if it is thought that the packaging of any commodity is inadequate.

Section 5

Refrigerated cargoes

Carriage instructions for refrigerated cargoes

Introduction

Refrigerated cargoes are invariably perishable to a greater or lesser degree, and their safe carriage depends on maintaining suitable storage conditions during transportation. This is true for all modes of transport and all cargoes, though conditions are more critical for longer journey times and for more perishable commodities.

Refrigerated cargoes include both frozen and chilled goods, the latter including fresh fruits and vegetables. Generally, frozen goods do not suffer if over-cooled, whereas chilled goods can be damaged by low temperatures, either by freezing or by chilling injury to fresh produce. Much tropical and sub-tropical produce is liable to chilling injury if subjected to temperatures below those usually experienced in the growing area.

Successful transportation is dependent on the carriage instructions, which define the conditions in which the goods are to be carried. If these instructions are incomplete, inadequate, contradictory, or wrong, then problems can be expected. For the shipper, there is the risk of loss of cargo. For the carrier, there is the risk of a claim even if the goods are undamaged. Many shippers and carriers are prepared to accept inadequate instructions either through ignorance or through unquestioning acceptance of what has been accepted previously by themselves or others. Instructions may be based on goods of different origin, which may have different requirements.

The way in which cargo is stowed into holds or stuffed in containers is important for successful carriage, and is dealt with later.

These recommendations have been drawn up to assist both shippers and carriers to re-assess their carriage instructions in order to improve the operation of refrigerated transport chains. Any suggestions for improving these recommendations would be welcome.

First, general requirements are considered. Thereafter, separate sections relate to containerised cargoes and to shipments in reefer vessels. For ease of

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reference, points that are the same for both types of transport are repeated in the appropriate sections.

General requirements

The responsibility for specifying carriage instructions is that of the shipper, the owner of the goods. Only the shipper knows the full nature of the goods, their prior history and their requirements. Frequently this responsibility is passed to the carrier, but in this case the shipper should agree the acceptability of the specified conditions prior to shipment. In either case, the exact nature of the cargo needs to be known – in the case of fruit, for example, carriage requirements may vary dependent on type, variety, maturity, origin and growing season conditions.

- If mixed loads of differing commodities are to be carried in a single cargo space, it is necessary to consider compatibility of temperature, atmosphere (especially ethylene levels) and liability to taint. This will usually require specialist cargo care advice.
- It may be necessary to ensure that carriage conditions are specified to all carriers in the transport chain, as on occasions an international journey may use different carriers at the start and end of the journey.
- Items such as relative humidity and maximum time without refrigeration should not be over-specified but should meet the necessary requirements of the goods.

- Over-specification of requirements is to be avoided as it tends to lead to more, and sometimes spurious, claims regarding technicalities which have not actually affected cargo quality.

Many of the items listed here may be taken for granted in the case of regular shipments, but may need to be specified if a new carrier is used.

Specific requirements for containerised cargoes

The parameters that may be included in carriage instructions for containerised refrigerated cargo are listed below:

- Pre-stuffing sanitation.
- Pre-cooling of containers.
- Cooling during part-loaded conditions.
- Prohibition of stuffing cargo at mixed temperatures.
- Stowage requirements.
- Ventilation.
- Carriage temperature.
- Maximum time with refrigeration.
- Air circulation rate.
- Relative humidity.
- Measurement and reporting requirements.
- Special conditions for cold weather.
- Need to pass instructions to subsequent carrier.
- Need to notify if limits exceeded.

For controlled atmosphere shipments, additionally:

- Levels (ranges) for O_2, CO_2, humidity, ethylene.
- Permitted time to reach specified levels.

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- Procedure in event of CA system failure.
- Safety requirements.
- Discharge atmosphere requirements.

Each of these is considered below:

Pre-stuffing sanitation

The proper cleanliness and lack of odour in containers to be used for refrigerated goods should be a matter of normal good practice, but any special or particular needs should be identified.

Pre-cooling of containers

Pre-cooling is only useful when loading from temperature-controlled loading bays; in other conditions, it can result in excessive moisture ingress from the atmosphere and is not recommended.

Cooling during part-loaded conditions

Part-loaded containers should be closed and temperature maintained if there is a delay before complete loading.

Prohibition of stuffing cargo at mixed temperatures

Properly pre-cooled cargo and substantially warmer cargo should not be mixed.

Stowage requirements

Any special stowage requirements, such as a protected or underdeck stow, should be stated.

Ventilation

The rate of fresh air ventilation for fresh produce should be specified. This should be as an absolute figure in cubic metres per hour. The specification of a percentage rate of ventilation only has meaning if related to a specific container size and a specific model of refrigeration unit.

Carriage temperature

It is not physically possible to provide refrigeration in the absence of temperature differences, both between air and goods and within the bulk of

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the goods. The only temperature which can be controlled is the set point, which corresponds to air delivery temperature for chilled goods and to air return temperature for frozen goods. The term 'carriage temperature' therefore has little meaning, and 'set point temperature' should be specified. If appropriate, this may be augmented by a maximum allowable temperature during periods without refrigeration.

Although degrees Celsius (°C) are the international standard, in the USA degrees Fahrenheit (°F) are still commonly used. As zero degrees C is a common chilled goods temperature and zero degrees F is a common frozen goods temperature, great care is needed to avoid possible confusion of units.

For USDA and other cold treatment quarantine requirements, maximum pulp temperature may have to be maintained below a specified temperature throughout a continuous period of days or weeks, and only approved equipment may be used.

Maximum time without refrigeration

Sometimes it may be necessary for statutory or other reasons to specify a maximum duration of time without refrigeration, either per event or in total for the journey. This should not be necessary if temperature limits are well defined.

Air circulation

Some containers have a high air circulation rate for chilled goods and a lower rate for frozen goods. If a speed change switch is fitted, low speed operation for chilled goods may be possible, but as this inevitably results in a wider range of cargo temperature, it is not recommended.

Relative humidity

When equipment with humidity control is used, a range must be specified. It is difficult to measure humidity regularly to better than the nearest 2 to 3%, so an acceptable range of at least ±5% should be specified, albeit with a tighter target. Special equipment is available to maintain either high (e.g. 90%) or low (e.g. 50%) humidity. Without such equipment, relative humidity is not controllable and should not be specified.

Measurement and reporting requirements

It is normal to record air temperature in refrigerated containers, and some equipment also records delivery air temperature. Any specific shipper requirement for reporting temperatures should be stated. When the refrigeration unit is not running, the recorded temperatures do not reflect cargo temperatures. Shippers may choose to put their own recording equipment within cargo, in which case they should inform both carriers and receivers.

Special conditions for cold weather

Sometimes special requirements exist for exceptionally cold conditions. However, it should be noted that most transport refrigeration equipment will control temperature using either cooling or heating as necessary to maintain specified conditions.

Need to pass instructions to subsequent carrier

If there is uncertainty at the start of a voyage as to who will be the final carrier, it may be necessary to request the initial carrier to pass on carriage instructions.

Need to notify if limits exceeded

Procedures for notification of out of specification conditions should be established prior to acceptance of cargo for shipment. This could apply to warm loading, or to equipment failures, for example. Standard procedures and safe limits should be available.

Additional requirements for controlled atmosphere shipments

Controlled atmosphere (CA) systems are designed to maintain an atmosphere different from normal, usually with low oxygen and increased carbon dioxide. They enhance the storage life of some produce when used in conjunction with refrigeration. There are additional requirements for such shipments, as follows:

Levels (ranges) for O_2, CO_2, humidity, ethylene

For each of the atmospheric gases to be controlled, upper and lower concentration limits should be specified.

Permitted time to reach specified levels

The maximum time allowed to reach the specified levels may be laid down.

Procedure in event of CA system failure

The failure of a CA system will not necessarily have a drastic effect on the produce if the refrigeration continues to run. In these circumstances it will be necessary to introduce fresh air ventilation to fruit and vegetable cargoes. This should be specified.

Safety requirements

CA produces an atmosphere which is deadly to humans – breathing an oxygen-depleted atmosphere induces rapid unconsciousness and may result in death. Adequate safety systems must be in place, and these may need to allow for the possibility of stowaways in the cargo.

Discharge atmosphere requirements

The safety requirements extend to those unloading cargoes. Proper ventilation prior to entering containers and training of workers are both necessary.

Containerised transport of perishables without refrigeration

Some perishable commodities are carried without refrigeration, possibly for very short-duration journeys, or in ventilated equipment. In these cases it is wise to consider which of the previous requirements may still apply.

Products with limited temperature sensitivity may be carried under refrigeration for certain journeys only. The following guidelines suggest when this may be appropriate:

- For any goods requiring close temperature control, refrigeration is essential. If temperatures need to be maintained within a band of 2°C or less, refrigeration should be virtually continuous.
- At the other extreme, for less sensitive goods with a maximum temperature

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tolerance of 30°C or above, refrigeration is only necessary for storage on land at high ambient temperatures. For containerised shipments at sea, a protected stow may be requested.

- If the maximum permitted temperature is 25°C or lower, refrigeration should be used for any journeys through the tropics and for any journeys anywhere in a summer season.
- If cargo requirements are marginal, either in terms of temperature tolerance or in terms of possible delays at high ambient temperatures, then the only safe option is to use refrigeration.

- Frozen foods may sometimes be carried without refrigeration for short journeys as long as the cargo is not subjected to more than the specified maximum temperature. This should only be done with the consent of the owner of the goods.

Specific requirements for reefer ships

The parameters that may be included in carriage instructions for refrigerated cargo are listed below :

- Pre-loading sanitation.
- Pre-cooling of cargo space.
- Cooling during part-loaded conditions.
- Prohibition of loading cargo at mixed temperatures.
- Stowage requirements.
- Ventilation (or lack of) during cooling.
- Ventilation thereafter.
- Carriage temperature.
- Air circulation rate.

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- Relative humidity limits or targets.
- Carbon dioxide limits or targets.
- Ethylene limits.
- Measurement and reporting requirements.
- Special conditions for cold weather.
- Need to pass instructions to subsequent carrier.
- Need to notify if limits exceeded.

For controlled atmosphere shipments, additionally:

- Levels (ranges) for O_2, and CO_2, humidity, ethylene.
- Permitted time to reach specified levels.
- Procedure in event of CA system failure.
- Safety requirements.
- Discharge atmosphere requirements.

Each of these is considered below.

Pre-loading sanitation

The proper cleanliness and lack of odour in compartments to be used for refrigerated goods should be a matter of normal good practice, but any special or particular needs should be identified.

Pre-cooling of cargo space

The pre-cooling of cargo spaces removes heat from steelwork and provides a check on the operation of the refrigeration system. However, an excessive pre-cooling time only wastes energy and time. Duration of 24 hours after the required temperature has been reached is sufficient. The required pre-cooling temperature may be a few degrees lower than required transport temperature.

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Cooling during part-loaded conditions

Part-loaded spaces should be closed and temperature maintained if there is a delay before completing loading. Care should be taken to ensure that under these conditions the temperature is not held at a pre-cooling temperature below the required transport temperature for long enough to damage the cargo.

