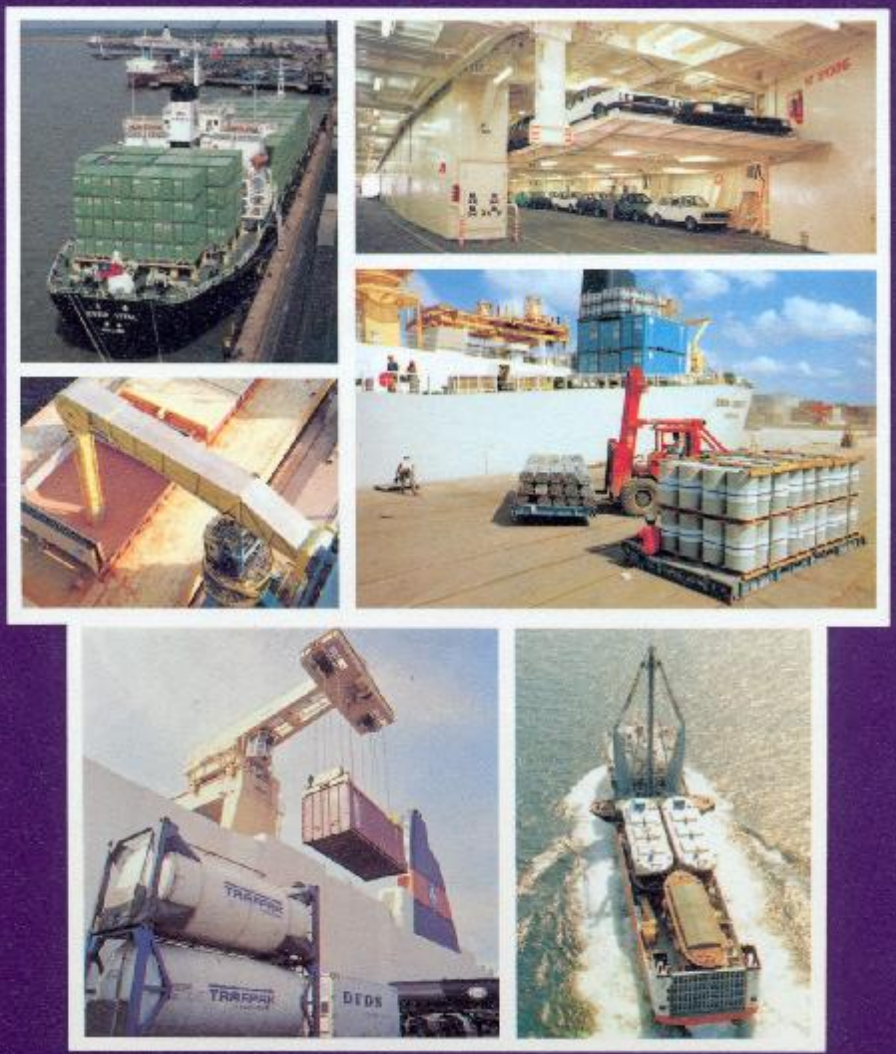
Thomas' Stowage

The properties and stowage of cargoes



FOURTH EDITION

Revised by Capt. K. S. RANKIN

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PART 1

SAFETY

INTRODUCTION

The majority of the world's merchant ships exist to carry cargoes on a commercial basis from one place to another. The types of ship undertaking these voyages vary enormously, and they may range in size from the smallest coaster to vast oil tankers with cargo capacity approaching half a million tonnes. In every case, the loading, distribution, stowage, security and monitoring of the cargo is of prime importance to the safety of the ship, her personnel and equipment as well as her ability to earn a profit for her Owners. In addition the cargo may represent a potential source of danger to other parcels of cargo on board, and some or all the cargo may pose a significant hazard to the environment should some disaster overtake the ship. Today, an increasing amount of the workload in planning and stowing the cargo is done ashore, often using computers, but the Master must always be aware that the responsibility for the safety of the ship remains with him. He must satisfy himself that at all times the ship is being maintained in a safe condition, and will be able to undertake a proposed voyage with no danger to her structure or her cargo.

SEAWORTHINESS

The legal concept of seaworthiness is not always the same as a layman's understanding of the word. A legally seaworthy ship may, in fact, have serious defects, but they would have to be defects that her crew could not reasonably have discovered. Legal seaworthiness is not generally an absolute standard but instead constitutes an adequate defence to liability for the Owners which will result if, amongst other things the Master and crew have exercised "due diligence". What comprises "due diligence" will depend on the particular ship, cargo and voyage contemplated. However, in general terms it means the exercise of reasonable care.

Improper stowage of cargo may cause a ship to be legally unseaworthy in two ways:

(i) it may make her unfit for the voyage contemplated. For example, if cargo is inadequately secured and liable to break loose rendering the ship unstable.

(ii) it may make her unfit to receive further cargo. For example, if cargo on board is inadequately secured and liable to break loose damaging subsequently loaded cargo.

In considering how to avoid a finding of unseaworthiness resulting from improper stowage, reasonable care or due diligence must be employed, particularly in relation to:

(a) Load Distribution
(b) Cargo Securing
(c) Effect of cargo
(d) Machinery and Equipment
(e) Good Seamanship

LOAD DISTRIBUTION

A vessel's ability to return to an upright position when heeled by some external force, such as by action of waves, is a measure of her stability. The force of gravity acting downwards and the buoyancy force acting in opposition cause a righting lever which acts to return the ship to the upright when heeled.

The magnitude of this lever is determined by the position of the Centre of Gravity within the ship which is itself affected by the disposition of cargo, fuel, ballast and fresh water etc. Broadly speaking, the lower the weights in the ship the lower the Centre of Gravity; the lower the Centre of Gravity, the larger will be the righting lever at successive angles of heel (that is, the greater the ship's ability to return to the upright).

To an extent this suggests that heavier goods be stowed in the lower part of the ship with lighter goods on top. However, it should be borne in mind that very large righting levers (an excess of stability by virtue of a low Centre of Gravity) may give rise to excessive, violent rolling and consequently potential damage to both ship and cargo. Some Classification Societies restrict the maximum permissible GM. This may be known as "super stability" and restrict the deadweight intake of closeweight cargoes. Careful loading will ensure adequate but not excessive stability — said to be neither "tender" nor "stiff".

When performing stability calculations the centres of gravity of various parcels of cargo can often only practically be arrived at by approximation. It is better to err on the side of safety, assuming the centre of gravity to be *higher* than it probably is. For instance, where ISO containers are concerned, the vertical centre of gravity almost always lies *below* the mid height point of the container; if the mid point itself is used, a safety factor for the overall stow will automatically be incorporated because the actual Centre of Gravity of the ship will lie somewhere below that calculated.

Apart from stability considerations, distribution of cargo (and to a lesser extent bunkers, ballast and fresh water) can induce unacceptable bending moments, sheer forces and torque — particularly in larger vessels. Care should be exercised to ensure that any limits established by her designers are not exceeded. Instances are on record of vessels having broken in two during cargo operations; continually subjecting larger vessels to excessive loads throughout the ship's life can give rise to structural failure in a seaway. Loading the vessel with excessive weights at each end also tends to make that vessel hog and be sluggish in rising to a head sea, and liable to undue strain in heavy weather.

POINT LOADING

This term refers to the deck strength and the maximum permitted weight loading of cargo, expressed in metric tonnes per square metre. Classification society rules will state these limits for tanktops, 'tween decks, weather decks and hatchtops, and is predicated on evenly loaded cargoes. In the case of bulk carriers their tank top strengths may vary from 10 mt/m^2 to 25 mt/m^2 where the holds have been specially strengthened.

If a bulk carrier loads a homogeneous cargo of, say, iron ore, the amount of cargo permitted to be loaded in the hold would be determined by multiplying the surface area of the tank top by the permissible load per m^2. The loading given by this calculation should never be exceeded.

Complications arise where a bulk carrier has to load steel coils. It will be appreciated that there is a very small area of contact with the tanktop for a steel coil of 15–25 mt.

Large bulk carriers doublebottoms normally have longitudinal intercostals about 800 mm apart. Bearing this in mind, the judicious use of dunnage to spread the load may be a solution. Charters/shippers may be reluctant to provide this facility but a compromise is normally reached.

CARGO SECURING

Roll on-Roll off cargoes present a number of problems, such as the unsuitable state or absence of lashing points on some road vehicles, high centres of gravity on certain loads, inadequate lashing equipment etc.

Inadequate lashing of cargo on Ro-Ro's has frequently been the cause of cargo shifting and the vessel taking on a list. The dangers are exacerbated by water entering onto the loading deck as a large "free surface" of liquid diminishes the vessel's stability, potentially to a point where a vessel heeled may have insufficient righting lever to return to an upright position.

Containerised Cargo: It is often not possible for ships' staff to examine or monitor the securing of cargo within a container, although the Master has the right to open a container for inspection should he suspect that all may not be well within. Cargo which is visible — such as that on flatracks — can be examined at the ship's rail and any lashing arrangements which are suspect may either be adjusted by ship or shore staff or alternatively the container should be landed ashore.

Cargo stowed on deck requires particular care in stowage and securing, whilst at the same time affording adequate access to sounding pipes, fire hydrants etc. and to the ship's side should the need to jettison arise. Whilst at sea deck cargo should be inspected daily and lashings tightened when required.

In general, it is not desirable to carry steel cargoes on deck. They are susceptible to the moist salt air and maintaining covering in heavy weather often proves impractical.

Carriage of bulk cargo as noted above may require the use of considerable measures to ensure that any shift of the cargo caused by motion of the ship will not endanger the safety of the vessel. In the case of grain cargoes, the stowage of the grain, and the calculation of its likely effect in the event of a shift must be in compliance with the IMO grain rules which will be implemented by the national legislation of the flag state of the ship. However, other cargoes carried in bulk may produce similar results in the event of a shift, and the need to restrain cargo, particularly athwartships, must always be considered. These aspects are dealt with further in Part 2 of this book — Bulk Cargoes.

EFFECT OF CARGO

Under this heading the Master must consider the effect of any given parcel of cargo upon other cargo carried on board, as well as possible effects of the cargo on the structure of his vessel. Clear guidelines apply to the stowage and segregation of dangerous cargo, and in some cases may require particular commodities to be carried in completely separate holds. Clearly, the interaction of two cargoes will not occur if the packaging of that cargo remains intact. However, the Master must always consider the possible effect should the cargo escape for any reason and should not restrict his consideration to those cargoes which are listed in the IMDG code. An example might be fruit juice concentrates which although having no risk to the ship or personnel, can write off an entire cargo susceptible to taint even if the escape is relatively small. For this reason, when loading the cargo particular attention should be paid to damaged containers and any which are not satisfactory should be rejected.

The Master should also bear in mind the effect of the cargo on his ship's structure. An example of this is the carriage of high sulphur content coal, which under certain circumstances can lead to the formation of sulphuric acid and very greatly accelerated wastage rates in the ship's steel work. He should also be mindful of the effect of the cargo on subsequent cargoes planned to be carried in the same space, particularly where foodstuffs are involved, which may lead to claims in the future based upon ship being in an unfit condition to load.

The planned rotation or loading sequence of heavy bulk cargoes should be strictly adhered to. The Master must resist commercial or operational pressure to alter this sequence.

MACHINERY AND EQUIPMENT

To ensure against the entry of sea water, rain or spray, all weather deck and hull openings (hatches, doors and ramps etc.) should be tightly secured and always maintained in good order. Manual hatch covers, if not interchangeable, must be clearly marked to show where they belong. Beams left in should be pinned.

Battening down with manual cleats can be a long job in larger ships with small crews. It must often be done at night, in inclement weather, and in similar circumstances in which the crew may not be as attentive to their duties as they should be; cleats left undone, eccentric wheels not turned up, multiple

panels incorrectly aligned and cross joint wedges not hammered up are amongst the most common sources of water ingress. Permanent local damage to gaskets with consequent leakage may also occur during battening down as a result of obstructions such as lashing wires or cargo residues left on hatch coamings or between panels.

When water penetrates a hatch seal, it is usually collected in a drainage channel and discharged clear of the hatchway. Water may spill over onto the cargo in the hold below if these channels are allowed to become blocked or restricted.

Any fork lift truck or other vehicle used on board must operate in an area free of obstructions. Because of the danger from fumes, units powered by diesel and petrol engines are not usually suitable for use within the confines of a ship's hold or 'tween deck unless adequate ventilation is available. (N.B. Diesel and petrol fumes can also taint some sensitive cargoes; see part 3 — Commodities). Any bridging used to improve working areas (e.g. flared holds in bow and stern) must be of adequate strength to accept the wheel loading of the equipment and its cargo. The same strength requirement of course applies to permanent equipment such as limber boards; see also Part 4 — Damage.