Prohibition of loading cargo at mixed temperatures

Properly pre-cooled cargo and substantially warmer cargo should not be mixed at loading.

Stowage requirements

Any special stowage requirements should be stated.

Ventilation (or lack of) during cooling

For most refrigerated cargoes, the cargo should be loaded at the required carriage temperature. For some cargoes, notably bananas and the less sensitive citrus varieties, cooling in transit is normal. In these cases a period of 48 hours should be specified, during which fresh air ventilation is stopped to allow maximum refrigeration.

Reference is sometimes made to the 'reduction period' which is the time from hatch closure to the air return temperature reaching within 18°F of the requested air delivery temperature. This is a parameter which may usefully measured and reported but should not be specified.

Ventilation thereafter

After cooling, or throughout in the absence of cooling, the rate of fresh air ventilation for fresh produce should be specified. This may be as an absolute figure in cubic metres per hour, or as a rate in air changes per hour of the empty volume of cargo space. Alternatively it may be linked to measured values of humidity, ethylene or carbon dioxide. Care is necessary to avoid requirements that conflict.

Carriage temperature

It is not physically possible to provide refrigeration in the absence of

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temperature differences both between air and goods and within the bulk of the goods. Carriage temperature for chilled goods must therefore be specified as the air delivery temperature. Pulp temperatures may usefully be measured and reported.

It may be required to specify a lower temperature for a limited period to ensure rapid cooling of warm cargo, known as 'shock treatment'. Dual-temperature regimes, in which the delivery air temperature is changed after a specified period of days, may also be stipulated.

For frozen cargo, it is usually sufficient to specify a maximum temperature that should not be exceeded. This may be subject to qualification for short periods.

For example:

> *Cargo temperature shall not exceed -18°C, except for short periods during power disconnection or defrosting, when temperatures shall not exceed -15°C.*

A single specified 'carriage temperature' is a meaningless specification that should never be accepted.

Although degrees Celsius (°C) are the international standard, in the USA degrees Fahrenheit (°F) are still commonly used. As 0°C is a common chilled goods temperature and 0°F is a common frozen goods temperature, great care is needed to avoid possible confusion of units.

For USDA and other cold treatment quarantine requirements, maximum pulp temperature may have to be maintained below a specified temperature throughout a continuous period of days or weeks, and only approved equipment may be used.

Air circulation rate

The rate of circulation of air around and through the cargo controls the range of temperature within the cargo, and also the rate of cargo cooling. Minimum rates may be specified, usually as multiples of the empty volume of the hold per hour. Often these multiples are misleadingly referred to as 'air changes per hour', or 'ACH', a term best used for ventilation rather than circulation rates.

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Relative humidity limits or target

Relative humidity may not be specifically controllable in shipments; if there are critical requirements, either special equipment or special packaging or both will be required. A sensible specification is as follows:

> *Relative humidity should be maintained at the maximum possible, after the delivery air temperature and fresh air ventilation requirements have been met.*

Over-specification of humidity requirements is likely to lead to conflicting instructions. When special equipment with humidity control is used, a range must be specified. It is difficult to measure humidity regularly to better than the nearest two to three percent, so that an acceptable range of at least plus or minus five percent must be specified, albeit with a tighter target.

Carbon dioxide limits or target

For many fruits, a maximum level of carbon dioxide may be specified, this to be the overriding parameter for ventilation rate control. Care is necessary to avoid conflicting ventilation requirements.

Ethylene limits

The measurement or specification of ethylene levels is rare, as accurate measurement at very low concentrations needs specialised equipment. If limits are to be specified, the measurement and control regime must also be specified.

Measuring and reporting requirements

It is normal for carriers to measure temperatures of the air in ships' holds. Any specific shipper requirement should be stated, especially if it involves cargo rather than air temperature. Shippers frequently choose to put their own recording equipment within the container/cargo in which case they should inform both carriers and receivers.

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Special conditions for cold weather

Sometimes special requirements exist for exceptionally cold conditions. However, it should be noted that most transport refrigeration equipment will control temperature using either cooling or heating as necessary to maintain specified conditions.

Need to pass instructions to subsequent carrier

If there is uncertainty at the start of a voyage as to who will be the final carrier, it may be necessary to request the initial carrier to pass on carriage instructions.

Need to notify if limits exceeded

Procedures for notification of out of specification conditions should be established prior to acceptance of cargo for shipment. For example, this could apply to warm loading, or to equipment failures. Standard procedures and safe limits should be made available.

Additional requirements for controlled atmosphere shipments

Controlled atmosphere (CA) systems are designed to maintain an atmosphere different from normal, usually with low oxygen and increased carbon dioxide. They enhance the storage life of some produce when used in conjunction with refrigeration. There are additional requirements for such shipments as follows:

Levels (ranges) for oxygen, carbon dioxide, humidity and ethylene

For each of the atmospheric gases to be controlled, upper and lower limits should be specified.

Permitted time to reach specified levels

The maximum time allowed to reach the specified levels may be stipulated.

Procedure in the event of CA system failure

The failure of a CA system will not necessarily have a drastic effect on the produce if the refrigeration continues to run. In these circumstances it will be necessary to introduce fresh air ventilation, which should be stated.

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Safety requirements

CA produces an atmosphere that is fatal to humans – breathing an oxygen-depleted atmosphere atmosphere induces rapid unconsciousness and may result in death. Adequate safety systems must be in place, and these should always admit the possibility of stowaways in the cargo.

Discharge atmosphere requirements

The safety requirements extend to those unloading cargoes. Proper ventilation prior to opening cargo spaces and training of workers are both essential.

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Fresh fruit and vegetables

The transport of fresh fruit and vegetables is a complicated topic. Differing fruit and vegetables have widely varying requirements for their safe preservation. The rate at which living fruits and vegetables age and eventually submit to senescence (old age), attack by micro-organisms and inevitable demise depends upon the environmental status afforded during storage and transit. During which periods the quality and condition of fruits and vegetables are maintained by retention at all times of their optimum temperatures. For safe carriage this will usually require that the commodities are pre-cooled and maintained at that temperature prior to being loaded into the transport unit, be it refrigerated ship, container or other mode of transport. Refrigerated systems used in transportation of commodities only have the capacity to adjust minor reductions of, and to maintain, the product temperature.

All fresh fruits and vegetables are living products and their life processes continue after harvest; the two most important being respiration and transpiration. The former being a complicated sequence of chemical reactions involving conversion of starches to sugars and the change of those sugars into energy. The normal respiration results in the fruit and vegetables consuming oxygen and giving off carbon dioxide; water; and varying, albeit immense, amounts of heat. The higher the ambient temperature surrounding the commodity the greater will be the temperature of the commodity itself and consequently the larger its rate of respiration. The second process, transpiration, is the loss of water by evaporation which will occur once the fruit or vegetable is removed from its tree or plant which has been the source of water during its formative period. Thus the storage/carriage conditions afforded the produce should be such that excessive water loss does not ensue.

Temperature

Many reference books include tables which provide data, including optimum temperatures, for the safe storage of commodities. Other publications specifically list the optimum transit (carriage) conditions. The storage data may, depending upon the commodity, refer to long term refrigerated storage requirements with any period quoted being that from harvesting to entry into the marketing chain. Published data applicable to sea-going carriage

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requirements may indicate slightly higher optimum temperatures. However it is essential to understand that published values of optimum temperatures for storage or transit are not absolute – the accurate optimal requirements are dependent upon varietal, climatic and other details of the produce. The optimum and required transport temperature of fruits and vegetables should be provided in writing by the shipper who will, or should, have full knowledge of the history of the produce and which temperature must be maintained by the carrier throughout the period under his control. Optimum temperatures determine low rates of respiration extend storage life and in addition reduce the rate of development of micro-organisms. Generally speaking the higher the temperature the faster will be the growth of moulds and bacterial infections.

Freezing points

The lowest safe limit of temperature for each commodity is its highest freezing point. This temperature is invariably slightly below 0°C, the freezing point of pure water, as the natural juices contain dissolved substances in solution which have the effect of lowering the freezing point. Thus generally speaking the main contents being sugars the sweeter the produce the lower the freezing point. Nonetheless it must also be remembered that stalks of fruit contain much less sugar and may freeze at a higher temperature than the fruit itself, resulting in death of the stalk tissue with possible consequences when the fruit is restored to ambient temperatures with likely loss of sound market values.

Chill damage

A second factor which establishes the lower safe limit of carriage temperature of some produce is that of chilling, which is a reduction in temperature that does not reach the freezing point of the produce. Numerous commodities especially those grown in tropical climates, or alternatively from plants originating from the tropics, are easily affected by low temperatures and inclined to injury to their tissues at temperatures well above their freezing point. Typical symptoms not only include pitting of surface tissues, discolour of flesh but also an increased susceptibility to decay.

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Relative humidity

Relative humidity may be defined as the ratio of the water vapour pressure present in air at an existing temperature to the water-vapour pressure which would be present if the vapour were saturated at the same temperature. Relative humidity is usually expressed as a percentage.

Difference of vapour pressure may cause water vapour to move from or to the produce within the ambient air. The water-retention capacity of air is directly proportional to the temperature of the air, i.e. an air mass at 90% relative humidity at +10°C contains a greater mass of water than a similar air mass at 90% relative humidity at a temperature of 0°C.

Nonetheless water is lost from produce at about double the rate when carried in a compartment whose air is at +10°C and 90% relative humidity when compared with the same air being at 0°C and 90% relative humidity.

Thus the relative humidity of the air within a cargo compartment of a refrigerated vessel, insulated refrigerator container or trailer directly determines the retention of the condition of the products carried. Relative humidity below the optimum range will result in shrivelling or wilting in most produce. The maintenance of an optimum range of humidity is often one of the more difficult to resolve during the carriage of fresh produce.

Relative humidity of air of 85% to 95% is usually recommended for the carriage of most perishable produce in order to preclude/impede wilting or shrivel caused by moisture loss. Exceptions to the above include the carriage of onions, dates, coconuts, ginger rhizomes, yams, dried fruits and some horticultural produce. If the relative humidity increases to 100% condensation may occur which would increase the likelihood of mould growth within the compartment and on the produce itself.

Air circulation

The circulation of cooling air within cargo compartments must be kept at an even required temperature throughout. Despite variable heat leakages which may occur in various parts of the system, and the inevitable increase in the circulating air temperature at return compared with delivery, the result of removal of respiratory heat from the produce, only a small increase should be acceptable. The comparison of delivery air temperatures and return air temperatures being one of the critical monitoring requirements of carriage. As the majority of produce carried should be presented to the vessel/container or trailer as pre-cooled, the exceptions will include cargoes of bananas, the field heat having already been removed. The circulating cooling air should therefore only be required to remove respiratory heat of the produce and the heat exchanged via exterior surfaces. A high velocity of circulating air should be unnecessary and in fact undesirable. Cooling air in modern refrigerated vessels and containers is usually circulated vertically, from the deck/floor, upwards. The system is designed to produce equal air pressures over the full area of the cargo space. However, any elaborate arrangement for air distribution can be rendered useless if incorrect stowage of the produce eliminates or reduces efficient airflow which tends to follow the route of least resistance. The difficulties of 'properly and carefully' stowing packages of fresh produce have become more complex with the use of palletised units and pallet boxes/bins.

Air exchange

During the carriage of fresh fruits and vegetables under ordinary conditions of refrigeration accumulations of gases such as carbon dioxide (CO_2) and ethylene (C_2H_4) will occur. Undesirable odours or volatiles may also contribute to off-flavours and hasten deterioration of the produce. These problems can be prevented by repeatedly refreshing the circulating air within the holds by admitting atmospheric air into the system. The introduced air entering at a point of lowest pressure within the circulation and the polluted air exiting the system at a point of highest pressure, or alternatively by use of an auxiliary air system driven by separate fans.

Rates of respiration and heat generation

Fresh fruits and vegetables and similar produce are live and as with all living products respire, i.e. the process by which oxygen from the air combines with the organic material of the produce to form, ultimately, water and carbon dioxide. The by-product of this chemical reaction being energy released as heat. The rate at which fruits and vegetables produce heat varies, some have high rates of respiration and they require more refrigeration to maintain an optimum carriage temperature than those which respire more slowly. The rates

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of respiration are determined by temperature and as before noted for every 10°C rise in temperature the rates may be doubled or in some instances tripled.

The storage life of produce varies inversely with the rate of respiration. Produce with short storage expectancy will usually have higher rates of respiration, e.g. fresh broccoli, lettuce, peas and sweet corn. Conversely potatoes, onions and some cultivars of grapes with low respiration rates have longer storage lives. The rate of respiration for any given product will depend upon its variety (cultivar), area of growth, the seasonal and climatic conditions experienced during periods of growth.

Climacteric fruit and vegetables

Some varieties of fruit and vegetables have rates of respiration which do not decline during their ripening period – that is between maturation and the onset of senescence. In fact their respiration rates increase, a critical event or period known as their climacteric. Produce may therefore be categorised as climacteric or non-climacteric. The former continuing to ripen post-harvest, where as the latter does not. The ripening processes include development of colour, texture (tissue softening) and flavour.

Many fruits are climacteric, such as peach, apricot, banana, mango, papaya, avocado, plum, tomato and guava and tend to ripen rapidly during transit and storage. Examples of non-climacteric fruit and vegetables include cucumber, grape, lemon, lime, orange, temple fruit (satsuma, tangerine, mandarin) and strawberry.

Weight loss in transit

Weight loss from harvested produce can be a major cause of deterioration during transit and storage. Most fruit and vegetables contain between 80% and 95% of water by weight, some of which may be lost by transpiration (water loss from living tissue).

To minimise loss of saleable produce weight and to preclude wilting and shrivelling, the produce must be maintained during transit at the recommended humidity and temperature. Whereas some weight loss will inevitably occur due to the loss of carbon during respiration, this will only be of relative minor proportions. However, the loss of water will not only result in weight reduction but also in produce of poor quality. Loss of moisture can often be minimised by the use of protective packaging to complement carriage under optimum temperature and humidity.

Supplements to refrigeration

Opportunities have been tried and tested to slow down ripening after harvest and thus extend the transit, storage and shelf life of fruit and vegetables – especially those in the climacteric category.

This can be achieved with controlled atmosphere (CA) storage and carriage; modified atmosphere packaging (MAP), storage and carriage (MA); or alternatively with edible coatings.

Basically and in all cases the atmosphere created is one of low oxygen (O_2) and high carbon dioxide (CO_2) when compared to atmospheric air. The low oxygen and high level of CO_2 depress the production of ethylene (C_2H_4), a gas emitted in small quantities by plant tissues, which accelerates during the ripening process and in turn expedites the process itself in the form of a chain reaction, especially true in the case of bananas.

Caution: Modified and controlled atmospheres are non-life supporting. Proper ventilation instructions of compartments/containers under CA/MA must be carefully followed prior to entry.

Edible coatings can create a modified atmosphere, similar to that of modified atmosphere packaging (MAP), which can delay ripening of climacteric fruit, delay colour changes in non-climacteric fruit, reduce water loss, reduce decay and maintain quality appearance.

It has been stated that edible coatings which should be tested and tailored for each product are a simple safe and relatively inexpensive means of extending the ultimate shelf life of fruit and vegetables provided there are good storage, shipping temperature and humidity controls.

Carriage of mixed produce

At times carriers are required to load and stow different produce in the same vessel, hold, or cargo container. Should a mixture be necessary it is essential

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that the produce is compatible in respect of:

- Temperature.
- Relative humidity.
- Odour production.
- Ethylene production.

Generally deciduous fruits, if having the same temperature requirements, can be stowed together.

Cross tainting should be avoided at all costs whereby strongly scented fruit and vegetables are stowed together. The many products which produce considerable ethylene naturally, including apples, avocados, bananas, pears, peaches, plums, melons and pineapples should not be stowed with or in adjacent compartments to kiwi fruit, water melons, lettuce, carrots etc. which can all be seriously affected by the ethylene.

Two commodities that have produced substantial cargo claims, pears and kiwi fruit, are dealt with in this article. There is also a brief comment on research into procedures for the ocean carriage of particularly sensitive fruits. Some data in that section also covers the storage of pears and kiwi fruit.

Pears

Pears are shipped to Europe and North America from South Africa and Chile. They are also shipped in quantity from New Zealand and Australia. Although pears are considered to have a relatively long life it is essential that they are picked at the right stage of maturity and pre-cooled if optimum life is to be achieved. There is a scientific procedure for determining the correct data for picking which is based on the starch content in the fruit. However, once the fruit has been picked, the starch is rapidly converted into sugar and it becomes impossible at a later date to determine whether the fruit was at a proper stage of maturity when picked. Pears are susceptible to various physiological disorders caused by chilling, excess atmospheric CO_2, and skin contact (bruising). They are also subject to microbiological damage resulting from infection by various organisms prior to harvesting. The two most serious types of disease are mild species *monilinia fructigena* and *botrytis cinerea*. The latter species can grow at temperatures as low as -4°C and the growth of this organism can, therefore, only be controlled by low temperature storage. The rate of decay increases rapidly as the temperature rises. As invasion usually occurs through damaged tissue the proper selection of fruit at the packing station is of paramount importance.

The prescribed temperature for the carriage of pears is 0°C to -1.1°C. It is therefore recommended the carrying temperature should be 0°C or marginally lower where ships have equipment which can control the delivery air temperature to plus or -0.2°C or better. The set points for the carriage of pears in containers should be 0.6° to 1.7°C.

Pears may suffer chilling injury at temperatures below -1.5°C. Certain fruit can tolerate lower temperatures and, even if freezing occurs, very slow thawing at low temperatures can result in the fruit remaining undamaged. Thus, claims for damage due to the delivery air temperature falling marginally below -1.5°C for short periods must be viewed with some scepticism.

Because of their comparatively large size and high thermal capacity, cooling of individual fruits through the whole tissue is a fairly slow process. When checking a cargo shipped as pre-cooled, the ship's representative should ensure spear temperatures are taken at the centre of specimens selected for checking. Other points to be checked are the nature of the packaging and the general appearance of the fruit, particularly skin blemishes. Caution should be observed when attempting to assess the maturity of the fruit and a surveyor should be consulted if in doubt.

Pears are susceptible to damage if the CO_2 concentration in the atmosphere rises much above about 1% so it is necessary to maintain fresh-air ventilation at regular intervals when carrying this cargo.

Where unsatisfactory outturns occur it is essential that expert advice is obtained as soon as possible.

Kiwi fruit

These are mainly shipped from New Zealand and California and increasingly from Chile. They have a long storage life if picked at the right stage of maturity and thereafter stored at temperatures in the range -0.5°C to -1.0°C. Storage at

Shipments of melons can be particularly difficult to handle and carry safely

temperature only slightly above this range (+3°C to +4°C) will substantially reduce the storage life.

Kiwi fruit are particularly sensitive to traces of ethylene in the atmosphere. This will prompt rapid ripening. Particular care must therefore be taken when kiwi fruit is loaded, whether in containers, which is usual, or in conventional refrigerated ships to ensure that the atmosphere in contact with the fruit cannot be contaminated with the atmosphere from other sources, e.g. containers stuffed with cargoes such as apples which release considerable amounts of ethylene and even exhaust fumes from certain types of forklift. As it is necessary for the kiwi fruit to be carried using a fresh-air ventilation system, the possibility of cross contamination of the atmospheres from different cargoes must be considered carefully at the time of loading.

Kiwi fruit are also subject to microbiological deterioration, primarily due to invasion by *botrytis cinerea*.

It is again of paramount importance for expert advice to be obtained as soon as possible where damage is feared.

Recent developments in the carriage of delicate fruits, exotic fruits and similar products

World trade in delicate products such as strawberries and certain tropical fruits has expanded. The products concerned frequently have a short shelf-life and

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are therefore transported by air when the distance between the growing region and the market methods of extending the shelf life of delicate products to enable them.

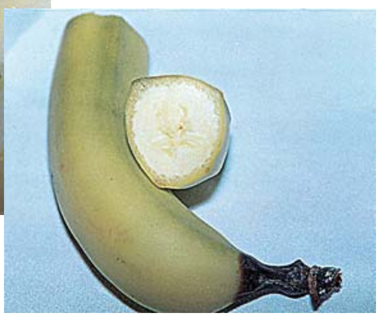
It has been known for many years that increasing the CO_2 concentration in a cargo space will depress the metabolic rate of living natural products and this fact has been utilised when carrying apples from Australia to Northern Europe and during storage worldwide. Recent research has developed more sophisticated gas mixtures, for use in containers or similar carrying units, which will not only slow the ripening rate of fruit and the onset of senescence in other living products but also render such products less susceptible to decay and damage caused by micro-organisms, insects and physiological disorders.

Controlled or modified atmospheric systems involve original dosing to produce an atmosphere of the composition required and then monitoring the atmosphere with automatic analytical equipment which, coupled to recycling equipment, maintains the original composition of the atmosphere by removing the excess of some components and dosing to increase the concentration of others.

Research work carried out has established that:

- Ethylene gas which promotes ripening of fruits is less effective in atmospheres containing less than 1% carbon dioxide.

Prolonged exposure to high levels of carbon dioxide can cause bananas to become 'green ripe' with soft ripe pulp and green skin



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- If the CO_2 content of the atmosphere is too high, serious physiological damage may result.
- As levels of carbon dioxide in the range 10-15% *botrytis* rot of strawberries and some other fruit is substantially inhibited.

Storage of certain products in modified atmospheres can cause problems such as irregular ripening in bananas, pears etc. at low oxygen levels (2%). Development of black heart in potatoes and brown heart in pears and apples at lowered oxygen levels are other examples.

Some products which clearly benefit from controlled-atmosphere storage are listed below, showing the optimum conditions for such storage, as reported by scientists in the USA.