SEAMANSHIP

While a vessel may be in good condition on leaving port, this condition must be maintained at sea by prudent handling and good seamanship. What constitutes "good seamanship" in this context is beyond the scope of this book, but examples include the alteration of course and/or speed to minimise damage to deck cargo and fittings in bad weather; effective load distribution and ballasting to improve stability and rolling characteristics; checking the condition of all cargo and associated lashings throughout the voyage where practicable.

ISM CODE

This is not a legal textbook, and it is not the place to fully consider the more recent developments which may affect the position of a shipowner whose vessel is "unseaworthy". However, most readers will be aware of the International Management Code for the Safe operation of Ships and Pollution Prevention, usually known by its short title of the ISM Code. This is IMO's first foray into providing guidance on how ships are to be operated, whereas previous conventions have aimed at the design and construction and equipping of ships.

The effect that the ISM Code has had on the safe operation of ships is still being evaluated by Flag States and the industry, although individual operators will by now have a fairly clear view of how it works for them.

However, on an individual vessel scale, it will be apparent to Masters that the requirements of the code that an owner have written plans, procedures and guidelines for the shipboard operations on a particular vessel (including how cargo is loaded, stowed and secured) and the maintenance of the ship and its cargo equipment will mean that these procedures will be subjected to close scrutiny in the event of loss or damage. In this context then, perhaps of even greater significance will be the reporting system required by the Code whereby reports on problems encountered are generated, corrective action is taken to remedy the defect in the way the ship is operated, and then monitoring of the change is implemented to ensure the revised system works. All of these steps must be fully documented.

It does not take a great stretch of the imagination to visualise a situation where a number of incidents have arisen with a vessel, which if taken together point to a serious defect in the ship herself or the way in which she is operated. The implications of this for seaworthiness or indeed for the position of the owner with his hull underwriters will depend on the circumstances of the case, but it is clear that ISM cannot be ignored when considering the factors that determine whether a vessel is seaworthy.

FIRE

The risk of fire breaking out amongst cargo in a ship's hold, the resultant damage to ship and cargo and the risk to personnel are obviously matters which must be borne in mind when cargo is being stowed.

Smoking, lighting matches, the use of electric cables with frayed insulation etc. must never be permitted in an area in which cargo is being handled — whether that be the ship's hold, the vicinity of open hatchways, the container or the container stuffing area.

Where Dangerous Goods are concerned, fire may be the principal hazard, though not the only one. In this respect Dangerous Goods are not only a potential source of ignition but can also greatly intensify or complicate a fire and make for difficulties in fire fighting.

It is particularly important to ensure that all normal precautions against fire are carried out. These should include:

1. The provision of all fire-fighting equipment (as required by local or national regulations) in properly maintained and fully operational condition.
2. The provision of proper instructions for emergency routines and the regular practise of any such routines. Fire fighting apparatus layout and cargo plans should be readily available to both ship and shore personnel.
3. Proper care and correct operation of cargo handling gear and other machinery.

Explosions can occur in a number of substances (not only those classed as explosives) with varying degrees of violence. Where this characteristic exists, care should be taken to ensure that any recommendations with regard to stowage are fully complied with. An explosion would almost certainly be followed by a fire.

Where IMO class 1 cargoes or class 3 (low flash point) cargoes are being handled by mechanical equipment, such equipment must be made safe to operate in the vicinity of such cargo, for example electric motors must be spark-proof

Fires and explosions often occur whenever a concentration of gases or vapours are present. It is possible for pockets of gas to form even although it is thought that proper ventilation has taken place throughout the stow. Vapours or gases from substances with a wide explosive range (e.g. acetylene) and particularly those of a density equivalent to air are most dangerous.

Certain goods, if loaded when wet, may be liable to spontaneously combust. To load such substances during or after rain is to increase the risk of fire during the voyage. Extreme insect infestation in certain bulk cargoes can form "hot spots" which may become the source of fire. A fire which has started whilst stuffing or shortly after closing, an ISO container may not become apparent until that container is loaded on to the ship and is on the high seas.

It is particularly important, therefore that all possible precautions are taken to prevent such an occurrence. Containers with combustible cargoes should be stuffed in a controlled environment and their contents properly declared. Cargoes liable to spontaneously combust "in stow" should not be unnecessarily ventilated and should be checked regularly for rise in temperature.

The securing of transport, containers and other cargo on the vehicle decks of Ro-Ro vessels must be arranged in such a way that fire-fighting equipment remains unobstructed and fully accessible during loading discharging and on passage. This includes valves, emergency pumps, etc.

ACCIDENTS

Accidents are often caused as a result of improper maintenance of cargo handling equipment. Regular inspection of blocks, sheaves, bushes, wire ropes etc. should be part of any planned maintenance programme. Any associated paperwork — such as test certificates — should be kept up to date and be available for inspection when required. Measures should be taken to avoid obstructing limit switches, e.g. when painting a crane or derrick. A careless application of paint may stop up vitally needed grease nipples.

The risk of accidents to personnel and cargo can be reduced by good "housekeeping" and proper procedures. These include:—

- Clear, unobstructed access to all cargo handling and storage areas.
- Proper lighting in the holds and other working areas.
- The removal of nails from old dunnage, or the removal of the dunnage itself to a safe place.
- Proper maintenance of equipment and compliance with Flag State and Class certificates etc.
- The provision of suitable clothing and equipment; e.g. special protective clothing should be available when certain dangerous goods are carried (see IMDG code).

— Walking boards to provide access for labour over delicate cargo, e.g. chilled foodstuffs, light carton goods etc.
— Regular inspection of cargo (where accessible) during the sea passage.
— Guard rails erected, where necessary, to protect personnel.
— Adequate barriers and controls to restrict the approach of unauthorised personnel where containers are being moved, stowed, stuffed, inspected or fumigated.
— Attention to gas-freeing and other safety precautions when entering spaces that might have a high gas content or insufficient oxygen — e.g. containers that have been carried under fumigation; deep tanks after discharge; containers that have been registered by Liquid Nitrogen, Carbon Dioxide or other refrigerant; spaces that have recently held certain Dangerous Goods etc. Certain scrap steel cargoes carried in bulk may produce life threatening oxygen depletion within the hold.
— Should emergency access to a suspect space be necessary, the operation should only be carried out under supervision and by trained personnel wearing breathing apparatus.

Certain bulk cargoes during loading may produce dust. This may be harmful and irritating if inhaled or in contact with skin. Steps should be taken to ensure that on-deck personnel are properly clothed and protected by face masks etc. Where practical, the accommodation should be turned into a dust free citadel by securing portholes, windows, and inlets. Access should be restricted to one or two doors. Normally air conditioning fans are well clear of cargo holds, but the system may be turned off if necessary. All decks and external bulkheads should be thoroughly washed down immediately after completion of loading.

— Safety helmets to be worn when cargoes are being worked on deck or down below.
— Hold ladders should be checked. Those that are damaged and dangerous (and which have not yet been repaired) must be roped off to prevent access.

CARGO LOSS PREVENTION

Consider the contrast between the excerpts of the Prologue and Epilogue of this book. On the one hand there is an almost spiritual relationship between the captain's assistant and his cargo. On the other there is a sense of helplessness.

Breakbulk and general cargoes are increasingly being carried in containers. The master has to rely on the shore organisation for their proper stuffing, loading, and identification (IMO labelling etc.).

In the case of chemical cargoes the master has to rely on the specification and description given to him at the time of loading and usually incorporated into the Bill of Lading. The results of footing samples taken is largely out of his hands.

Grain bulk cargoes are accompanied by a moisture certificate drawn up while the commodity is in the silos. It is well nigh impossible for a duty officer to detect a small parcel with excessive moisture coming on board as loading continues 24 hours a day and the holds are enveloped in clouds of dust.

Nevertheless, as explained in previous paragraphs, there is the obligation for the master and his crew to exercise due diligence. Should a cargo claim arise, it may be defended on the basis of "inherent vice". Provided the holds are properly washed, clean, dry, and there is no trace of previous cargoes or taint. In the case of chemical carriers, the tanks must be scrupulously clean and the surfaces sound. It has been known for chemicals to be absorbed into the coating and to leech out into the next cargo. Containers presented for loading must be clean, sound, and free from taint.

The master and his crew must be vigilant and record any abnormality or deviation from the description of the cargo. It is essential that the Mate's Receipts reflect, as far as practical, the true condition of the cargo. These observations should be reflected in the Bill of Lading. The Master's Letter of Authority to agents to issue Bills of Lading on his behalf must be explicit in the requirement for Bills of Lading to be issued in conformity with Mate's Receipts.

P&I clubs and insurers are increasingly pro-active in identifying areas where claims arise and notifying members and clients. For example, this may be in the form of a circular warning of problems with rice cargoes from the Far East, or notifying a draught problem at a port in the Philippines. Reliance is on agents and correspondents to produce this information promptly.

On board, proper records and reports must be kept on cargo damage and how it occurred. If possible, these should be accompanied by photographs. Deck logs, ventilation logs, records of inspection, maintenance records, letters of protest, draught surveys, should also be produced.

PART 2

TECHNIQUES AND SYSTEMS

GENERAL INTRODUCTION

The principles of stowing the basic types of cargo, although treated as separate sub-sections, do in very many instances coincide. The techniques in handling and stowing bagged cargo, bales, cases and cartons, must be similar in most handling modes. The principles of taint, sweat, separation and ventilation remain unchanged, with slight variation of application for the different handling modes. Wherever possible cross referencing has been used to avoid repetitive text.

The different types of cargo referred to in this section are:

Break Bulk Cargo — including general information on the handling and stowage of different cargo types such as bags, bales, cases, drums, etc. Also this sub-section holds the most information on ventilation, taint, dunnage, etc.
Dangerous and obnoxious cargoes.
Livestock.
Unitised cargoes.
Containerised cargoes including ro/ro system.
Iron and steel products. Timber.
Refrigerated cargoes.
Bulk cargoes.
Petroleum, LPG, LNG, and liquid chemical cargoes.
Oils and fats.

Although passing reference may be made it is not within the scope of this book to go into detailed stowage requirements of barge carrying vessels (except in so far as the stowage of the barges can be considered general or bulk cargo stowage.)

The proper and adequate stowage of cargo, whether onboard ship, inside a container or into barges, is the result of good pre-planning and careful attention to the requirements of the trade and mode of carriage employed. Properly carried out it should ensure the following:

1. The preservation of crew and ship from danger or injury arising from the manner in which the cargo is stowed.
2. Protection of the cargo from damage, or deterioration and thus ensure sound delivery of same.
3. An economy of cargo space by which depends the earning capacity of the vessel.
4. Speed of operation at time of loading and discharge, This in turn affects the turn round time of the vessel and thus the earning capacity of the vessel during the voyage. (N.B. In the case of Ro-Ro and Container vessels, this requirement is usually of greater importance than the economy of cargo space. Indeed, efficient use of space may be sacrificed to achieve greater despatch).
5. Accessibility of cargo for each port without disturbing cargo intended for a subsequent port, i.e. the minimum number of overstows.

BREAK BULK CARGO

Introduction

Break Bulk Cargo operations includes the handling, carriage, stowage and storage of cargo in individual items, i.e. crates, cases, cartons, bags, bales, bundles, drums, barrels etc., listed in a number of Bills of Lading, each consisting of a different commodity.

The characteristics of the different cargo types (crates, bags etc.) are described under the general heading of Break Bulk Cargo, but many of the handling, stowage and storage requirements of these items are equally applicable when other modes of carriage are employed e.g. containers, Ro-Ro vessels etc.

General Stowage

Charter Parties normally call for the cargo to be loaded under the supervision and or responsibility of the Master. The Master must at all times ensure that the stowage is safe and does not endanger his ship. The charterer may have time foremost in his mind. Should the Master be dissatisfied with the stow for any reason the loading should be stopped and the matter brought to the attention of the superintending stevedore and the charterers representative. Tallies and mates receipts must accurately record the quantity and condition of the cargo. To issue a Bill of Lading that does not accurately reflect the condition of a cargo is fraud. (see also Part 5 — Tallies and Bills of Lading).

The loading stevedore may have despatch at his end much more in mind than speed of operation at the other end; so that, if left without firm guidance and control by those interested in despatch at the ports beyond, he may find it to his advantage to confine to one or two holds cargo which would discharge twice as fast if stowed in three or four, especially if he is working on a per ton (or all inclusive rate) basis — the covering and uncovering of extra hatches, the employment of foremen (and sometimes gangs) for less than a full day's work etc., eating into his profits, as they must, naturally tell.

In the case of multiple port loading, the stowage may be carried out by several stevedoring companies. Unless the loading is supervised by the Master and his officers, there may be a tendency for the stevedores to choose easily accessible stows for their cargo. This may complicate matters at subsequent loading ports and almost certainly create problems at the discharging ports.

In the case of multiple port loading, the loading is done by as many stevedores, and unless the stowage is under the control of the ships' officers the tendency which exists for the stevedores in the earlier ports to pick the easy spots for their cargo may very seriously complicate the stowage at the subsequent ports, and react in a serious manner at the discharging ports as well.

Stowage should aim at distributing the cargo for any particular port equally or as nearly so as circumstances permit, in every hold, thus provision is made that all the cargo handling equipment is employed to its full capacity throughout the time the vessel is loading and discharging. It is best to ensure that the "heavy" hatch does not have to remain working for extensive periods after all other hatches are finished and have been battened down, with the added restriction, probably, of only one gang and one hook being able to get access to the space being worked.

Where foodstuffs and fine goods are stowed (that is, goods such as carpets, clothes, etc, which may be easily damaged or take on taint) only clean nail-free dunnage should be used and stowage should be found in separate compartments away from such obnoxious commodities as creosote, aniline, essential oils, petroleum, copra, hides, manures, cassia, certain chemicals, turpentine, newly sawn or most kinds of timber, green fruit, onions, etc.

Weighty packages such as cases of machinery, railway bar or plate iron, blocks of stones, ore billets, ingots or pigs of metal, etc., should always be stowed on the tanktop or floor and the lighter cargo on top.

As a general rule fragile and light packages should be stowed in 'tween deck spaces — the ground floor of such being, if necessary or advisable, covered with weighty goods — where they will not be subjected to excessive top weight.

The nature of the packages sometimes calls for them to be kept in a certain position, i.e. coils and rings on the flat, etc. Avoid stowing bale and light goods on top of cargo which has life and spring.

or against bulk head stiffeners, deck beams, brackets, frames, stanchions or other projections, using plenty of dunnage to protect them from contacting such projections and rough surfaces.

Each tier should be kept as level as possible (with packages of uniform size it should be perfectly level). Packages should not be stowed in such a manner or position that they tilt either way, as will occur at the turn of the bilge, or with the rise in floor in the fore part of the forward hold, etc., unless properly dunnaged or bridged.

Broken Stowage

Any break in stowage — or broken stowage — caused by the presence of pillars, stanchions, brackets, web frames, etc., for the filling of which certain packages are not available, or space which is unsuitable to receive a package of cargo, should be packed firmly with suitable dunnage or airbags, in order to prevent any movement of cargo in a seaway and to afford a stable and level platform for the next tier.

The loss of valuable cargo space, where the nature of the cargo justifies economy, is best avoided by:

1. Compactness of stowage.
2. Selecting packages which, by the nature and value of their contents and their construction, are suitable for filling broken stowage. Reels of barbed wire, bales of binder twine, coils of small wire, for example, are very useful for this purpose.
3. Always keeping a supply of such packages, or of low freighted goods, ready at hand in the holds, for use when wanted.
4. Stowing casks and drums upright rather than on their sides.
5. Nesting and/or stowing pipes "bell and cantline". Blocking in spaces left between large cases with smaller packages. Care should be taken that these packages cannot become crushed.
6. Special selection of cargo suitable for filling beam spaces, i.e. cargo which is not liable to chafe or damage by sweat, if moist or heated cargo is carried in the same compartment, or refrigerated cargo in the compartment above. It should be borne in mind that up to 6/8 per cent of the hold capacity in 'tween decks may be contained between the deck beams.

General Cargo in Refrigerated Chambers

An important consideration when stowing general in refrigerated chambers is that of avoiding damage to brine pipes, insulation, and airtrunks. Where practical soft packages and cases should be stowed in the hatch wings. Bulky or unprotected heavy cargo should be stowed in the hatch square. These should be clean lift as dragging out from the wings and ends can cause damage to insulation.

Advantage follows if the floor or ceiling in squares of hatchways are protected by means of stout boards or sheathing. Sizeable packages, having flat surfaces (cases in preference to bales), should be selected for stowing against the pipe battens at sides and ends, so as to minimise the risk of cargo protruding into the grids and, by exerting pressure on the piping, cause the same to leak at the joints.

The permanent battens should be in good order or, in the absence of such, battens should be provided for the protection of the piping and cargo, such to be placed vertically, close spaced and "stopped" in position.

When bale, bag or other goods liable to damage from sweat or rust stains are carried, the piping as well as other ironwork should be covered with kraft paper etc.

Goods or liquids such as creosoted materials, aniline oils, essential oils, cargoes with a phenolic base, chemicals, etc., which leave behind strong odours, which cannot safely be dissipated by ventilation, should not, on any account, be stowed in refrigerated chambers. Some of the most serious claims for damage and consequent costs for getting chambers again fit for refrigerated cargoes have been through phenol taint. All dusty cargoes liable to choke air passages should be avoided.

Heavy packages should be stowed on the ceiling with dunnage or bearers in order to avoid damage to ceiling and insulation by evenly distributing the weight over the maximum surface.

Bagged Cargo

Materials

The materials from which bags are made will depend on a number of factors, i.e. the c to be shipped, its physical composition and its properties (e.g. moisture content, sens contamination, etc.). The principal materials are manufactured in different weights and stren may be used singly or in multiples (i.e. several layers), may be sewn, glued or welded, etc. The materials include:

Paper (single or multi-ply) — which may be sewn or glued.
Plastic (which may be air tight).
Woven polypropylene. May also have an inner sealed bag made of polythene.
Jute, hessian, etc. (traditional materials and the type most likely to have repeated use second-hand bags, which having carried previous commodities may hold residu moisture, or be stained). However, bags made with these materials are rarely used th for reasons of economy.
Open mesh sacks (e.g. nets, open mesh plastic fibres, etc., for maximum ventilation).

N.B. Some bags, particularly jute and hessian, may have a re-sale value.

Commodities

The commodity itself has to be robust to withstand outside pressure and compression, for th will only hold the contents in one place and will not provide protection against external damage often these are the sort of commodities that might be carried in bulk or mini bulk operations (see those headings). Such commodities might typically be fertilisers, grain (rice, maize, wheat, etc.), dried fruit, sugar, cement, coffee, flour, salt, mineral sands and ores, meal (fish, seed, copra, etc.), milk (casein, etc.).

Characteristics

The sizes of the bags vary although it is standard practice to have such a size which, when f with the particular product, can be handled and carried continuously by labour working throughо shift. The most common filled weight of bags today is 50 kilograms. This weight of bags allows ra and easy calculation of weights taken on board, into containers or to make up sling loads, etc. C must be taken when loading large quantities of bagged cargo to allow in calculations for gross, n and tare (bag) weights.

The shape of the bag, and therefore the ease or otherwise with which it can be stowed, made up i slings, pallet loads, etc., varies with the type of commodity and the way in which the bag has be constructed. The bag may be "shaped", usually these are of paper or plastic construction, and, form near rectangle which is stable and has flat surfaces. Bags made out of materials such as jute are usua sewn flat at each end and, therefore, tend to have no flat surfaces, although these may be induced the pressure during the storage or stowage cycle. If the contents are powdery (e.g. cement) the packa is more likely to conform to outside pressures around it, such as weight on top, pressure from the side etc. If on the other hand the contents are hard and bulky (e.g. frozen offal then the bags will be irregular shape and will probably not respond to the influence around it.

Commodities in hessian and woven polypropylene bags may be subject to contamination fro powder or small granular cargoes stowed beside or above them (see "Damage"). Cargo i polypropylene or hessian bags, if of a powder or granular nature, may itself sift though the bags wit resultant risk of loss and contamination. Bags which have recently been filled tend to settle and spread outwards and this can affect stowage arrangements, e.g. containers (see "Unitised Cargoes"). Woven polypropylene bags, because of their non-absorbant characteristics, may be more suitable for moisture inherent/sensitive cargoes (e.g. rice, sugar, coffee, etc.) than traditional hessian. These bags may have an inner layer of polythene.

Increasing use is being made of jumbo bags. These vary in size and normally consist of woven polypropylene with handling straps sewn into the bag. They may weigh several tonnes and are most suitable for hatch square stowage where they can be clean lifted upon discharge. Wing and end stowage is not recommended unless special lifting equipment is supplied. (see I.B.C.).

Handling

Different bagging materials lend themselves to different handling methods. For instance a jute bag with good "ears" on it may be more easily lifted by the human hand than, say a heavy fully filled plastic sack with nothing to grip. There is a great temptation therefore for labour to use "cargo hooks" to manhandle these into and out of their stowage positions in holds, containers, etc. Since most bagged commodities (see above) are of an easily spillable nature, and some of them are very valuable (e.g. coffee), it is important that cargo hooks should not be used for bagged cargoes except in particular circumstances — these will be indicated against the particular commodities listed in the alphabetical section.

Different bagged materials and different commodities may find themselves more suited to one handling technique than another. For instance tightly filled, bulging plastic bags may be extremely difficult to make up on to pallet loads because of the tendency to slide and the shape of the bags. Some bagged materials (multiply paper sacks) may not be safely lifted by rope slings or snotters without fear of rupturing the bags. Flat webbed slings from man-made fibres are probably best suited for slinging most bags, and the "clover leaf" sling arrangement may be used to advantage with bags that are difficult to handle, i.e. because of shape or material. These may also be used for pre-slinging requirements and unit loads (see "Unitised Cargoes"). Canvas or similar materials may be required for loading and discharging such commodities as flour, coffee, cocoa, etc., where the nature of the bagging materials and the value of the commodity makes them vulnerable to high cost damage if bags are ruptured. The care of mechanical handling equipment drivers (cranes, winches, fork lift trucks) is also required when loading or discharging this type of cargo so that damage is not incurred by swinging or rubbing against obstructions such as beams, hatch coamings, etc.

Stowage

Most bagged cargoes are liable to be damaged if stowed with moist cargo or cargo liable to sweat. They should be well protected against obstructions such as beams, brackets, stringers, etc., because as the cargo settles pressure on the unsupported or projecting part of the bag may result in tearing and spilling the contents. They will benefit by being protected by mats, paper, etc., from bare steel work and from likely sources of moisture running down bulkheads, pillars, etc., and serve to protect the bags from discolouration by rusty metal.

Where two types of bagged cargo are carried in the same space, and risk exists of one contaminating the other (e.g. bagged plastic granules over bagged rice), then proper protection should be provided in the form of plastic or similar sheeting between the different cargo types. Similar sheeting should be provided where sifting or loss of cargo might be expected — particularly in the use of valuable cargo such as coffee — so that sweepings may be collected and included in the discharge. Any such protective separation must be carefully handled at time of discharging, and any spillage collected and cleared before moving to the cargo below (see "Sweepings").

Careful tallying is essential and to facilitate this slings should always be made up of the same number of bags, as should pallet loads. Bagged cargo bills of lading should be endorsed "weight and quantity unknown" or at the very least "said to contain . . .". Slack or damaged bags must be rejected as also should be damp or stained bags. The latter particularly applies to bagged sugar, cocoa, and coffee.

Some commodities are liable to rot the natural fibre bag, e.g. certain manures and chemical products. In all such cases the bills of lading should be claused so as to protect the ship from having to bear the cost of re-bagging. The ship should also be protected against any claim for loss of contents due to leakage from bags which are not sufficiently strong or not of the correct texture to prevent such loss; sometimes to prevent loss from the above causes double bags are used.

The stowage factor will vary depending on whether the bags are well filled (as for instance coffee and cocoa) or otherwise.

Bleeding of Bags

At certain ports cargo may be loaded by cutting and bleeding bags into the hold from the edge of the open hatch. This is normal practice, however, care must be taken that the bags are fully emptied of their contents before they are discarded. The bags may be bled through a wire or rope grille in order to ensure that the bags themselves do not end up in the hold. In practice this frequently occurs and it is also quite common for foreign or "field matter" to be mixed with the contents. Should the presence of bags and foreign matter be observed in the stow, Master should stop the loading and draw these deficiencies to the attention of the stevedores. He should also draw this problem to the attention of the charterers. Mates receipts should be claused accordingly.