Commodity	Temp. °C	% O_2	% CO_2
Apples	0.5	2 – 3	1-2
Kiwi fruit	0.5	2	5
Pears	0.5	2 – 3	0.1
Strawberries	0.5	10	15 – 20
Nuts/Dried fruits	2.25	0.1	0.1
Bananas	12 – 15	2.5	2.5

The addition of carbon monoxide at levels of 1-5% in atmospheres containing 2-5% oxygen has been shown to reduce discoloration of damaged or cut lettuce tissue. At levels of 5-10% it will inhibit the development of certain important plant pathogens. Use of this gas has been the subject of experimentation in the USA.

The table of temperatures on the following pages, maximum storage/transit and shelf life etc., is for guidance only. The required details of temperature and humidity should be provided in writing by the shipper who has the full knowledge of the product history. The shippers instructions should be maintained at all times.

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Fresh fruit and vegetables

Fresh fruit and vegetables	Approx max storage, transit and shelf life	Optimum transit temperature		Container temperature set points		Highest freezing points		Relative humidity
	Days	°C	°F	°C	°F	°C	°F	%
Apples – non chilling-sensitive	90-240	-1.1 to +1	30 to 33.8	+1.1 to +2.2	34 to 36	-1.5	29.3	90 – 95
Apples – chilling sensitive	35 – 45	+1.5 to 4.5	34.7 to 40	+4.4 to +5.6	40 to 42	-1.5	29.3	90 – 95
Apricots	7 – 14	-0.5 to +1	31 to 33.8	+1.1 to +2.2	34 to 36	-1.1	30	90 – 95
Asparagus	14 – 21	+2.2	36	+2.2	36	-0.6	30.9	90 – 95
Avocados – Fuerte and Hass	21 – 28	+5 to +8	41 to 46.4	+5 to 12.8	41 to 55	-0.3	31.5	85 – 90
Bananas – green	14 – 21	13 to 14	56 to 58	13 to 14	56 to 58	-0.7	30.6	90 – 95
Blueberries	10 – 18	-0.5	31	1.1 to 2.2	34 to 36	-1.3	29.7	90 – 95
Carrots – topped	30 – 180	0	32	0.6 to 1.7	33 to 35	-1.4	29.5	95
Cherries – sweet	14 – 21	-1.1	30	1.1 to 2.2	34 to 36	-1.8	28.8	90 – 95
Clementines	14 – 28	4.4	40	3.3 to 4.4	38 to 40	-1	30.3	90 – 95
Coconut – flesh	30 – 60	0	32	1.1 to 2.2	34 to 36	-0.9	30.4	80 – 85
Corn – sweet	4 – 6	0	32	0.6 to 1.7	33 to 35	-0.6	30.9	90 – 95
Courgettes	14 – 21	7.2	45	7.2 to 10	45 to 50	-0.5	31.1	90 – 95
Cucumbers	10 – 14	10	50	10 to 11.1	50 to 52	-0.5	31.1	90 – 95
Dasheens	42 – 140	13.3	56	11.1 to 13.3	52 to 56	-	-	85 – 90
Garlic	140 – 210	0	32	0.6 to 1.7	33 to 35	-0.8	30.5	65 – 70

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Fresh fruit and vegetables	Approx max storage, transit and shelf life	Optimum transit temperature		Container temperature set points		Highest freezing points		Relative humidity
	Days	°C	°F	°C	°F	°C	°F	%
Ginger rhizomes	90 – 180	13.3	56	12.8 to 13.3	55 to 56	-	-	85 – 90
Grapefruit	28 – 42	13.3	56	14.4 to 15.6	58 to 60	-1.1	30	85 – 90
Grapes	56 – 180	-1.1	30	1.1 to 2.2	34 to 36	-2.2	28.1	90 – 95
Guavas	14 – 21	10	50	9 to 10	48 to 50	-	-	85 – 90
Kiwi Fruit	28 – 84	0	32	1.1 to 2.2	34 to 36	-0.9	30.4	90 – 95
Kumquats	14 – 28	4.4	40	4.4	40	-	-	90 – 95
Lemons	30 – 180	12.2	54	10 to 12.8	50 to 55	-1.4	29.4	85 – 90
Lettuce – Iceberg	10 – 18	0	32	1.1 to 2.2	34 to 36	-	-	90 – 95
Limes	42 – 56	9 to 10	48 to 50	9 to 10	48 to 50	-1.6	29.1	85 – 90
Lychees	21 – 35	1.7	35	1.7 to 2.2	35 to 36	-	-	90 – 95
Mandarins	14 – 28	7.2	45	7.2	45	-1.1	30	90 – 95
Mangoes	14 – 25	13.3	56	12.8	55	-0.9	30.4	85 – 90
Melons – Honeydew	21 – 28	10	50	7.8 to 10	46 to 50	-1	30.3	85 – 90
Mineolas	21 – 35	3.3	38	3.9 to 6.7	39 to 44	-1	30.3	90 – 95
Nectarines	14 – 28	-0.5	31	-0.6 to +/-1	31 to 32	-1	30.3	90 – 95
Onions – dry	30 – 180	0	32	0.6 to 1.7	33 to 35	-0.8	30.6	65 – 75

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Fresh fruit and vegetables

Fresh fruit and vegetables	Approx max storage, transit and shelf life	Optimum transit temperature		Container temperature set points		Highest freezing points		Relative humidity
	Days	ºC	ºF	ºC	ºF	ºC	ºF	%
Oranges – Blood	21 – 56	4.4	40	4.4 to 6.7	40 to 44	-	-	90 – 95
Oranges – California and Arizona	21 – 56	6.7	44	6.7 to 7.8	44 to 45	-0.8	30.6	85 – 95
Oranges – Florida and Texas	56 – 84	1.7	35	1.1 to 2.2	34 to 36	-0.8	30.6	85 – 95
Oranges – Jaffa	56 – 84	7.8	46	7.8 to 10	46 to 50	-0.7	30.6	85 – 90
Oranges – Seville	90	10	50	11	52	-	-	85 – 90
Parsnips	120 – 150	0	32	0.6 to 1.7	33 to 35	-0.9	30.4	95
Peaches	14 – 28	-0.5	31	0.6 to 1.7	33 to 35	-0.9	30.4	90 – 95
Pears – Anjou	120 – 180	-1.1	30	0.6 to 1.7	33 to 35	-1.6	29.2	90 – 94
Pears – Bartlett	70 – 90	-1.1	30	0.6 to 1.7	33 to 35	-1.6	29.2	90 – 94
Peppers – sweet	12 – 18	10	50	10	50	-0.7	30.7	90 – 95
Peppers – hot	14 – 21	10	50	10	50	-0.7	30.7	90 – 95
Pineapples	14 – 36	10	50	10	50	-1.1	30	85 – 90
Plantains	10 – 35	13	57.2	14	57.2	-0.8	30.6	85 – 90
Plums	14 – 28	-0.5	31	1.1 to 2.2	34 to 36	-0.8	30.6	90 – 95
Potatoes – seed	84 – 175	4.4	40	5	41	-0.8	30.5	90 – 95
Potatoes – table	56 – 140	6	42.8	7	44.6	-0.8	30.5	90 – 95

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Fresh fruit and vegetables	Approx max storage, transit and shelf life	Optimum transit temperature		Container temperature set points		Highest freezing points		Relative humidity
	Days	°C	°F	°C	°F	°C	°F	%
Satsumas	56 - 84	4	39	4	39	-	-	85 – 90
Sweet potatoes	90 – 180	14	57	14	57	-1.3	29.7	85 – 90
Tangerines	14 – 28	7	42.5	7	42.5	-1.1	30.1	85 – 90
Tomatoes – green	21 –28	13.3	56	13 to 14	56 to 58	-.5	31.1	90 – 95
Tomatoes – turning	10 – 14	9	48.2	10.6	51	-0.5	31.1	90 – 95
Ugli fruit	14 – 21	4.4	40	5	41	-1.1	30.1	90 – 95
Watermelons	14 – 21	10	50	8 to 10	46 to 50	-0.4	30.9	85 – 90
Yams – cured	49 – 112	16	61	16	61	-1.1	30.1	70 – 80

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Table grapes

Table grapes are expensive and may be carried on pallets either in containers or in break bulk refrigerated vessels.

As grapes do not continue to ripen once they have been cut from the vine, they must be harvested in fully mature condition. Harvesting itself is a critical operation. Grapes can easily be physically damaged, and poor handling can result in a variety of physiological defects such as 'wet shatter' and 'dry shatter'. The grape berries are attached to single stem called pedicles. The pedicles in turn are attached to larger stems known as laterals. The term 'wet shatter' means that individual grapes have broken from the bunch either by a clean break between the berry and the pedicle, or as a result of the pedicle itself breaking along its length up to and including breaking directly from the lateral. When berries have become physically damaged, they are more susceptible to microbiological invasion.

When the grapes have been cut from the vine, they should be chilled as soon as possible. Even comparatively short periods of exposure at normal temperatures, say six hours at 20°C, can result in dehydration and browning of the stems which then often results in bunch 'shattering' during handling. It is therefore normal practice to cool grapes as soon as practicable after they have been harvested. Vinifera fruit (destined for winemaking) is treated with sulphur dioxide at this stage to minimise the risk of deterioration of the fruit due to fungal growth. Later and particularly during storage, sulphur dioxide treatments are repeated at regular intervals.

Weather conditions, particularly rain, prior to and during the harvest period, can have a significant effect on the storage life of grapes, because wetted grapes are more susceptible to fungal invasion than grapes which have been harvested after a period of dry weather. If rain falls during harvesting, it is advisable that cutting should be suspended for three days so that any fungal attack can be noted. Excessive heat during the growing season can result in the berries becoming shrivelled.

Various species of micro-organisms will invade grapes. The most common found in transportation is *botrytis cinerea*, which produces typical grey mould,

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white mould, or some forms of berry rot frequently seen on bunches of grapes. This organism can grow at a temperature as low as -4°C. Fungal infection is more likely to arise if, during the growth period of the berries, the weather has been wet, but *botrytis* mould can develop on grapes which have not been exposed to wet conditions before harvesting. It is impossible to completely control or arrest the spread of fungal infection by this mould, as it will tolerate high levels of sulphur dioxide treatment. Other species of micro-organisms which cause deterioration include *cladosporium herbarum*, *alternaria*, *penicillium* and *aspergillus niger*. Confirmation of the type of micro-organism causing rotting, can only be determined by laboratory examination of specimens of the grapes concerned.

Grapes are stowed in refrigerated containers in pre-cooled conditions. At the normal temperatures for loading, the rate of metabolic heat production is low so there should be no ‘heat load’ problems. The carrying temperature, i.e., the air delivery temperature, must be as low as possible and container units are normally set to 0°C. Although grape berries will not freeze at temperatures above approximately -2°C, the stalks will freeze at -1.5°C to -2°C. On thawing, the stalks blacken, shrivel and become brittle, so that there can be substantial shatter (i.e. individual grapes becoming detached from bunches) with over-cooled fruit, even if the berries themselves are unaffected.