It will be appreciated that the presence of foreign material and bags in the cargo causes difficulties at the discharge port and many claims may be raised at this time.

The ship should endeavour to check the intake by means of an accurate draft survey. Shippers will inevitably want clean bills of lading, however if there is a presence of foreign matter every endeavour should be made to have this noted in the bill of lading. Where relevant, charterers should be advised of this problem and encouraged to deal with the consequences. Shippers in certain countries may offer a letter of indemnity which is of no comfort to the ship as it is the owners who will be sued by the receivers. The likelihood of recovery from the shippers is extremely remote.

Discharging

Avoid heaving slings of bagged cargo out of the wings, or ends of holds. Such treatment will tear the bottom bags on plate butts and landings or even from splinters from wooden tank top ceilings or other obstructions.

If the type of bag and cargo warrants it a needleman should be available for sewing up open or torn bags when loading and discharging bagged cargo.

All torn, slack or empty bags and packages should be carefully inspected while discharging is in progress and delivered (against tally) along with the cargo, otherwise a claim for short delivery is likely to follow.

Bales and Bundles

Materials

Hessian or similar strong material usually constitutes the outer cladding. Other materials include plastic; paper; woven man-made fibres; waste from the contents of the bale. For more valuable goods a secondary covering or even a tertiary one is included. Some bales, e.g. straw, hay, etc., have no covering whatsoever.

Commodities

Typical commodities that are baled will include wool, cotton, vegetable fibre (e.g. jute, kapok, hemp), paper pulp, tobacco, skins, furs, rubber, hair, cloth and other material.

Characteristics

Sizes of bales vary. Some commodities (wool and hemp) may be compressed into high density bales. It is even more important in these cases not to rupture a covering, break the binding material or in some cases, allow ingress of moisture. The resultant expansion of the commodity can make unloading almost impossible, and, in containers might distort or rupture the side walls.

Sizes and weights will, where applicable, be found under the commodity name.

Bales may vary quite considerably in shape. Some may be square, (e.g. wool, unless double dumped when the shape becomes oblong), cylindrical or completely shapeless. In many cases the bales are designed as modules of the interior of an ISO container.

Hessian is a common outer covering, but in some cases (e.g. low grade skins, rags etc.) waste items of the commodity itself may be utilised. Close woven polypropylene has a non-absorbent water resistant quality which is particularly suitable for some commodities.

Handling

While cargo hooks are acceptable for raw cotton, wool, etc., they are totally unacceptable for high quality goods such as skins, furs, cotton piece goods, etc. Most baled commodities are impervious to damage from rolling or dropping from limited heights. However, it can be dangerous to drop bales of rubber due to their ability to rebound in almost any direction.

Metal or other banding is usually employed to hold the bale in compression, and should never be used as a lifting point, unless marks or labels indicate to the contrary.

Stowage

Being as a rule vulnerable to chafe, they should be well protected by matting and dunnage from sharp edges and other cargo which may cause damage. They should not be stowed between hatch beams for this reason.

Bales with torn or stained covers should be rejected, or the bill of lading claused accordingly. They should not be stowed with dusty or dirty cargo as they can mark or stain the covers. Particular attention should be paid to baled cotton (see Commodities).

Cases, Crates, Cartons, etc.

Materials

Cases and crates are usually made of timber, which may be plywood or thin low grade material. Heavier cases may be built up of 150 mm × 25 mm (6″ × 1″) planks with strengthening pieces internally and externally. Some crates are built in a skeletal fashion to allow air to permeate through the contents, or alternatively to reduce the weight of the crate. Larger cases and crates will almost certainly have skids or bearers to allow mechanical handling equipment to gain entry, or for slings to be put in position. These skids are normally about 50 mm deep (2″). Large cases with high density goods may well be built to have certain parts specially strengthened for lifting. These will be marked on the outside and any slings, snotters, chains, etc., should be slung at those points; similarly any securing should make use of the stronger points of the case.

Cartons are usually made of single or multi wall fibre board. Very often the contents provide part of the strength and shape for the cartons, and this should be borne in mind when stowage is being carried out. Some carton material is waxed or otherwise protected against moisture absorption. Wooden crates and cases may have to be treated in order to comply with Government and State quarantine immunisation.

Commodities

Cases and cartons hold a very wide range of commodities depending on the requirement of the particular cargo. Canned goods are nearly always packed in cartons. Many refrigerated goods are packed in cartons or open-sided crates. Attractive items that may be vulnerable to pilferage are often packed in strong well constructed cases.

Loading Project Cargo (*Photo: Forth Ports Plc*).

Characteristics

Some large cases, e.g. C.K.D. (cars knocked down), may be stored outside prior to shipment. In these circumstances the crates and sometimes the contents are already wet or damp on shipment, with the possibility of introducing moisture into the hold, container, etc., to the detriment of adjacent cargo. In some instances, for example, very large cases of construction items may have to move a long way inland to remote construction sites, and so the packaging is most important for the protection of the contents as well as, sometimes, having a subsequent use as storage or even temporary accommodation. Crates or cases holding machinery may leak oil.

Cartons may absorb moisture and give out moisture under certain atmospheric conditions. Carton material will equilibrate with the moisture content of the air surrounding it in about 36 hours. This means that cartons of goods from a damp area may be relatively full of moisture when loaded into the hold or container. A moisture content of less than 12% in the fibre board is usually considered safe from this particular problem. There have been known instances where carton material has been actively wetted by the packers of the goods to make the material more flexible and more easy to put into shape prior to filling with canned goods. A container load or a compartment load of cartoned goods can therefore have a very high volume of moisture inherent in the cartons at time of loading, with subsequent possible problems of condensation (see "Ventilation").

Handling

Where relevant shippers/charterers instructions should be obtained as to how many high they may be stowed. It may be necessary to dunnage at intervals to avoid tier compression.

Cargo hooks should never be used on cartons. They can sometimes be used to good effect on heavy crates. Very heavy crates normally require mechanical handling equipment, e.g., pallet trucks or fork lift trucks. Cartons are best lifted on board or ashore by means of cargo trays. The slinging of heavy crates mentioned above should be undertaken with due regard to the strength points in the crates themselves. Metal strappings or banding round crates, cases and cartons should never be used as lifting points.

Stowage

Heavy cases should be reserved for bottom stowage where possible with smaller packages on top. Small, very heavy packages should not be placed on top and within the four corners of larger, lighter packages, or resultant damage may occur. Any marks or indications for stowage upright or for protected stowage should be carefully observed and adhered to. Light cases and cartons should be stowed one upon the other so that each one below bears the full weight of the one above and particularly in the case of cartons of canned goods, no overhangs should occur which might distort the cartons and rupture the contents. Special care in the case of refrigerated cargo should be taken to make sure that adequate air flow can move through and around the cases, crates or cartons as required for the particular commodity (see "Refrigeration"). Any broken or holed cartons, cases or crates should be examined at time of loading and if the contents are intact they should be mended prior to stowing. Any cases pilfered or damaged should be rejected or the bills of lading claused accordingly.

Drums, Barrels, Casks, etc.

Materials

Drums may be made out of metal, fibre board or rigid plastic. Casks are built of wood staves and bound by hoops.

Commodities

Liquids such as latex, chemicals, whisky, detergents, oils, molasses, casings, paints etc., may be carried in drums and casks. Powders, granules and other solids such as chemicals, cement, some ores, swarf, scrap metal (sometimes cast in spheres usually in second-hand drums) may also be shipped in these containers. Some of the above may be classed as Dangerous Goods, in which case the packaging requires the appropriate approvals and labelling.

Characteristics

The bilge (the part with the greatest circumference) of the barrels or casks is the part least able to support external pressure, so the weight should be taken by the quarter — which is near the ends of the barrels or casks. Metal drums may have hoops to improve their strength and to facilitate rolling and manoeuvring by hand. However, care should be taken that these have a level stow as the bands or rims may produce chafe damage to adjacent drums or cargo containers. Light drums such as fibre board can only take top weight when in the upright position.

Handling

Normally rope slings, nets or trays for lifting on or off the ship. Metal drums may usually be gripped using drum handling attachments or mechanical equipment which grip the top rim of the drums (e.g. grabomatics). Care by the operator is often needed to avoid puncturing the drums when gripping or carrying them this way. Side clamps and barrel handlers are also standard attachments for mechanical handling equipment and are used if drums and barrels are sufficiently robust to take this type of treatment. Although often practised it is not recommended to balance drums or barrels on the tynes of a counter balanced fork lift truck for positioning and stowage. This system is prone to accidents and spillages. If drums or barrels are placed on pallets there will be a loss of space particularly if the pallet is not square and does not have plan dimensions which are multiples of the diameter of the drums. While it is not recommended, it may be necessary for drums, etc., to be dropped, e.g. while unloading a container on its trailer from ground level. In this case some form of protection should be provided — e.g. old tyres — to break the fall.

Stowage

Drums stowed on their side should not have other cargo stowed on top. Drums holding liquids should always be at the bottom of the stow with the bung or lid upmost. Barrels stowed on their sides should be "bung up and bilge free", i.e. the bilge of the barrel should not support any weight, and quoins (shaped wedges) should be used to support the weight at the quarter. As a general rule, fibre board drums should always be upright. When more than one tier of metal drums are to be stowed, particularly into the container where vibration may be experienced during inland transport, it is prudent to lay soft dunnage (wood, hardboard, chipboard) between each tier. This may not be necessary if drums are designed to nest one above the other, although in the case of containers it is usually prudent to provide intermediate dunnage. This dunnage allows the rings of the drums to bite in and grip and also protects against chafe. Since some rolling hoops on metal drums form part of the drum wall itself, these hoops may be very vulnerable to chafe, and in some instances may need protection with soft dunnage to prevent them rubbing one against the other and rupturing while in transit.

The tops of drums which have been standing out in the open may hold rain water, frost or snow trapped within the rims. This should be tipped out and if possible the damp areas allowed to dry before loading into a compartment or stuffing into a container — particularly if other cargo in that compartment can be affected by moisture.

Returned empties (that is drums, barrels, etc., which have been emptied of their cargo and are being returned to that source) should be treated as far as contamination, source of liquid, dust, etc., is

concerned as though they still held the original commodities. Unless a certificate is provided to say otherwise, returned empties should always be treated as though they still hold traces of the previous contents. This means they may be a source of dust, moisture, taint, or infestation. It is most important that empties being returned after carrying dangerous goods be treated as "dangerous" unless a chemist's certificate declares that they are free of residue from the previous cargo (see "Dangerous Goods").

Discharging

Drums and casks should not be dragged out from wings or out of a tight stow using snotters or slings. Any damage sustained at this stage will be to the ship's account.

Intermediate Bulk Containers

Definition

An I.B.C. may be described as a disposable or re-usable receptacle designed for the carriage of bulk commodities in parcels of between 0.5 and 3.0 tonnes. They are interchangeable between various transport systems and the design incorporates attachments to facilitate efficient mechanical handling using commonly available equipment. Some are designed for carrying liquids. They are not suitable for pressurised commodities and emptying should be possible without the use of pressure. They differ from ISO Freight Containers in size and non-uniformity of shape. Indeed, some are designed to be modules of the internal dimensions of ISO Freight Containers (see "Containers") and are thus compatible with that system.

Materials and Construction

They may be constructed in either a flexible form, i.e. bags able to carry dry bulk or liquids, or a rigid form, e.g. of fibre board (either collapsible or non-collapsible with or without linings).

Dry bulk bags may be constructed of:

Woven polypropylene and nylon;
P.V.C. or P.U. coated polyester;
plastic and rubber.

Rigid bins may be constructed of:

Fibre board, glued or stapled;
all welded metal;
welded plastic;
a combination of the above.

Commodities

Typical commodities might include cement, china clay, sugar, plastic granules, carbon black, sand, powdered chemicals, syrup, fruit juices, oils, detergent liquids, non-hazardous chemical liquids.

Characteristics

Construction of bags and bins are usually carried out to satisfy particular customer's requirements and the requirements of the commodities to be carried.

The size also varies, depending on the user's requirements and the commodity to be carried. Plan dimensions may be compatible with standard pallet sizes — indeed some I.B.C.s utilise pallets as part

of the base. This allows stacking and handling to be complementary to the stacking and handling of other unit loads.

Bins may be square or octagonal in shape and may have lifting points on top or access for fork lift tynes at the bottom. The fibre board bin is constructed from heavy duty double walled corrugated fibre board which is sometimes glued and more usually stapled at the joints. The lining may or may not be available or required. If it is used is usually of a light plastic material of a throw away nature.