The lugs in which the grapes are packed must be carefully stowed, this is normally the responsibility of the shipper. The key responsibility of the ship is to ensure the carrying temperature (0°C) is maintained and that there is a legible record to confirm it. From what has been said above, it necessarily follows that grapes infected with *botrytis cinerea* will continue to deteriorate, even at 0°C, but the rate of deterioration falls as the temperature is lowered, which is why carriers are advised to keep the grapes at the lowest practical temperature, always ensuring it is above -1°C.

There is another potentially serious problem which can cause damage to grapes and that is as a result of sulphur dioxide bleaching; there are also occasions when deterioration can be due to ageing. Very old grapes are soft and flaccid, with dull skins.

There are many types of physiological disorders which can result in commercial losses of grapes and as can be seen from this brief article some of the causes arise during the growing, harvesting and handling rather than during ocean voyage. If therefore, damage to grapes is reported, the master should ensure that a surveyor is called in to carry out a very careful survey.

Surveyors should be able to recognise the various conditions of infection or deterioration and take adequate samples to enable specialists to assess the nature of such damage. It is important in cases of fungal infection, that samples are drawn which illustrate each particular type of fungal deterioration so that the causative organisms be identified. This is important as the types of infection involved can give an indication of the underlying cause. Experience has shown that claims for damage to cargoes of grapes frequently concern shipments made from the same source at about the same time. This could mean there were problems with a particular harvest. It is clearly important that owners should advise the Association as soon as any allegations of damage are received so that the information can be collated and an investigation be commenced to determine whether there is any particular pattern involved.

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Frozen fish on reefer vessels and in containers

Introduction

According to the UN's Food and Agricultural Organisation, there are more than 28 million people engaged in fishing operations worldwide. The annual world catch of fish exceeds 100 million tonnes, of which around 25 per cent is processed into frozen fishery products. Each year, a high proportion of these frozen products enters international trade and is carried by sea.

Sometimes cargoes of frozen products are found to be damaged when they are unloaded from ships and rejected, leading to claims against shipowners and agents alleging that the damage is due to negligence on the part of the masters and crews of the carrying vessels.

Clearly a vessel is not liable for damage that was sustained before loading, or during handling if due to the actions of third parties. Frequently it is difficult to establish the precise cause and chain of events leading up to the damage. Specialised knowledge is required to sample and inspect fishery products, and relate their condition to the events of the voyage. However, vessel operators also need adequate technical knowledge to minimise the risk of problems occurring, and to act in the event of a claim.

These guidelines are intended to advise ships' masters, officers and crew on good practices to be observed during the loading, storage, carriage and discharge of frozen fishery products carries as bulk cargoes. They also provide detailed guidance on how vessel operators can limit their liability for damage, by ensuring adequate pre-shipment inspection and by acting promptly to preserve evidence when a problem occurs. Other sections also provide background information on factors which affect the condition of frozen fish cargoes during trans-shipment and transport and advice on how to spot signs that a fish cargo is running into problems.

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Frozen fishery products

Types of frozen fishery products

A variety of frozen fishery products are carried by sea in reefer vessels and reefer containers. The main types, in approximately descending order of frequency are as follows:

Whole, gutted[1], or dressed[2] fish individually frozen

Tuna intended for canning is a typical example.

Whole fish, individually frozen

Whole, gutted, or dressed fish in blocks

This is a common form of presentation for small and medium-sized fish intended for further processing. Blocks are rarely more than 10cm thick or more than 50kg in weight. Common sizes are 25 and 50kg. Blocks are either unwrapped or wrapped in plastic film and are sometimes packed in strapped cartons.

Fillets of fish, frozen in a block, wrapped and packed in a carton

[1] Gutted fish are whole apart from removal of the viscera.

[2] Dressed fish have head and guts, and perhaps tails and fins, removed.

Fillets of fish frozen in blocks

Fillets of fish are often frozen into geometrically shaped blocks. Blocks are usually wrapped in plastic film and packed into inner display packs. The display packs are then commonly packed in outer cartons.

Fillets of fish, individually frozen

These are fillets frozen as separate pieces, and perhaps then coated with batter, or batter and breadcrumbs. Fillets are either placed in packages for retail sale or loosely packed in plastic bags. Small display packs are packed in outer cartons while loosely packed fillets may be packed in bags within outer cartons.

Cephalopods, frozen in blocks or as packaged products

These include squid, cuttlefish and octopus. Both processed and unprocessed products are typically frozen in blocks weighing 10 or 25kg. Blocks are occasionally individually packaged, but more usually are over-wrapped in plastic with several blocks being packed together in a single outer carton.

Cephalopods (squid) frozen in blocks

Crustacean shellfish, frozen in blocks or as packaged products

These include lobster, crayfish, shrimp and crab. Smaller crustaceans and crustacean meats are often frozen in blocks weighing up to 1kg. Blocks are packed individually in cartons or over-wrapped in plastic film and then packed into outer cartons.

Crustacean shellfish, individually frozen

Large crustacea, for example lobsters and crayfish are individually frozen, whole or as tails, wrapped and packed in cartons.

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Freezing and storage of fishery products

Introduction

The master of a vessel carrying frozen fishery products does not generally need to be concerned with how the products have been frozen and stored before delivery to the vessel. Indeed, he has no means of knowing or verifying these conditions, except perhaps when fishery products have been prepared and frozen at sea and transhipped directly to the carrier vessel. However, the quality of the cargo discharged from the vessel is affected by freezing, storage and distribution practices before transfer to the vessel, as well as by the manner of loading, stowage and carriage on the vessel.

The following is intended to inform masters and crew about the technologies involved in freezing and storage of frozen fishery products, and the effects of freezing and storage on product quality.

The freezing process

When a fish product is cooled in a freezer its temperature drops rapidly to about -1°C, when ice begins to form. However, not all the water in the fish turns to ice at this point. As more heat is extracted, more ice forms, but the temperature of the product drops only slowly until about -3°C. This period, when the product temperature changes very gradually, is known as the 'thermal arrest period'.

The product's temperature then begins to drop rapidly towards the operating temperature of the freezer. (Fig A)

When the product is allowed to thaw, the temperature will follow a curve similar to Figure A, but in the reverse direction. That is, the temperature will rise quite rapidly to about -3°C, then slowly to about -1°C as it passes through thermal arrest, then rapidly again until the product reaches the ambient temperature.

It is important for the quality of the frozen product that the thermal arrest period is as short as possible, preferably less than two hours. This rate of cooling can only be achieved in equipment designed for the purpose – **merely placing fish in a cold store will not achieve a sufficiently high freezing**

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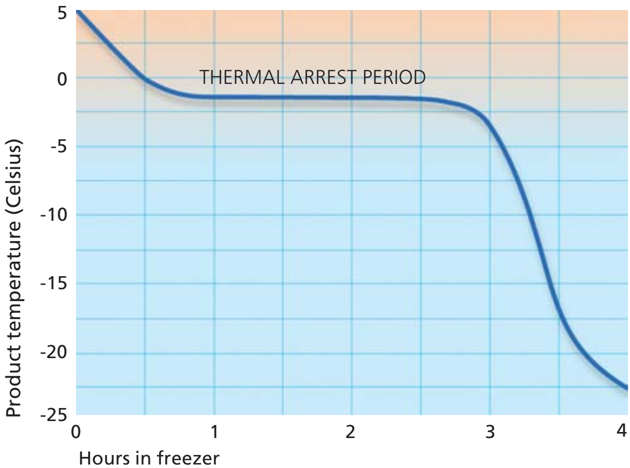

Fig A. Freezing curve of fish initially at 5°C

rate. The refrigerated holds of reefer ships are designed as cold stores to maintain the temperature of already frozen products; they do not have the refrigeration capacity to freeze products at the required rate.

Examples of freezing methods

Brine freezing of individual fish

Brine freezing is used for larger, whole fish like salmon and tuna. The technique is used almost exclusively onboard fishing vessels, particularly tuna-catchers. The fishing vessel is fitted with one or more insulated tanks containing refrigeration coils. Before fishing starts, these tanks are filled with sea water, which is then cooled to around 0°C. As fish are caught, they are dropped into the tanks. When a tank is full, salt is added to lower the freezing point of the brine and the temperature is lowered so that the fish freeze. The temperature that can be achieved depends on the concentration of the brine – the minimum, when the brine is saturated, is about -21°C. In practice, fishing vessels aim for a solution giving a temperature of around -12°C. Once the fish are frozen, the brine is drained from the tank and the fish are held in dry condition with the refrigeration system on.

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Freezing of blocks

Small products, including small fish, fish fillets, squid, octopus and shrimps, are often frozen in blocks. The product is laid in trays and frozen, either in a tunnel through which cold air is passed or between pairs of hollow plates through which refrigerant is circulated. The frozen block is knocked out of the tray, protected by some form of over-wrapping and perhaps packed into cartons.

The quality of frozen fishery products

Quality of products

Complaints about defects in the quality of frozen fishery cargoes usually fall into one or both of two categories:

- Abnormal and offensive odours, flavours or texture, or any other defects that will influence the consumers' perception of quality.
- Physical damage affecting the processability or merchantability of the product (can occur during the freezing process, though more usually happens during handling of the frozen product).

Quality defects in both categories can arise during handling, processing and storage of the product before delivery to the vessel, during loading into the ship's holds, and while the product is stored on the reefer vessel.

Loss of quality can occur both before and after freezing. However, the nature of the defects differs in the two circumstances and an experienced assessor should be able to distinguish between them.

Loss of quality before freezing

Fish of all kinds are notorious for the speed at which they spoil (even when chilled) and for the unpleasant nature of the spoiled product. Spoilage affects the appearance, odour and flavour of the product. Freezing halts the spoilage process and fixes the quality as it was at the time of freezing. When frozen products are thawed out, the quality can be no better than it was at the time of freezing. If defects in the quality of frozen fishery products at time of delivery are shown to be a consequence of spoilage, then no blame can be attached to

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the carrier of the frozen goods unless the product had thawed out during the voyage.

Loss of quality during frozen storage

Frozen fishery products are not completely stable in the frozen state and will deteriorate over time, resulting in changes in texture, odour and flavour of the product. Changes in texture are similar in character across most fishery products – the product becomes dry, stringy and tough. But changes in odour and flavour depend on the type of fishery product. Lean fish with low oil content (such as cod) develop the characteristic odours and flavours described as 'musty', 'cardboard', and 'wet dog', while fish with high oil content (like tuna, herring and mackerel) develop rancid odours and flavours reminiscent of new leather, linseed oil or old-fashioned oil paints. Odour and flavour changes in frozen crustacean shellfish and cephalopods are similar to those in lean fish. Oily fish deteriorate faster, and produce off-odours more quickly than lean fish during frozen storage.

The main factors influencing the rate at which fishery products deteriorate during frozen storage are **temperature of storage** and **exposure to air**. The lower the storage temperature the slower the product deteriorates. The storage life of fishery products carried at -18°C ranges from 3 to 12 months. In general, storage life is halved for each 5°C rise in storage temperature. For example, a product with a storage life 8 months at -18°C will have a storage life of 4 months at -13°C. Since ship' refrigeration systems can maintain products at temperatures below -18°C, and since voyages are generally less than a month long, there should be no significant loss of quality due to frozen storage-related defects during a voyage.