Rigid bins are often supported by a metal frame which improves the rigidity and allows tiers of bins to be stacked one on top of the other. The bags themselves are usually designed to be lifted from above and may have facilities on the under side for gravity discharging the contents.

The lifting points which are built into the bags may consist of loops or sleeves, depending on the material and the lifting modes to be used. Alternatively a harness or clover-leaf sling may be permanently attached to the bag and provide the necessary lifting points.

I.B.C.s should not be filled with commodities which can damage the material or construction in such a way as to reduce their overall strength. The I.B.C.s should not be filled with more goods than the label or certificate indicates. Appropriate national or international regulations should be complied with, e.g. IMO dangerous goods code.

Handling

The majority of bags are designed for existing methods of cargo handling such as fork lift trucks, cranes and derricks. Single, double, or four-fold lifting points may be provided — and it is important that all those provided should be utilised whenever the loaded bag is lifted.

Bins are usually supplied with skids, fork pockets or similar, and should always be lifted and handled using those facilities correctly.

Stowage

Some I.B.C.s are constructed in such a way and of such dimensions that they are suitable for stuffing into ISO containers to obtain maximum utilisation of cube and weight. When a container is so stuffed, care must be taken to ensure all lifting points are easily accessible when stripping the container.

When stowed on general cargo ships it is advisable to keep I.B.C.s separate from other forms of break bulk cargo. They are required to be lifted and handled and positioned using mechanical handling equipment.

When I.B.C.s are damaged during handling or stowage they should immediately be given temporary repairs to preserve their integrity until the end of the voyage. I.B.C.s that are designed for one voyage only should not be re-used — particularly if damaged.

Manufacturers' recommendations for handling should be followed at all times regarding hoisting methods, stacking, securing and lifting points. They should not normally be stacked more than three or four high. Stacking I.B.C.s several tiers high should only be carried out when the construction of the I.B.C. itself or the strength of the contents will permit the resulting pressure of such top weight. If stored in the open, protection against weather and sunlight should be provided.

Special lifting cradles have been designed to facilitate the multiple handling of I.B.C.s. Care should be taken to check S.W.L. of these cradles.

Deck Cargo

Introduction

A large variety of goods, because of their inherent properties — length, other proportions, weight of individual units, etc. — are carried on deck. The bills of lading must be claused accordingly, and suitable provision must be made for safe securing of these cargoes.

It may be prudent for the Master to check the bill of lading to establish which Cargo Convention the goods are being carried under.

On deck only means an uncovered space, special deck houses having doors which can be continuously open (except in heavy weather) may be used. N.B. Deck houses and mast houses can be considered suitable for either "on deck" or "under deck" stowage and Dangerous Goods stowage.

Included amongst goods normally carried on deck are: (a) certain goods classified as Dangerous Goods amongst which maybe, compressed gases, flammable liquids, substances giving off inflammable vapours, corrosive substances, etc., for which on deck or on deck only stowage is prescribed or desirable; (b) heavy logs of timber, sleepers, props, etc., sawn timber exceeding that which can be stowed under deck as per charter-party, long structural steel and other forms of steel; (c) heavy bridge girders or sections, pipes, railway engines, boilers, pontoons, boxed machinery, small vessels, etc.

When planning a deck cargo the following points should be considered.

1. The weight involved, its location and distribution.
2. Strength of the deck and its shoring. Point Loading (max permissible weight expressed in tons or tonnes per square feet or metres) should be obtained from ships plans.
3. Stability of the carrying vessel at the time of loading and discharging the heavy lifts.

Notwithstanding that deck cargo is usually at shipper's risk, liability for loss of or damage to same may rest with the ship in certain circumstances, e.g. if due diligence and practical measures were not observed in securing and preserving the cargo; and the stowage was negligent or improper, such as by overstowing weak packages with heavy goods, etc.

Should Dangerous Goods be carried on deck, the packaging should not exceed in size or weight that which can be conveniently handled should the necessity arise to jettison that cargo in the interest of crew or ship. While it may not be possible to jettison containers laden with Dangerous Goods (although there are proprietary pieces of equipment available for doing so in special circumstances) when those commodities are carried which are so sensitive that they may require to be jettisoned, then access to those containers must be clear, doors or other fastenings clear for opening, and the containers themselves stowed at deck level so they may be easily opened and entered.

When deck cargo is carried, access to all important parts of steering gear, boats, bilge and tank sounding pipes, etc., should be preserved and where such is called for, properly made and protected gangways should be provided for the crew.

Securing

Additional ring bolts and eye plates may be necessary to facilitate the securing of deck cargo and these should be firmly riveted or welded to deck plates and beams, deck stringer plate or upper part of the sheer strake, and closely spaced.

Chocks or beds on which the packages are to rest should be positioned over the beams. When particularly heavy items are carried on deck they should if possible be placed so that the heavy part is over the bulkhead below — and the decks, where appropriate, be given additional support by shores placed under and over beams wedged up hard to fine wedges. When dunnaging is necessary under heavy cargo it should be of sufficient size and material to distribute the weight, and spread over the deck, the boards should be laid diagonally (at an angle of 45 degrees) to avoid the buckling of deck plates.

Heavy Indivisible Loads

Introduction

Heavy indivisible loads may be defined as those weights which, because of their mass and/or their shape cannot be handled by the normal gear available on board ship or on the quay alongside.

Loads of 20 and 30 tons, i.e. containers, are handled fast and continuously at specially constructed terminals. In those circumstances they can no longer be considered as heavy lifts, but in ports and on ships where specialist gear is not readily available, they may have to be handled and treated as heavy lifts.

The techniques for handling and transporting very heavy indivisible loads have changed and become more specialised with the growth not only of the offshore industry, but the developments in

construction for onshore oil and chemical plants and the move to gas for power stations. Although the offshore market has the largest indivisible loads, because they rarely move on land other than a few metres to load out onto barges or semi-submersibles, the other markets have also taken to modular construction and technical advances have created much heavier and more dense loads. The newest gas turbine thermal blocks are over 550 ts in a small concentrated area and the oil refinery reactors are frequently over 1,400 ts in a single tower.

National road limits vary from country to country, but the controlling factors are usually any bridges that have to be crossed, elevated highway sections that cannot be shadowed by running underneath, or physical size obstructing movement where just removal of street furniture is insufficient to clear a passage. In extreme cases, buildings have been removed to allow passage and then rebuilt after movement.

Commercially heavy lifts are divided into four groups for lift on/lift off operation. They are: (a) under 200 ts, (b) 200–499 ts, (c) 500–1,100 ts, (d) above 1,100 ts. There is tonnage available to handle ocean transport for groups a–c, but above 1,100 ts at this time either floating or mobile cranes need to be utilised for both load and discharge. Currently building are two vessels with 1,600 ts lifting capacity.

Group (a) heavy lifts are frequently handled by the general cargo/container feeder vessel market using two cranes in tandem, or the older style liner vessels with a heavy derrick (vanishing due to age). Groups (b) and (c) are mostly handled by the specialist heavy lift project vessels, and the Group (d) lifts are mostly handled by roll on/roll off specialist vessels, including the semi-submersible vessels being used as deck ships.

The Load

At the time of booking and pre-planning the transport of heavy indivisible loads, certain information is vital:

(a) the weight and size and construction of the loads;
(b) what support points of the loads are required — or are permissible;
(c) the maximum load of each specific support point which the design would tolerate;
(d) where may the lifting attachments be made on the load and how are they to be made;
(e) what securing points are available on the load and where are they located;
(f) is the speed of movement of the load in any way critical;
(g) what additional lifting equipment is required to handle the load, what is its weight, who provides it, does it travel with the load;
(h) position of centre of gravity. This information is frequently missing, yet is crucial for major heavy lifts, specially where lift is to be made with multiple lifting gears.

Shippers will frequently require lifting diagrams showing lifting stresses and full lashing and securing diagrams. In many cases this will be a charter party/booking note detail to be approved by both parties before booking is concluded. Shippers will often require both their own engineers and the warranty surveyor's approval of the drawings before lifting can proceed.

Lashing and securing drawings will often have to have accompanying calculations showing anticipated maximum forces the cargo will experience during transit on the vessel.

Closest point on wharf that load can approach, thereby defining the outreach needed. Shortest outreach possible is preferred, but ports frequently have service ducting close to the edge of the wharf forcing heavy loads to be delivered further from the wharf edge. Some wharves will only allow landing of heavy cargo at high tide to avoid excess stress on the harbour wall; usually also demanding prompt removal while tide is still high.

Preparation

Where traditional heavy lift derricks are used which are themselves supported by the mast or samson post, these supports, unless suitably stiffened, should be themselves supported by not less than three stays; one leading fore and aft and the other leading to each side forming an angle of about 45 degrees with the former. Stays, also shrouds, should be set up taut and stretching screws securely

stopped. A slack stay will not commence to function until after the mischief has been done. Careful attention should be given to the ships plans relating to the rigging and staying of the heavy lift gear.

All leads should be set up to avoid chafing the falls. Avoid slack turns getting on to the winch barrel when winding in slack wire — the presence of such is fraught with great danger when the derrick becomes loaded. Where "steam guys" are led to a single winch, care must be taken to ensure that the weight of both remains balanced, and that one does not become slack during any stage of the operation. It is sometimes the practice to overcome this problem by securing the end of the topping lift purchase to a yoke which in turn supports the end of each steam guy. Thus although the derrick may be topped or lowered a weight is maintained on the steam guys no matter at what angle the derrick is operated. In these circumstances care must be taken to ensure that the yoke is so positioned that it will operate correctly.

It is important that the vessel is trimmed to an upright position before heavy lift operations commence. In many instances vessels are now fitted with suitable fast flooding ballast transfer tanks.

Vessel should not only be upright when lifting commences, but should, if possible, be maintained close to that position throughout the operation by use of ballast tanks.

When vessel is working heavy cargo with its inherent risks, all crew should be on deck and all non-essential shore personnel should be put ashore for their own safety.

The Gear

In the U.K. a heavy derrick, crane or hoisting machine with its gear, has to be tested with a proof load which should exceed the safe working load as follows:

Safe Load	*Proof Load*
Up to 20 tons	25% in excess
20–50 tons	5 tons in excess
Over 50tons	10 tons in excess

The gear should be adequate for the load, including any extra weight, i.e. for lifting tackle, which itself may well weigh many tons.

The heavy lift derrick should not be operated in a depressed condition, e.g. near the horizontal, since if the vertical component of the thrust becomes low, there is danger of the heel springing out of the shoe.

When using container cranes to handle uncontainerised heavy indivisible loads, there may be provision for a "rams horn hook" to be installed in place of the container spreader. In some instances the spreader has special lugs to which lifting wires may be shackled, and the heavy lift supported directly by the spreader. Where shore gantry cranes are used, it must be ascertained that the port of loading and port of discharge have cranes of suitable capacity, with the necessary distance between the legs (and/or a revolving spreader) to allow the load to be handled.

The Gear in use should be exactly as indicated in the diagrams that have been approved by the shipper's engineers or warranty surveyors, and match the calculations that have been approved.

At all times check validity of all parts of the lifting gear before contracting to lift.

Tackle

Slings should be made up of the appropriate wire or chain to provide an adequate safe working load, and of the correct length so that they do not damage the cargo and do not require shortening because of too long a drift.

The two ends of slings should be connected to the block of the derrick with the eyes on the bow of the shackle and not on the pin, especially if the drift between lift and shackle is short and the spread large — which should be avoided where possible.

Slinging should be set up in such a way that the load remains level. However there may be occasions, when, to allow a particular awkwardly shaped load to enter the hatch square, the load will have to be slung at an angle. If this is the case it must be ascertained that the load itself will not be damaged by such treatment, and the slings made up accordingly.

Where goods may be become crushed, or where the length of the load is such that the angle of the sling will create unacceptable bending moments on the load, the use of a spreader, or beam may be required. As mentioned earlier the weight of any such tackle must be included in the calculations for the lifting gear.

Full use must be made of all proper lifting points on the load, and those points which are marked as suitable for placing the sling.

Use only the certificated tackle as approved in the lifting and securing diagrams.

If, for any reason, an exact following of the lift and securing diagram is not possible and additional or different tackle is required, err on the side of caution and use higher rated tackle. If new calculations can be approved for lesser tackle then this can naturally be done, but always check all calculations done by others before proceeding.

Vertical and Horizontal Movement

Careful winch driving is essential to avoid the gear being put to undue strain. Too great a speed of operation increases the strain on the hauling part and may be dangerous if for any reason it should become necessary to stop suddenly.

Horizontal movement may be necessary for the full loading operation (and/or discharging operation), or for stowage in the wings of the holds. For this latter purpose heavy drag links should be fitted on bulkheads and deckheads, with suitable doublers to prevent buckling to which the hauling or bowsing tackles may be attached. The use of beam grabs or clamps, may distort and disfigure beams, frames and stiffeners, and is not a recommended practice. Consideration must be given to the coefficient of friction between the moving surfaces and the effect of gravity if the move is other than on the level (e.g. if a list develops). Consideration must be given to the break out force required to overcome inertia and start the load moving, not just the (usually) smaller force needed once it is moving. It is necessary, particularly when moving loads which are not on the level, to consider the need for restraining mechanism.

The ability to move a very heavy load horizontally, can be improved by using various methods each of which reduces the coefficient of friction, the time of break out, and for moving the load.

System	*Approx. Coefficient of Friction*		*Approx. Bearing Pressures*
	Break-out	*Running*	
Primitive Slides			
Ship launching greases	0.25	0.055	1.0
Molybdenum disulphide greases	0.06	0.04	700
Sophisticated Slides			
PTFE	0.12	0.05	14/45
PTFE woven	0.08	0.0.55	70
Thin Film Fluid Bearings			
Air	0.005	0.001	0.035–0.35
Water	0.002	0.001	0.07–0.4
Grease	0.005	0.0015	6.8
Oil	0.0015	0.0005	6.8
Thick Film Water Bearing	0.035/0.05	0.02/0.3	0.6/1.0
Air hover systems	0.01	0.005	0.002/0.014

When lifting or lowering into or out of the hold, weight should be slowly taken up or lowered down so as not to stress the gear.

When traversing either in or out of the hold from or to the shore, the vessel should, if possible, be maintained as close as possible to upright using ballast.

When lifting from or lowering to the wharf, the weight must not be taken up or taken off by use of the power alone. If possible, when lowering a heavy load to the ground after just touching, where almost all of the weight is still on the hook, the vessel should be ballasted further down to take most of the weight from the hook. If this is not possible then a falling tide can do the same as ballasting down, but may be slightly lower. Unwinding the weight too quickly direct from the winch will cause the vessel to heel and possibly drag the heavy lift with it, creating dire consequences. When lifting, a rising tide can be used if de-ballasting is not an option. In a closed dock situation, where moving ballast is not an option, then all movement should be very slow and carefully monitored.

When transferring a heavylift contracted for water/water movement, the calmest conditions possible are needed and the added difficulties involved should be taken into account when contracting. Landing or picking up a floating heavylift in even a small swell puts excess stress on the tackle and the gear.

Stowage Requirements

The stowage position must be selected which can best support the weight of the heavy lift. There may be also a requirement to have the heavy weight in such a position in the ship that the g forces generated by pitching and scending will not affect the load or its securing.

The load should be positioned in such a manner that heavy point loading is not exerted on deck or tank top plating in between frames and beams. When this is not possible, bearers should be provided to spread the load. Usually the bearers should be laid fore and aft or diagonally to achieve the maximum support from floors and beams.

Support pads provided for container stowage may, occasionally, be used directly for the support of uncontainerised heavy lifts. In certain circumstances flat racks, platforms, often specially designed for heavy lifts, may be located in the container stowage positions and utilised for supporting the heavy lift.

It must be borne in mind that when heavy lifts are carried on the tank top of a cellular vessel, there is most likely to be a loss of container stowage positions vertically above that cargo.

Where possible, heavylifts should be stowed in the hatch square or box hold vessels only.

Load spreading should take into account both the transverse frames and the longitudinal strengthening.

Restraint

As mentioned earlier the cargo may have to be restrained during the loading operations — particularly if it is in a low friction device such as air or water skids. Once stowed in position lashing and securing and tomming must be carried out to prevent the slightest movement of the load. All lashings must be set up tight, wooden tomming must be secured in such a way that it cannot be dislodged by ship vibration, working and movement. As a rule of thumb a total lashing on one side of a load should have a combined breaking strain of at least $1\frac{1}{2}$ times the total weight of the load to be restrained. Tomming and chocking would be extra to this.

All lashing and tomming should utilise the appropriate and approved points on a load to give the support. Where necessary extra securing points will have to be welded or riveted to ships' frames and decks.

Lashing and securing should follow the securing diagrams as approved, and gear used should be of the same specification as detailed.

Remember the higher the centre of gravity the more the heavy lift will tend to lift in a seaway, so sufficient downward lashings are required.

Where possible, weld bracing to the deck to hold in position, and any additional methods of securing that can be welded direct to the deck/tank ceiling should be used. Always remember safety rules when welding over tanks! Wooden tomming is insufficient on really heavy loads and steel restraints should be used.

After completion of discharge remove all welded securing devices, grind smooth and coat to avoid damage. Remember the underside of tank ceiling/deck plate will also have been damaged and need recoating.

Loading

The ship should be upright when loading (or discharging) a heavy lift and have adequate stability. The double bottom tanks must be either pressed up or dry. If ship's gear is being used it must be remembered that the effective centre of gravity of the load moves to the derrick head as soon as the lift is floated.

Lifting operations should be interrupted to carry out checks on the slinging arrangements:

(a) as soon as the weight is taken by the slings.
(b) when the load has been lifted a short distance.

The whole system should be checked through to ensure that no undue strain is being imposed on gear, equipment, or the load itself.

Clear lines of communication should be established between all those involved in the operation, with one person only in charge. It may be necessary to discontinue other operations close by on ship or shore to allow those involved with the heavy lift to hear and understand the control signals.

Discharging

Similar precautions should be taken as described under "loading". Furthermore it may be that the vessel, being at the end of a voyage or passage, may have less bottom weight in the form of fuel oil or water. This will have to be taken into account when considering the stability requirements. It should also be borne in mind that when a heavy lift is hoisted from its place of rest the centre of gravity of the weight is transferred to the derrick head. Again it is important that one person only should be in charge of the operation, and that all activities are pre-planned with appropriate stops to check equipment and gear.

Occasionally heavy lift cargo has to be offloaded straight to the sea. This might be a requirement of semi-submersible vessels, or a requirement of the cargo itself (e.g. lighters, launches, cylindrical and rectangular tanks, etc.). In such cases, and provided that the pieces are of sufficiently strong and robust construction to withstand the stresses and falls, they are carried on deck and launched over the side at destination.

In the case of cylindrical objects, which of course must be perfectly watertight and free from small parts protruding, they should be mounted on a strong launching structure built of timber, the inboard end of which rests on top of the adjacent hatch and the other on the bulwark, being adequately supported at intermediate points. The frame of the structure should dip about 2 degrees in the direction of the ship's side.

So mounted the discharging is a simple process and is affected by lifting the vessel in the desired direction by means of water ballast or fuel oil. Tanks not in use for that purpose should either be empty or pressed up hard and it should be borne in mind that when the weight drops off the vessel it will roll sharply in the opposite direction.

For lighters, rectangular tanks, etc., a similar structure is built, extending a little beyond the bulwarks.

On top of the main structure a movable cradle like arrangement is built to the shape of the craft so as to support it at three or four different points, according to its length. This is mounted on launching or slipways formed integral with the main structure with suitable means of locking it into position. The craft is securely lashed by wire lashings to prevent movement during transit and is launched overboard sideways by giving the ship the necessary lift.

After Discharge

It sometimes becomes necessary to unship stanchions when stowing heavy lift cargo. All such, forming as they do important parts of the structural strength of the vessel, should be properly restored and secured in their original position before stowing any cargo on the decks above.

Where as sometimes happens, it is not possible or convenient to restore all stanchions into the position without seriously embarrassing the stowage, heavy shores of timber, laid on stout timber fore

and aft bearers, should be fitted and tightly wedged into position to carry the weight of the deck above. Neglect to do so will likely result in the decks being set down.

Special Cargo ("Specials")

This term is usually applied to attractive goods for which special stowage, supervision, and careful checking and tallying is considered desirable. This may be on account of the value: the ease with which attractive articles can be removed (e.g. small items easily pocketed) or consumed (e.g. liquor). Precious or valuable goods would be treated as bullion — with the appropriate special strong room stowage (see below).

Typical articles which might be described as "specials" include: beer in bottles or cans; bottled spirits; wearing apparel; fancy goods and jewellery; furs; laces; mail; portable electronic equipment; toiletries such as packaged perfumes, etc.

This cargo should be received and in turn kept in a lock up or special cargo locker or cage ashore. if circumstances or quantity permits, it should be carried onto and off the ship. An officer should be personally tallying or in attendance — and handling by night avoided — if possible.

Every vessel engaged in general cargo trade should be provided with a special cargo locker, of substantial construction, fitted with reliable locking arrangements and well lit. Its location should be remote from crew's quarters, and ventilators leading to the locker should be fitted with iron bars.

It is false economy to be too sparing in regard to the size of these special compartments and even if all the space provided is not required on most occasions, it should be an easy matter to fill unwanted space with suitable ordinary cargo.

Where "lockups" on the wharf are not available, safety of this class of cargo demands that it be put on board under lock and key, as soon as received. However that may be difficult, if not impossible, to arrange in the case of a vessel receiving cargo for multiple ports where only one special cargo compartment is available — as the goods destined for the last port must be stowed first and so on. This, added to the fact that all specials are not delivered to the dock until near completion of loading, necessitates this class of cargo remaining on the dock and being exposed to pilferage for a longer period than actually should be necessary.

This difficulty is easy to overcome in Break Bulk Cargo ships by designing a special cargo locker: (a) in the upper 'tween deck between hatches; (b) divided into four or more compartments formed by means of heavy steel netting suitably stiffened and framed with light angle bars, the doors to be of the same construction with suitable locking arrangements; (c) each compartment to be entirely separate from the other, having its own separate door; (d) the doors being inaccessible unless the hatch covers on that deck are in position, as opposed to the customary arrangement of doors in the wings where they may be tampered with; (e) arranged in such a way that special cargo may be received at the appropriate locker at any time and in any order; (f) when discharging, the door of one compartment only need be open thus reducing opportunities for pilfering and eliminating risk of over landing or over carrying.

Bullion and Specie

Bullion should not be received on board unless the vessel is fitted with a proper strong room or safe with suitable capacity.

Strong room should be fitted with two locks having different keys, one in the custody of the Master, the other in that of the Chief Officer or other responsible person.

Gold and silver bullion, i.e. uncoined gold and silver respectively: shipped in ingot or bar form, packed in strong well made boxes which are usually fitted with strong rope brackets for handling; very rarely, silver is shipped in large ingots unboxed.

ISO Containers, if used for the carriage of bullion and specie, should be of all steel construction. A careful inspection should be carried out before presenting the container to the shipper to ensure that the container is in a structurally sound condition, with door locking rods and cams working correctly. Special locks and seals to shipper's requirements may be affixed in addition to those customarily used for the trade. Because of its volume/weight ratio, bullion should be stowed as near as possible to the

side and end walls where the best floor strength prevails. Careful chocking and bracing is essential to prevent any movement, while at the same time having regard to the requirement that individual boxes or crates may need to be opened and contents checked at any stage during transit.

Receiving

The utmost precaution should be observed at every stage of receiving, stowing and delivering this very valuable cargo; each operation should be personally supervised by the ship's officers, assisted when necessary by responsible members of the shore staff. If putting bullion on board by winch, it should be slung by means of special closed nets to which a small buoy is attached by a long line — care being taken to avoid breaking the seals. If carried by hand over open gangways, nets should be spread under the same, or the gangway closed temporarily for boarding. Use special bullion bags or strong canvas suitably roped — two men to a bag — but if such is not available and the cases have to be carried by hand the men should not be permitted to carry them on their shoulders — the only safe way is to carry them with both hands in front. An officer should tally bullion at the rail and its progress to the bullion room should be carefully watched. A further tally check should be carried out in the bullion room before stowing, recording every mark and number, and also examining the seals. Mates' receipts should specify all marks and numbers and bills of lading suitably annotated.

Delivery

Delivery should never be made by Ship's Officers to anyone except on a written order from the Master, owners or agents (clearly specifying marks and numbers to be delivered) who will have satisfied themselves as to the bona fides of the consignees, etc., and only against a clean receipt clearly specifying marks and numbers, seals intact, etc. Any disputes should be settled before delivery.

Masters of vessels taking in bullion abroad should satisfy themselves that the bill of lading contains a clearly worded clause exempting the vessel and owner from all risk of loss, damage or theft, howsoever arising, whether through the fault of a servant of shipowner or not. Failing such clause in the bill of lading the bullion should not be carried unless the entire risk is covered by special insurance policy.