Rate of deterioration is also affected by exposure to air. Block-frozen products are usually protected by close wrapping with plastic film or by coating with a water glaze. To maintain quality, it is important that this cover, film or glaze is not damaged or lost.

Another defect arising during frozen storage is excessive loss of moisture from the product, which leads to general or localised dehydration known as a 'freezer burn'. The dehydration is signified by white patches which appear where glaze is lost or where there are tears or breaks in the protective wrapping. In unprotected material, dehydration occurs first in thin parts of the product such as the fins of the whole fish and the tail-ends of fillets, or at the corners of blocks. These dried areas do not re-hydrate when the product is thawed and are indicated by blemishes in the thawed product.

Physical damage to frozen products

Physical damage takes a number of forms, but complaints about the quality of reefer cargoes are usually concerned with distortion or compression of the product. This kind of damage, which affects individually frozen fish or blocks of products, occurs when warm fishery products (i.e. warm relative to the recommended storage temperature) are subjected to pressure, for example in a stack of fish stored in the ship's hold.

When water is frozen, it changes from a liquid to a hard solid, ice, at 0°C. Although fish typically contain 70-80% of water – the exact percentage depends on the species – the situation is more complicated than freezing water alone. Water in the fish tissues starts to freeze at about -1°C but at this point only a proportion of the water is converted to ice. Progressively, more water freezes as the temperature falls. At -18°C, the maximum temperature usually specified for carriage of frozen fish in reefers, around 90% of the water has turned to ice. It is very hard to deform frozen fish at this temperature and below, except under extremely high pressure.

Indentations caused when warmed, soft tuna were pressed onto ridged floor plates by the weight of the stack of fish above them

If the product warms at all, some of the ice melts. The fish tissue holds an increasing proportion of liquid water and a decreasing proportion of ice as its temperature rises.

As the proportion of ice decreases, the fish tissue, though still partly frozen, becomes softer and can be deformed by moderate pressure. For example, it is possible to deform the surface of a product at -7°C by pressing hard with the point of a pen, a temperature probe, or even a thumbnail. At -3°C, 'frozen' fishery products are soft enough to deform and to sag under their own weight. If the cargo in the hold of a reefer is stacked to a height of 4 or 5 metres, as is often the case, there is sufficient pressure to distort fish to some extent at -7°C, and to distort and compress fish considerably at -5°C or higher.

Individually frozen fish can be severely indented where they lie across each other, and tend to take up the shapes of the surfaces they are pressed against – ridged floor plates or edges of structures in the hold. In an extreme case, a stack of fish can be compressed together into a solid mass, with almost no spaces between the fish. Blocks of products are squeezed, flattened and distorted and will extrude into gaps between cartons, they can also be indented by floor plates or pallet boards.

Frozen products at low temperatures are often brittle and prone to damage by rough handling. For example, tails are easily broken off whole fish and blocks can be shattered or chipped.

Products can also be damaged by contamination. If oil or chemicals are spilled, they may penetrate the wrappings and affect the contents. When cartons and wrappings are torn, the contents are more vulnerable to both contamination and dehydration.

Pre-shipment inspection

The need for inspection

Loss of quality in fishery products can be caused by damage both before and after freezing. Carriage of frozen fish by sea is just one stage in a long sequence of processing, handling, distribution and storage operations – products can be damaged or decline in quality at any stage. Receivers of damaged cargoes of frozen fishery products might allege that loss of quality occurred solely while the material was in the charge of the shipowner.

Pre-shipment inspection is therefore essential, to determine as far as possible the condition and quality of the product at the time of loading, and to note any circumstances that could lead to an exaggerated loss of quality during carriage in the vessel. Such information has an important bearing on any claim that loss of quality or damage occurred during carriage in the reefer. The inspection should take into account the nature of the material, its packaging and its presentation.

Pre-shipment inspection by the ship's officers is generally confined to visual inspection of the cargo and to measurement of physical properties such as temperature. Officers are not expected to carry out detailed evaluations of the quality of the material, which would require examination of material after thawing and perhaps also after cooking.

Nature of the consignment

The deck officer should check that the materials to be loaded are consistent with the bill of lading. However, information provided on a bill of lading is usually very brief – a cargo may be described as 'fishery products', which encompasses many different product types. Wherever possible, deck officers should record any additional information, for example, in the case of individually frozen fish, the species or variety, the presentation (whole or dressed) and the name of the fishing vessel.

It is also important to record the details of any labelling on wrapped or cartoned material, particularly production dates or batch codes. The absence of any labelling, particularly of batch or production codes, should also be noted.

Information on the nature of the consignment and all details of labelling should be recorded on the mate's receipt. If labels are detachable, one can be removed and attached to the receipt.

Temperature of the consignment

It is essential to measure the temperature of frozen fish presented for loading. Since fishery products suffer damage if they are stowed at a high temperature,

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temperature records provide important evidence of the state of the product at the time of loading.

The terms of carriage normally stipulate the temperature, or at least the maximum temperature, at which the cargo should be carried. Holds of reefer vessels are intended for storage of frozen material loaded at the required temperature of carriage. Refrigeration systems have little spare capacity to lower the temperature of products which are put into the hold at above its operating temperature. Material that is above the operating temperature of the hold will take a long time to cool down and will lose quality as a result.

The terms of contract between the provider of the frozen products and the recipient sometimes specify the maximum temperature at which the products should be stored and delivered to the vessel – a maximum temperature of -10C would be typical for frozen tuna delivered from a tuna fishing vessel. Even if there is no specific requirement for the cargo's temperature on delivery to the vessel, the master may refuse to accept a product if he considers the temperature too high and the product at risk of damage during stowage and carriage.

The deck officer should ensure that sufficient measurements are taken to provide an adequate summary of the temperature cargo, and that the measurements are accurately recorded. Guidelines for temperature measurement are given in the Appendix at the end of this article.

During loading, supervising officers should note any softening of the flesh of fish during transfer to the vessel – this can be gauged by pressing the surface of the fish with a thumb nail or the point of a temperature probe. Even when the temperature measured at the core of a fish is low, the flesh on the outside can be soft enough to be damaged by the pressure of a stack within the hold.

Condition of the material

It is not easy to assess the intrinsic quality of frozen products by visual examination, but, with experience, one can get some indication of pre-freezing quality from the appearance of the eyes and skin in the case of whole fish, from the colour of the shell in the case of shell-on crustacean shellfish, and from the colour of the skin in the case of cephalopods. Of course, these indications of

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	Good quality fish	Stale fish
Colours	bright, demarcated	degraded and dull
Eyes	clear or slightly cloudy; flat to the head or even projecting slightly	yellowish or reddish; sunken or missing
Skin	clean – no discoloured slime or coating	abraded and covered with yellowish slime or blood-stained brine; head region of tuna takes on a diffuse pinkish hue

Tuna spoiled prior to freezing – note sunken, discoloured eyes, dull colours, pinkish discolouration of head, loss of skin and dirty, bloodstained slime

quality will not be visible in packaged products unless some of the cartons are opened. Whenever possible, photographs should be taken of any defects.

Visual indication of spoilage in individually frozen fish

The inspecting officer should examine frozen fish individually for signs of spoilage before freezing. The table above summarises the difference in appearance between good quality and stale fish.

Nature and integrity of packaging and wrapping

Packaging is intended to protect the product from physical damage. The inspecting officer should record any damage to outer wrappings, particularly if the damage has caused exposure of the contents. Sometimes the packaging includes strapping, particularly where a carton contains individually wrapped, heavy products like blocks of fillets. The nature and integrity of any strapping should be noted.

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Wrapping, which may or may not be supplemented by further packaging in a carton, is intended to prevent contamination and dehydration. Wrapping is only effective in protecting against dehydration if it is sealed or is closely applied to the product. The record should include details of the type and condition of any wrapping.

The officer should note any staining of cartons and outer wrappings, including the character and nature of the stain – lubricating oil, fuel oil, water, fish juices, for example. Oils tend to be dark in colour and leave the wrappings soft, even when frozen; fish-juice stains are yellowish or reddish. The officer should note if the staining is extensive, covering all or most of the container or wrappings, or localised. When stains are localised, note whether they are predominantly on corners or edges of packages or on the sides.

Blemishes, stains and contamination of the product

When the surface of the product is visible, it should be inspected for blemishes and contamination. Blemishes include surface damage to whole fish like abrasions and tears to the skin or splits in the flesh, and surface damage to blocks such as patches of freezer burn. An attempt should be made to assess the proportion of the consignment affected.

It is important to record an unusual discolouration or staining, and if possible the nature of the defect, for example, blood or bloody brine (particularly on brine-frozen tuna), oil, and chemicals. The product should also be examined for contamination by dust, organic matter such as fish offal or vegetable debris, and any other foreign matter.

In all cases of blemishes or contamination, the inspecting officer should note

Damage to outer carton, though wrapping and contents look unharmed

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the extent of the damage and estimate the proportion of the consignment affected.

Signs of thawing or partial thawing

Sometimes claims are made against shipowners on the basis that a cargo had thawed or partially thawed during the voyage, and had then frozen again to the stipulated carriage temperature. It is therefore important to check that a potential cargo does not show signs that it had thawed and refrozen *before* it had been presented for shipment. Such thawing or near thawing is often indicated by distortion of product shape and release of liquids from the product.

Oil-stained cartons

Distortion

Distortion of whole or blocks of fish indicates that the material has thawed or partially thawed since freezing, or was distorted during the freezing process.

Individually frozen whole fish often have slight pressure marks formed during the freezing process. These minor distortions must be allowed for during examination of frozen products. The nature of the marks depends on the freezing process. For example, fish frozen in trays are slightly flattened or have indentations on one side where they have lain on the trays during freezing. Brine frozen fish tend to float in the brine tanks and are restrained below the level of the brine by a grating. As a result, the fish may have slightly flattened sides where they have been compressed, or shallow cylindrical-shaped depressions where fish lay across each other as they froze. Sometimes the pressure on tuna during brine freezing results in splitting of the skin and flesh, usually on the dorsal surface at the base of the dorsal fin. Any other splitting should be noted by the officer.

Any distortions other than slight flattening or the presence of minor depressions suggest that the product has warmed up, softened, and refrozen in the distorted shape. The officer should note the nature and extent of any distortions.

Blocks of fish should reflect the sharp angles and regular, geometrical shape of the tray or former in which they were frozen. Blocks of fish which have thawed while stored on pallets or in stacks show signs of slumping, bending, or compression and material is often squeezed into spaces between blocks. Restraints such as strappings and the framing of pallets and shelf-supports cause indentations in the blocks of fish. Again, the inspecting officer should note the nature and extent of distortions.

Release of liquid

Fish release liquid as they thaw. The cargo officers should check for pools of liquid collecting within wrappings, and for signs that liquid has been squeezed from the blocks and has refrozen on the sides of the stack or on shelves and pallets. Staining of cartons is sometimes an indication that the contents have thawed and released liquid.