The keys of the bullion room should be kept in the safe in the Master's, Chief Officer's or Purser's room or equally safe place and should never be allowed to get into the hands of anyone except the senior officers.

Precious Stones, etc.

This includes pearls, gems, currency notes, bonds, travellers' cheques, postage or revenue stamps, high class jewellery, etc. All of these items, because of their size and value, are very tempting to thieves. Travellers' cheques are particularly vulnerable because of the case with which they may be exchanged for cash.

The packages should not be brought on board until shortly before the vessel sails. Delivery should be made to the Master, Chief Officer or Purser on board who should carefully examine each package to see that it is in sound condition and all seals intact (defective packages should be rejected) and note every mark, number, address, etc. Receipts and bill of lading should be clearly endorsed "nature and value of contents unknown said to be . . . ".

Custody — immediately the packages pass into the custody of the Ship's Officers they should be safely locked up in the safe or spécie room where they should remain until the vessel reaches its destination. The key of safe or specie room should not leave the custody of the Master or other responsible officer in charge of their custody.

Delivery — consignee should be called upon to take delivery immediately the vessel reaches her destination. This should be effected on board the vessel unless the bill of lading makes a special stipulation to the contrary, as is sometimes the case, when delivery has to be made at a bank, etc. In such a case the officer entrusted with delivering the package should be accompanied by an armed police guard and should make the journey in a vehicle.

Delivery should only be made on an order specifying numbers, marks, addresses, signed by owners, agent or Master, who have satisfied themselves of the bona fides of the consignee.

A clean receipt specifying seals intact, etc., should be demanded and the bills of lading surrendered; any dispute should be settled on the spot.

The loss of a package or part of the contents of any of these sort of commodities would be such a serious matter that no attempt should be made at carrying the same by any vessel that is not equipped with a thief proof safe suitably placed, or a specially built specie room of steel plating with thief proof locking arrangements. Neither should such be shipped without it being agreed beforehand that the bill of lading should be clearly worded so as to protect the owner and vessel from the consequences of loss, damage or theft, howsoever arising, whether through the fault of the shipowner or the fault and/or by the privity of his servants or not, unless such risks are entirely covered by a special policy of insurance held by the owners or agents, in which connection it should be noted that most protection and indemnity clubs will not cover any risks of this class unless they have approved in writing of the contract of carriage and of the spaces, apparatus and means used for the carriage of such valuables.

Ventilation

Ventilation of cargo spaces may be necessary to:

Remove heat.
Dissipate gases.
Supply dry air to help prevent condensation.
Remove taint.

Not every commodity requires or even benefits from being exposed to ventilation during transport. Cargo loaded in bulk carriers may only benefit from surface ventilation, i.e. a change of air between the underside of the deck or hatch above and surface of the commodity. It follows that if there is a problem within the stow such as pockets of moisture, ventilation will have little effect.

Heat may be generated by live fruit, wet hides, vermin, and commodities liable to spontaneous combustion.

Gases which may require dissipation include inflammable and explosive gases such as those given off by coal; vehicle exhausts on Ro-Ro ships; CO_2 and ethylene from ripening fruit and vegetables.

Condensation appears in two basic forms: ship sweat and cargo sweat. The former appears as tiny beads of moisture condensing on the ship's metalwork, and typically, might occur on the side of the hold when the sea temperature falls and reduces the adjacent metal temperature to a value below the dew point of the surrounding air. Cargoes sweat forms on the surface of the cargo when its temperature is below the dew point of the air adjacent to it.

The removal of existing or residual taint by means of ventilation may be carried out in conjunction with an ozonating unit. It may be required to reduce the probability of sensitive cargo becoming affected by the taint, or to improve working conditions for labour.

The proper ventilation of holds therefore, is indispensable to the correct carriage of some goods, and may assist in the preservation of the ship's structure itself. Sometimes with coal cargoes and those which give off inflammable and explosive gases, or are liable to spontaneous combustion, it may be absolutely necessary for the safety of crew and ship.

A well designed system of ventilation — natural or mechanical — aims at inducing a constant circulation of air throughout the holds and the mass of cargo by which heat, moisture, fumes, vapours, gases and odours given off by the cargo are discharged into the open air and replaced by air of a dew point suitable to the prevailing conditions.

Three systems of ventilation are in general use:

(a) The natural ventilation of ordinary cargo compartments, supplemented in certain cases by modified mechanised air circulating systems.
(b) The temperature control system of circulating air in insulated compartments, controlling its temperature and carbon dioxide content given off by certain commodities (see "Refrigerated Cargo").

(c) Mechanical ventilation in cargo spaces and control of humidity in the compartment. The principle of most of these types of mechanical ventilation is to reduce the dew point of air in ships' compartments by de-humidification to the point at which ships' sweat and cargo sweat cannot occur. No attempt is made to change the temperature condition in the holds, the whole object being to control the dew point of the air surrounding the cargo.

Correct ventilation can keep cargo in good condition in the great majority of circumstances if properly employed. No system of ventilation can prevent damage if the Ship's Officers do not know when to and when not to use it. Also, of course, stowage of the cargo must be correctly planned with regard to the various classes of commodities of which it is composed, together with proper dunnaging and positioning to ensure that the ventilation reaches all the necessary cargo.

Open-top, Open-sided and Flatrack containers may sometimes be stowed with cargo requiring ventilation while on board, e.g. fruit, vegetables, spices, etc. If stowed on deck then it must be ensured that adequate ventilation can reach the contents while properly covered against rain and spray. Moreover the container should be stowed on deck in such a position that the tilt is protected against damage from wind and waves during the passage. Below decks the stowage position should be so situated as to take maximum advantage of any mechanical ventilation installed, and care should be exercised against cross-taint, e.g. a container of wet hides might leak strong-smelling brine.

When to Ventilate — Some Guidelines

Ventilate if the dew point of the air is lower than the dew point of the cargo space. The changing air will ventilate the cargo space and there should be little danger of condensation.

Restrict ventilation if the dew point of the outside air is higher than the temperature of the cargo. To ventilate under such conditions would cause danger of condensation on cargo as the outside air with higher dew point comes into the cargo space.

When the vessel is fitted with a mechanical ventilation system, the air should be re-circulated within the cargo space when the introduction of external air is restricted. Despite this guidance special attention must, of course, be given to conditions where cargoes are giving off fumes, etc., where according to certain circumstances ventilation may be necessary despite the possibility of condensation. The aim should always be to avoid stowage of cargo requiring different ventilation treatment within the same compartment. Similarly two compartments with different ventilation requirements should effectively be sealed off from each other.

It is often required that cargo normally of a very dry nature, e.g. milk powder, casein, etc., has to be stowed in the compartments adjacent to hard frozen chambers. Experience has shown that the most effective method of carrying cargo under these conditions is to restrict the ventilation completely during the passage. In some refrigerated vessels, decks or bulkheads are fitted with thermal injection. The principle of such being to provide a heat input equal and opposite to the heat loss from the refrigerated compartment. The fitting of this equipment is of considerable value in ensuring safe out turn of cargoes stowed under such conditions, but does not warrant departure from the basic principles of ventilation.

The importance of maintaining a dry ship and dry cargo cannot be over emphasised. The cargo should be protected from all unfavourable exposures of temperature and moisture from the point of origin to the delivery, and the shipowner for his own protection should know more thoroughly the history of the products delivered to his charge and of the condition that the products are received. Typical of this category is the carriage of perishables in open top and open side containers. It is often the practice for the tilts of these containers to be left open while stowed below decks to improve the prospect of ventilation. These covers should be replaced and secured at time of (or prior to) unloading. Similarly when loaded on board the ship's staff should check the appropriate covers are drawn back to take maximum advantage of below deck ventilation. In cases where terminal staff have been adjusting covers for the same purpose during the container dwell time at the terminal, it is important that ship's staff and terminal staff liaise to maintain the weathertight integrity of these containers while at the same time affording the contents maximum ventilation.

The responsibility of the terminal operator involves protection of the cargo impounded on the receiving pier in so far as practical conditions permit. The stowage, subject to the same limitations, should provide the most advantageous condition in the ship. Through an understanding of what takes

place within a loaded ship, the officers can reduce sweating hazards and provide intelligent operation or sealing of ventilation systems.

There are two alternatives in meeting the problem of cargo sweat: the control of the dew point in all parts of the loaded cargo space. The tempering of the cargo to keep it above the dew point of the air to which it may be exposed while at sea or at warm ports of call or at its destination. As an example canned condensed milk is sometimes shipped in a warm condition out of temperate latitudes so that cargo sweat has less chance of occurring during the passage through warmer climates.

Ship sweat may be prevented by air conditioning systems efficiently designed and efficiently operated. Air conditioning plants are not the panacea for all ills and unless the cargo being served by them is delivered in temperatures above the dew point of the air at the port of delivery, there is no guarantee that condensation will not occur.

The temperature of the air both outside and in different cargo compartments should be regularly taken and recorded. Attention to the ventilation should always be entered in the Deck Log. It is of utmost importance that attention to the ventilation of cargo be clearly and regularly recorded in the Mate's Log with special mention to be made of any opening of hatches, etc. The absence of such records has on many occasions involved the owners in heavy claims for alleged neglect.

Except with cargo which gives off highly inflammable or explosive vapours or gases such as petroleum spirits, etc., a certain number of hatch covers, should, when conditions of sea and weather permit be kept open at each end of each hatch leading to holds containing goods which give off heat, moisture, strong odours, etc., such as fruit, jute, seeds, copra, sugar, hides, coal, gambier, etc.

With cargo which sweats profusely such as rice, maize, jute, etc., in order to avoid heavy condensation which might be produced by heavy downward rush of cold air, it is best to open the hatches gradually.

Dunnage

Dunnage may serve the following purposes, according to the nature of the cargo carried:

1. To protect it from contact with water from the bilges, leakage from other cargo, from the ship's side or from the double bottom tanks.
2. To protect it from moisture or sweat which condenses on the ship's sides, frames, bulkheads, etc., and runs down on to the tanktops and eventually into the bilges.
3. To protect it from contact with condensed moisture, which is collected and retained on side stringers, bulkhead brackets, etc.
4. To facilitate the passage of air around the cargo when ventilation is taking place.
5. To prevent chafe as well as to chock off and secure cargo by filling in broken stowage, i.e., spaces which cannot be filled with cargo.
6. To evenly spread out the compression load of deep stowages.
7. To provide working levels and protection for the cargo on which labour can operate and serve as a form of separation.
8. Provide access for cooled air round or through the cargo for temperature controlled requirements (see "Refrigeration").

Throughout Part 3, "Commodities", recommendations are given regarding the use of dunnage, matting, etc., to protect the cargo from contact with metal decks, bulkheads, beams, etc. However, modern fast vessels, with reduced time on passage and fewer stanchions and other metal obstructions, combined with high cost of labour and materials, frequently omit the use of such dunnage especially where bagged commodities are concerned. Whilst the results generally turn out to be satisfactory, it does not ensure that all reasonable precautions for the safe carriage of cargo have been taken. The consequence therefore of any claim against cargo out-turn will perforce still be judged against whether all reasonable precautions have been taken or otherwise.

Permanent Dunnage

The floors of many ships, above the double bottoms of which are intended to carry fuel oil, may be completely sheathed with 635 mm or 760 mm planking laid on battens so as to provide an air space

so that any leakage from below or from cargo above and condensed moisture coursing down the bulkheads is drained into the bilges.

Ship's sides may be fitted with dunnage boards or spar ceilings of about 50 mm thickness, usually 150 mm to 180 mm in width, spaced close enough (should not be more than 230 mm) to prevent packages from protruding into the frame spaces, and to interfere with ventilation or coming into contact with frames or shell, and thus be damaged by condensed moisture coursing down the same.

For ordinary cargoes, the permanent ceiling or dunnage is sufficient, provided it is dry, clean and free from oil stains or otherwise in a condition likely to cause damage to a cargo such as bagged or baled goods. Care should be taken that the spar ceiling brackets are flush and not liable to damage the cargo. Where the position of permanent dunnage is otherwise, dunnage and matting are necessary. In this connection it is as well to remember that a cargo such as bagged grain, in close contact with the ceiling the surface of which may appear to be dry, may draw moisture from the timber by capillary action and so be damaged.

In the bilges, however, and on top of cement caps, on stringers and brackets it is always necessary to lay dunnage as the condensed moisture runs down the former or is retained by the latter.