Carton has been stained by fish juices when the block partially thawed

Transfer, stowage and carriage

Temperature control during loading

It is very important for maintaining quality that frozen fishery products be held at low temperatures at all times. Although it is inevitable that the product's temperature will rise during loading into the hold, the loading operations must be conducted so as to keep this rise to a minimum. The product's quality suffers not only due to the immediate rise in temperature as material is stowed in the hold, but also because of the time taken to bring the product back down to the required temperature after stowage.

As far as possible, the cargo should be loaded at, or below, the required temperature of carriage – typically around -18°C. Officers and crew should attempt to minimise warming of the cargo while it is being loaded and stowed in the holds, preferably so that the temperature of the cargo is not above -10°C by the time it is stowed. Although the ship's crew may have little control over loading operations, the master should co-operate with the ship's agent, and particularly with the stevedoring company, to ensure that good practices are adopted during loading and stowing.

Good practices during loading

- Ensure that delivery to the ship's side is matched to loading onto the vessel to reduce the time that products are waiting on the quay.
- Products should be delivered in insulated containers or lorries, or at least in covered vehicles.
- If the material must be unloaded onto the quay or held on the deck of the reefer, it should be placed on pallets or on an insulating base, packed as tightly as possible and covered with a tarpaulin or similar protection against sun and wind.
- The cargo should be protected from exposure to wind, rain and sun until it is about to be transferred to the vessel.
- In tropical climates, avoid loading for two or three hours either side of noon and consider loading the vessel at night.

Good practices during stowage

- Ensure that the hold is cooled to below the carriage temperature before loading begins.
- During breaks in loading, cover holds or decks with at least the hatchcovers, even if the thermal covers are not put in place.
- Refrigeration to the holds should be turned on during long breaks.

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- Transfer cargo as rapidly as possible from the quay or discharging vessel to the hold.
- Once loaded, the cargo should be covered with tarpaulins.
- Where consistent with efficient loading, use only one hatch at a time to avoid through currents of air in the hold.

Maintaining low temperatures during carriage

There is usually an explicit or implicit requirement to hold the cargo below -18°C during carriage. The ship's refrigeration system must be capable of delivering air to the holds at a temperature a few degrees below the target temperature to allow for heat leaks though the ship's structures. Cargo spaces in reefers are usually cooled by re-circulating air systems, which are only effective if the air can circulate freely through and around the stow.

Most heat leaks into the cargo hold occur through the sides and bulkheads, and it is important to ensure that there is free circulation between the cargo and the structures to the hold. Sides and bulkheads should be fitted with vertical dunnage (without horizontal battens which could obstruct air flow) to keep the cargo away from the structures. There should be an even gap of at least 20cm between the top of the stowed cargo and the lowest part of the deckhead.

Cartons should be stacked with gaps between them while stows of individually frozen fish will inevitably have spaces between the fish unless the fish are deformable and have been compressed.

The ship's engineer should ensure that refrigeration equipment is well maintained and can achieve the design temperatures. Evaporator coils must be defrosted as required to maintain the cooling capacity. Frequent need for defrosting is a sign of high temperatures in the cargo and should be noted in the engine room log. In addition, the engine room log should record temperatures at critical and meaningful positions in the refrigeration system – for example, the outlet and return air streams in air cooling systems, and the outlet and return fluid temperatures in pipe-cooled systems.

It is vital to take and record temperature measurements in the hold. How meaningful these measurements are depends on the location of the

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temperature sensors. Material in the centre of the stow is the slowest to cool because the source of refrigeration is mainly around the sides of the stow. Refrigerated air percolates gaps between fish or between cartons and the cooling effect depends very much on the existence of uninterrupted spaces. Sensors attached to the sides or bulkheads of the hold are exposed to cold air circulating through the dunnage against the sides or bulkheads and therefore tend to indicate temperatures lower than the bulk of the cargo. Sensors should be attached to posts or other structural members running through the hold, where they are more likely to reflect the temperature of the bulk of the cargo accurately.

Protecting the cargo from contamination

Every effort must be made to protect the cargo from contamination. Good shipboard practices will prevent direct contamination by sea water, bilge water, fuel oil and the like, but it is important to be aware that fishery products are rapidly tainted by odours picked up from the ambient air. This is a vital consideration when using air-cooled refrigeration systems – the air must not become polluted by odiferous materials such as fuel oil, paints or chemicals used on the ship. A simple guideline is that if the air circulating through the hold has an odour, then that odour will be picked up by the fish products.

Unloading

When a cargo is unloaded from the ship, similar precautions should be taken to those recommended during loading to minimise warming. Unloading should be completed as quickly as possible and the cargo should be protected from wind, rain and high temperatures.

Documentation

The importance of documents

Documents are fundamentally important in the investigation of any claim involving damage to cargo. They will be examined by the technical surveyors, and may be used as evidence in any subsequent legal proceedings. The following documents are likely to be important in the event of a claim.

- Ship's log.
- Bill of lading.
- Mate's receipts and attached record of the inspection of the cargo prior to and during loading.
- Deck log of loading and unloading.
- Stowage plan.
- Engine room log.
- Any documentation arising from disputes during unloading and/or receipt of cargo.

In addition, photographs and video recordings can provide important evidence in support of statements in the logs and inspection reports.

Mate's receipts

The mate's receipts should include the record of the pre-shipment inspection (see previous section). This record should detail all observations on the cargo's condition at time of receipt, including results of at least a visual inspection of each part of the consignment. Records should also include temperature measurements, taken at sufficiently frequent intervals to provide a fair indication of the average temperature of the cargo.

Any observations which indicate that cargo temperature is high, or that cargo was delivered in a damaged or deteriorated condition, should be supported as far as possible by further evidence. This evidence might include photographs taken during pre-shipment inspection or results of reports by cargo surveyors.

The mate's receipt should include any information on the nature of the consignment supplementary to the bill of lading, as well as details of any labels.

Deck log for loading

Loading

Many charterparty agreements specify a minimum rate of transhipment or loading. To demonstrate compliance with this, and to provide evidence in case

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of claims concerning damage to the cargo during loading, the timing and sequence of events during loading should be noted in the deck log. At minimum, the log record should include the following:

- Time alongside.
- Where cargo was loaded from – quay, lighter, fishing vessel.
- Times of opening and closing of hatches.
- Arrival and departure of stevedores onboard.
- Times when the refrigeration system was turned on and off.
- Start and finish of cargo stowage.
- Any breaks in loading.
- Weather conditions (sun, wind, rain, ambient temperature).
- Any unusual or irregular events which might affect the condition of the cargo during stowage or subsequent carriage.

Deck log for unloading

Unloading

Normally, unloading may be the responsibility of the receiver, and the master of the vessel could consider that his responsibility for the cargo is over. However, the deck log should continue to record conditions during discharge, logging similar information as listed above for loading.

Stowage plan

A stowage plan should be drawn up for all cargoes – an accurate plan is a central piece of evidence in any damage claims arising against the vessel. The stowage plan should indicate the location of each consignment and part of consignment and should include the following information:

- Number of units (pallets, cartons or blocks) in each location.
- Gross and net weight.
- Origin of each part.

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- The corresponding bill of lading.

Engine room log

The engine room log is one of the most important documents, since it contributes evidence about the temperature of the ship's cargo during stowage and carriage. The log should document at least the following:

- The locations of temperature sensors in the holds.
- Temperatures at the sensors in the holds.
- Times when compressors were turned on and off.
- In air-cooled systems, the temperatures in the air streams entering and leaving the holds and compartments.
- In pipe cooled systems, the temperatures of refrigerant to and from the cooling pipes.

Actions in case of dispute

Action by the master of the vessel

The master must load the cargo in apparent good order and condition and act to maintain it in this state. This section describes actions to be taken when a potential problem is identified.

In the event of any concern or dispute over the condition of the cargo while loading or unloading, the master of the vessel should contact his owners or charterers or his P&I correspondent. Best practice would indicate that loading or unloading should cease until instructions have been received, although this may not always be possible.

As soon as any question is raised over the condition of the cargo, the ship's master should begin to document the events surrounding the discovery of defective material, and the nature and possible extent of the alleged defects.

If possible, loading or unloading of the vessel should be halted and the hatches closed until a cargo surveyor is present. Ideally, cargo should be inspected and sampled while still in the hold, or even during discharge,

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allowing the surveyor to determine if the nature and extent of the damage is in any way related to the position in the hold.

Once the cargo has been discharged into store, relating damage to location in the hold is obviously more difficult, or impossible, unless the cargo is adequately labelled. Therefore, if loading or unloading must continue, the master should ensure that each cargo unit is labelled with the hatch number and deck as well as location within the hatch and deck, as it leaves the hold. The deck log should also record the destination of the material and the agent responsible for handling it.

Records

The master should ensure that all records and documents relevant to the dispute are secure, and that they are only made available to parties representing the ship's interests.

Services of surveyors

When a problem is identified during loading or unloading – for example, if the temperature of the material is too high – loading or unloading should cease until the cargo has been inspected by a specialist surveyor.

If the dispute concerns the quality of the product, it will probably be necessary to call in at least one specialist surveyor to examine the cargo, establish its current quality and determine the nature and cause of any defects.

If it is suspected that defects result from maritime causes – for example, physical damage from movement of cargo, or from contamination with sea water, fuel oil or bilge water – an expert in ship operations should be called in. However, if the defects could be attributed to the initial quality of the material when loaded, or to the way the product was stowed and carried on the vessel, a specialist surveyor would be appropriate.

Many of the surveyors appointed by local shipping agents are general marine surveyors, often with a seagoing background; they are not necessarily skilled in the evaluation of the quality of fish cargoes. Masters and agents are therefore advised to check the expertise and qualifications of surveyors

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carefully to ensure that their technical background and experience are appropriate for the particular job.

As a general rule, a single surveyor should not be commissioned for both a cargo survey and a survey of vessel condition. Since the skills required for each type of assessment are very different, it is unlikely that one person would have experience in both areas at the levels of expertise required. A fish cargo surveyor should have a background in food science and the inspection of food products, and, ideally, some experience in assessing the quality of frozen fishery products.

Official inspectors and sampling procedures

Where official inspectors – for example, port health officers or veterinarians – are involved, the master should document the authority under which the officers visited the vessel and the name and status of each officer.

The master is also advised to record the nature and amounts of any samples taken by representatives of the owners or by officials. Such records should include the location of the samples within the hatch or deck, the authority under which the samples were taken and the destination of the samples.

If part of the sample is given to the master, he should ensure that it is fully labelled, and, if possible, that it is sealed in a container under the impress of the person taking the sample. The master should store the sample in a secure place, under conditions such that the quality of the sample will not change.

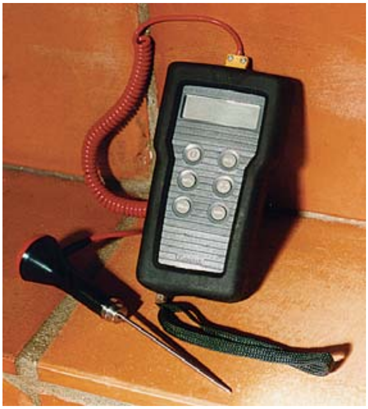
If the cargo is in store, the surveyor should take into account the manner of discharge and delivery to the store, in case these operations could have affected the quality of the product or could in themselves be responsible for any damage.

Appendix

Measuring the temperature of frozen fishery products

Equipment

The most convenient thermometer for measuring the temperature of frozen food products is a water-resistant K-type thermometer with a digital display reading to 0.1°C. Typically, these thermometers have a measuring range down to minus 50°C and an accuracy of ±0.5°C in the range required when measuring temperature of chilled or frozen foods. This accuracy is adequate for the purposes described in these guidelines.



Thermometer and probe

There are several types of probe available for plugging into the instrument. The best all-round probe for measuring temperatures of fishery products is a 100mm long, 3-4mm diameter, stainless steel penetration probe on a 1m lead. There are also stouter, hammer-in probes on the market for forcing into frozen fish (provided the temperature is not too low), but these have long response times. It is usually preferable to drill holes and use a thinner probe.

Measuring the temperature of frozen fish

It is not usually possible to push a probe into frozen products. Normal practice is to drill a hole, with an ordinary engineer's hand or power drill, of such a diameter that the probe fits tightly. The bottom of the hole should be at the thermal centre of the object that is at the position that will cool down or warm up most slowly. The thermal centre is usually at the backbone in the thickest part of a fish, or at the centre line of a block of fillets. The hole should be around 100mm deep – that is, sufficiently long to take the whole length of the probe. This may mean that the hole must be drilled at an angle to the surface of a fish, or along the centre line of a block from one of the smaller side faces.

Once the probe has been inserted, note the lowest temperature reading given in the next 2-4 minutes. While the hole is drilled and the temperature measurement taken, the product warms up, so measurements should be taken as quickly as possible, and preferably while the product is still in the hold.

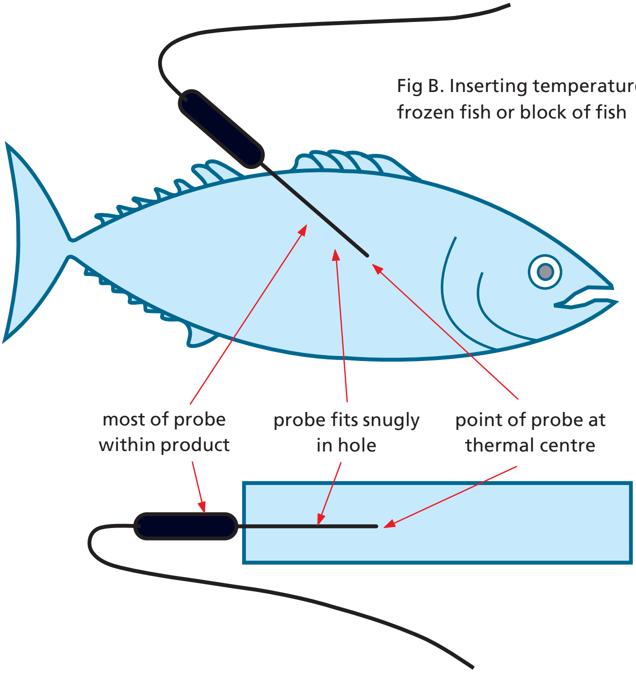


Fig B. Inserting temperature probe into frozen fish or block of fish

Measuring the temperature of products in cartons

Products in cartons may be delivered in regular stacks or in random loads. In a regular stack of cartons – for example cartons on pallets – temperatures can be measured by inserting the probe between cartons. The warmest areas are the corner of the stack.

Temperature should be measured at diagonally opposed top and bottom corners and in the centre of a face. Insert the whole length of the probe between cartons, or between the flap and body of a carton, on the mid-line. Insert the probe between vertically stacked cartons rather than horizontally adjacent cartons as the weight of the cartons above ensures a good thermal contact with the probe. Record the minimum reading. Pushing the probe between cartons will result in some frictional heating, so five to ten minutes

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Measuring temperature within a carton

may be required to reach equilibrium. When measuring temperatures of cartons, it is useful to have several probes, cover the stack to avoid heat loss, and allow 5 to 10 minutes before connecting the probes in turn to the thermometer.

When cartons are loosely stowed, it is necessary to measure the temperature within cartons. If the contents are loose – IQF fillets, for example – the probe can be forced through the side of the carton into the product.

Thermal contact is poor in such cases – it may take 10 minutes, or more, to reach thermal equilibrium. If the cartons contain blocks, it should be possible to insert the probe between blocks to drill a hole in a block through the side of the carton. The carton usually has to be split to locate gaps between blocks and the centres of faces of blocks.

Calibration of the thermometer and probes

Instruments are calibrated by their manufacturers, but it is possible to check thermometer/probe combinations at 0°C on the vessel.

Finely crush some ice made from fresh or distilled water, and pack it tightly in a vacuum flask or jar. Add cold water to fill the flask and insert the probe to its full length in the ice/water mixture in the centre of the flask and leave the flask and probe for a while in a cool place – perhaps a refrigerator or chill room – before taking a temperature reading. Since a mixture of ice and fresh water at thermal equilibrium has a temperature of 0°C, any deviation of the probe/ thermometer combination from 0°C is the correction for that system.

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Meat and meat products in containers

Contamination by odour

Meat is particularly vulnerable to foreign odours and substantial claims can result. Health authorities are naturally concerned when this occurs but even in cases where the authorities are not involved, remedial treatment can be costly. If the intensity of the odour or its penetration of the meat surface is significant, the warehouse or cold store where the meat is stored may reject it because of the risk of taint to other meat already in store. Modern cold stores usually have no facilities for carrying out remedial treatment for small quantities and it can be difficult and expensive to carry out the treatment at other premises.

Soft condition

Apart from complete failure of the refrigeration plant, this damage is usually brought about in the case of Con-Air system containers, by the incomplete closure of the vents at the connection point, where the ship's refrigeration has been disconnected. Damage can comprise blood-stained and misshapen carcasses and the distortion and staining of cartoned meat in the area of the ambient airflow.

Chilled beef

It should be borne in mind that the shelf life of chilled beef is about 10 weeks from the time of slaughter and that it may have been in store for some time before shipment. Occasionally on arrival at destination, the amount of free blood in the vacuum pack is found to be far in excess of normal. Provided that there is no evidence of intra-muscular icing at the time of discharge, any allegation that the transit temperatures were too low should be refuted. The cause could be that the meat has been kept below its freezing point (-2°C) before shipment, in an effort to keep it as cool as possible and prolong its shelf life.

Vacuum packed chilled meat

During the past few years a number of claims have been raised by receivers of chilled vacuum packed meat of high quality, primarily in northern european

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ports. They have complained that their meat had suffered a considerable depreciation as a result of the presence of ice crystals in the meat.

The object of chilling is to provide meat which resembles, as closely as possible, fresh meat and to retain the maximum degree or flavour, texture, appearance and nutritive value.

Vacuum packed meat is placed in a gas impermeable film of plastic bags at a temperature slightly above 0°C. After the meat has been placed in the bags, the air is then exhausted, the film tightly applied to the meat surface and the temperature held at the appropriate level. The purpose of this process is to reduce bacterial growth and surface dehydration activity and hence prolong the storage life of chilled meat.

It should be noted that, because of the absence of air, chilled meat may show an abnormal discoloration and upon removal of the vacuum packing can give off a characteristic and distinctive odour. On exposure to air, the colour of the meat reverts to normal and the distinctive odour will disappear. Thus no immediate conclusions should be drawn as to the condition of the meat after removal of the packing.

The claims made by receivers are on the basis that, because of the presence of ice crystal, the meat can no longer be considered to be chilled (or fresh) meat but it to considered as 'frozen chilled meat' and they claim the difference in market value between chilled and frozen meat at the time of delivery at the port of discharge. It is quite possible that the difference in market value of these two types of meat may be as much as 20-25% bearing in mind the high quality of the meat involved.

The usual carrying temperature will range from -1.4°C to +2°C but on short voyages the shippers may require a carrying temperature as high as 0°C. The shippers should normally issue precise instruction on this point and if they do not, ships' masters should press for such instruction to be given preferably in writing. As the meat is vacuum packed, spike temperatures cannot be taken upon loading but spot checks on individual cartons, placing the thermometers between the layers, is recommended. Should there be any significant variation above or below the recommended carrying temperatures, it is suggested that a competent surveyor be called in.

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For significant ice crystal formation to occur within the meat requires exposure to temperatures lower than -2°C for prolonged periods because the meat contains various salts which lower its freezing point. Minor quantities of crystal near the surface within the meat should not be taken to demonstrate a deterioration in condition or value. Crystals may also form on the meat at temperatures of 0°C (the freezing point of water) and below. These crystals between the meat and the vacuum packing result form moisture migration and are not indicative of any deterioration in the quality of the meat or any fault in the carriage. Any claim presented on the basis of the presence of such crystals should be strongly resisted.

Transhipment

There have been isolated instances where, as a result of damage to the original container during transit, re-stowage of the cargo into a sound container has been necessary. If such a transfer is carried out without veterinary control, in a country designated as a 'disease pollution' area, such as the United Kingdom, the consignees in some countries may reject the consignment on the grounds that there has been a breach of their own health regulations.

Insulated and integral refrigeration containers

The shipment of chilled meat in Con-Air units has been accomplished with great success with carriage temperatures as low as -1.4°C. However, when similar carriage temperatures are attempted in containers fitted with integral refrigeration equipment, problems with intra-muscular icing have been encountered. It is recommended that chilled meat shipments are not carried in integral refrigeration containers with temperature settings lower than -0.5°C.

Regulations in the United Kingdom

It appears that in the United Kingdom, there are two regulations which govern the importation of foodstuff, namely:

- The *Imported Food Regulations* 1994, and 1997 with subsequent amendments; and
- The *Products of Animal Origin (Import and Export) Regulations* 1996 and subsequent amendments.

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The first of these includes matters of importance to shippers and importers and in Schedule 4, sets out specific requirements as to wrapping, packing and transport of imported meat. For instance, the temperature controls are:

- For carcasses and cuts (excluding rabbit, hare meat and poultry meat) not higher than +7° C (chilled) or -12° C (frozen).
- For offals (excluding rabbit offals, hare offals and poultry offals) not higher than +3° C.
- For rabbit meat, hare meat, poultry meat, rabbit offals, hare offals and poultry offals not higher than +4° C.
- For meat products – temperature as specified on the label (when appropriate).

The foregoing temperature variations and constraints are not as rigorous as those normally applied by for instance, the North Atlantic Conference Lines and possibly other shippers or carriers. The second regulation mentioned above relates primarily to veterinary requirements and applies mainly to shippers and importers.

There are of course, a number of other regulations which touch upon the same aspects and these include:

- The *Food Safety Act* 1990; and
- The *Channel Tunnel (Amendment of Agriculture Fisheries and Food Import Legislation) Order* 1990

So far as the Committee is aware however, only the Imported Food Regulations 1994, noted above, incorporate specific temperature requirements.

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