With the ever increasing cost of dunnage material and attendant labour a number of types of permanent dunnage are now in use particularly in insulated compartments (see also "Refrigeration"), viz:

(i) Permanent Collapsible Dunnage (P. C. D). This is 50 mm × 50 mm or 75 mm × 50 mm suitably varnished or painted timber, the lengths of which can be easily collapsed together. The fitting is secured to the bottom of the inboard or outboard bulkhead of chambers with a swivel fitting, so that the dunnage when not used can be housed in a flat and vertical position. Not suitable for holds or large decks where cargo has to be dragged over it.

(ii) Aluminium Strip Dunnage. Closely corrugated aluminium made in easily portable dimensions 3 m × 500 mm. Suitably strengthened so that fork-lifts can operate over it. This dunnage can normally be left under general cargo and is easily cleaned. With this method squares of 'tween deck hatches have to be battened in the conventional manner.

(iii) Steel Grating Dunnage. Similar in principle to (ii) but more permanent in character and is being fitted over lower hold tank top ceilings. Suitable for fork-lift work.

(iv) Permanent Gratings. Frequently found in small lockers or in vessels with a limited number of refrigerated compartments. They can be cumbersome to handle and therefore difficult to clean.

(v) ISO Containers. Insulated and refrigerated Containers usually have extruded aluminium "T" section floors built in. (See also "Containers").

All the permanent types of dunnage described must prior to loading be closely inspected, damage made good and thoroughly cleaned.

Dunnage Materials

Many different sorts of wood and materials are in use for and make good dunnage, but in all cases it is necessary that it be sound and dry, clean and free from oil, grease or creosote stains, or matter likely to develop maggots, etc. Many authorities prohibit the landing of bark covered dunnage (i.e. Australasia). There have been numerous cases of vessels being delayed during discharge, when local authorities have detected insect ridden dunnage and have instructed the vessel to be fumigated, and/or the offending dunnage to be taken ashore and burned. Oily or greasy dunnage should never be used with dry goods, while nothing will excuse the use of wet dunnage.

Bamboo — Loose or in Bundles

If loose sign for quantity unknown. If in bundles they should not, unless permitted by Bill of Lading, be cut open. Make excellent dunnage for dry goods liable to heat and throw off moisture. Stow on ends, sides and bulkheads, to facilitate heated air to rise.

Battens

Of 50 mm × 50 mm (2″ × 2″) or 76 mm × 76 mm (3″ × 3″) used largely with refrigerated cargo.

Boards

Generally of rough 150 mm × 25 mm (6″ × 1″) or 100 mm × 50 mm (4″ × 2″); largely used for 'tween deck dunnage, for laying over bulk and as a platform for the necessary tiers of bags to secure same, for making a platform over ores, wet goods such as oil barrels, jaggery, etc.; also for laying on bulkheads, spar ceilings, etc.

Coir

In dholls, sometimes used in the Indian trade. The greasy kind is very useful with drums of oil, etc., but it should not be used with dry goods.

Dunnage Bags

These may be re-usable and disposable. Both are inflated with compressed air. Different sizes and different materials allow almost any cargo to be restrained. They incorporate a valve to allow the quick release of the compressed air at port of discharge, where the bags should be carefully emptied and retained for future use. Disposable bags may be made of paper with plastic linings. Used on the same principle as the others, the means of collapsing them is to puncture the bag. The technique for securing in both cases is to work the cargo from bulkhead or other secure position on either side and the resultant gap remaining in the middle of the cargo is filled with dunnage bags which exert pressure on both sides, thereby restraining the cargo and providing a wide area of pressure. Ideally suited for securing cargo that is fragile or difficult to restrain in any other way.

Hardboard, Chipboard, etc.

Usually in sheets 2,440 mm × 1,220 mm (8″ × 4″) or 1,830 mm × 915 mm (6″ × 3″). May be used to protect bagged and baled cargo, etc., from contact with ships' metalwork and other cargo. May also be used for separation. Chipboard may be used in lieu of plywood as walking boards.

Laths

To lay between tiers of green fruit or cartons of refrigerated cargo so as to assist in the circulation of air. May be of wood or polystyrene. Usually 9 mm ($\frac{3}{8}$″) thick. 25 mm or 50 mm (1″ to 2″) in width.

Paper

Kraft or similar paper is frequently used to good effect in protecting cargo from contact with bare metal, and in separating one cargo from another. Care must be taken in ensuring that the paper does not shift out of position after being laid, particularly when the practice of "dumping" bagged cargo into an open hold is carried out.

Rattans

In bundles. Those of superior quality are seldom, if ever, permitted to be used as dunnage. Bundles must not be broken up. Rattans absorb moisture and form air courses, and are so ideal dunnage for floors, sides and bulkheads, with cargoes which are liable to heat and sweat such as pepper, dry rubber (though not on floors), sago, tapioca, etc. Stow on ends at sides and bulkheads and for cargo specially liable to heat, such as pepper it is a sound practice to lay a tier between the bags at about mid height.

N.B. When different consignments of the same class of cargo to be used as dunnage are shipped, they should be stowed apart — in different compartments if at all possible — in order to avoid mixing and confusion on delivery. With horns, hooves, bones and similar goods, Mate's receipts and Bills of Lading should be endorsed "weight and quantity unknown, all on board to be delivered".

Sawdust

Comes in very useful to absorb the drainage from certain cargoes such as gambier, creosoted goods, etc., but the use of such with linseed or other seed oils is very dangerous, in as much as sawdust, when impregnated with vegetable oil, is very liable to spontaneous combustion.

Weight of Dunnage

As full cargoes of some commodities require a very considerable amount and weight of dunnage in loading, it is well that, when a vessel is chartered on a deadweight basis, it is borne in mind that the "weight of dunnage used and necessary for stowing cargo is to be counted part of the deadweight called for by the charter".

N.B. Many traded classes of goods are shipped at a low rate of freight on the understanding that they can be used as dunnage and/or for filling broken stowage, but with certain exceptions their use as such must be confined to clean cargoes. In all such cases the Bill of Lading should contain a clause authorising their use for such purposes the Mate's receipt to be endorsed to like effect.

Dunnage with Refrigerated Cargo

Dunnage used with refrigerated cargo serves a twofold purpose, i.e. providing channels for thorough circulation of the cooled air, and, as with other cargoes, even distribution of superimposed weight.

To ensure the former, dunnage is to be in line with the air flow; the amount used being dependent on the system of refrigeration being installed (see "Refrigeration").

ISO containers usually require no dunnage for refrigerated cargo, as the floors, walls and ceilings have their own built in battening (see "Containers").

Dunnage over Refrigerated Cargo Space

There are many instances where it is necessary to load general or chilled cargo over a hard frozen refrigerated space. Adequate dunnage should be laid in order to ensure that the cold air will not strike through to the cargo stowed in the compartment above. On unsheathed decks it is advisable to have at least 127 mm (5") of dunnage, i.e. 50 mm × 50 mm (2" × 2"), crossed and overlaid with 150 mm × 25 mm (6" × 1") boards, and as additional insulation a sprinkling of approximately 50 mm (2") of odourless sawdust. On sheathed decks, approximately 76 mm (3") of dunnage is sufficient, provided that the insulation beneath is known to be sound. Hatch coamings, iron ladders, etc., should be well covered. The most effective way of avoiding damage over any hatch coaming by condensation is to box the coaming with dunnage wood and fill in same with sawdust.

DANGEROUS GOODS

Introduction

Most countries have legislation for the safe carriage of Dangerous Goods. Dangerous Goods are defined as those classed in any such acts, rules or bye-laws or having any similar characteristics, properties or hazards. Legislation covers the classification, packaging, stowage (including permissible proximity and positioning) of Dangerous Goods during transport and storage.

The handling and carriage of Dangerous Goods must be carried out in full compliance with the laws of the country from which the Dangerous Goods are being shipped, the laws of the country in whose vehicle or ship it is moved, the laws of any country through which the goods will transit, and of course the laws of the country of destination.

So the classification, packaging and stowage of Dangerous Goods must be in accordance with any legislation which may be enforced in: (a) the country or origin; (b) the country of destination; (c) any country which it has entered; (d) the country under whose flag the carrying vessel operates.

IMO

The International Maritime Organization has produced the code for the carriage of Dangerous Goods in ships (the IMDG Code). This code is based on the report of the United Nations Committee of Experts on the Transport of Dangerous Goods, which also forms the basis for legislation and recommendations for transport of Dangerous Goods by other modes, e.g. ADR, RID, IATA — road, rail and air. The IMDG Code now has wide universal acceptance and has been adopted with legal standing in most maritime countries. It does form the basis for international movement of Dangerous Goods (with regard to classification, documentation and stowage), which is particularly important where shipping companies are operating within international consortia. It is important to maintain a library of the organisation's publications.

The IMDG Code 1994 has been superseded and consolidated into two volumes and a supplement and published as IMDG Code 2000. Volume 1 deals with definitions, general provisions, categories, testing procedures, stowage and packaging etc. Volume 2 has an index of dangerous goods and they are tabulated in 18 columns, the first of which is the designated United Nations Number. There is also a chapter on Radioactive Material. The supplement contains, inter alia, safety equipment requirements, emergency procedures, and medical advice.

Classification

The IMDG recognises nine broad classes of Dangerous Goods. For the correct classification and labelling of Dangerous Goods the IMDG Code should be referred to. The fact that a substance may not be listed in the IMDG Code should not be taken as evidence that it is non-dangerous. It is the particular properties of each individual commodity which must be taken into account.

Class 1: Explosives

- Division 1.1: substances and articles which have a mass explosion hazard
- Division 1.2: substances and articles which have a projection hazard but not a mass explosion hazard
- Division 1.3: substances and articles which have a fire hazard and either a minor blast hazard or a minor projection hazard or both, but not a mass explosion hazard
- Division 1.4: substances and articles which present no significant hazard
- Division 1.5: very insensitive substances which have a mass explosion hazard
- Division 1.6: extremely insensitive articles which do not have a mass explosion hazard

Explosives in this class are subject to stringent national legislation and port bye-laws.

Class 2: Gases
Class 2.1: flammable gases
Class 2.2: non-flammable, non-toxic gases
Class 2.3: toxic gases

Gases in this class may be explosive, flammable, poisonous, or corrosive. Some gases may polymerise and must be stabilised and inhibited prior to shipment.

Class 3: Flammable liquids

The main danger associated with carriage of these substances is the escape of flammable vapour which may also be toxic.

Class 4: Flammable solids; substances liable to spontaneous combustion; substances which, in contact with water, emit flammable gases.
Class 4.1: flammable solids, self-reactive substances and desensitized explosives
Class 4.2: substances liable to spontaneous combustion
Class 4.3: substances which, in contact with water, emit flammable gases

Cargo in this class, where practical, should be monitored for any unexplained rise in temperature.

Class 5: Oxidizing substances and organic peroxides
Class 5.1: oxidizing substances
Class 5.2: organic peroxides

Cargo in this class should be stowed away from combustible material. Spontaneous combustion may occur and certain commodities may be carried under controlled temperature.

Class 6: Toxic and infectious substances
Class 6.1: toxic substances
Class 6.2: infectious substances

These cargoes must be handled and stowed with care and with due regard to human health.

Class 7: Radioactive material

State authorisation must be obtained for the shipment to proceed, i.e. Panama Canal Authority.
(See page 308)

Class 8: Corrosive substances

The escape from packaging of these substances may damage other cargo and be injurious to human health.

Class 9: Miscellaneous dangerous substances and articles

These substances, which although dangerous, have not been allocated to any other class.

The numerical order of the classes and divisions is not that of the degree of danger.

Marine Pollutants

Many of the commodities assigned to classes 1–9 are marine pollutants and where identified as such, should carry the Marine Pollutant mark on the packaging.

Labelling

(a) Packages — All Dangerous Goods' packages offered for shipment must be correctly labelled (or stencilled) with the appropriate Dangerous Goods labels and show the correct technical name as used in the shipping documents (in addition it may also be necessary to fix labels as required by certain national regulations). This label should indicate the principal hazard and where one or more secondary hazards exists, additional label(s) indicating that hazard — but with the numeral on the label deleted

Sample IMDG Code Labels.

— should also be affixed. Any discrepancy in correct labelling should be noted and rectified and the reason investigated.

(b) ISO Containers — Four Dangerous Goods' class labels should be affixed to the container, one on each side including one on the right hand door. The label on each side should be positioned so as to be clear of the container doors when opened and secured back. The label on the front end of the container should be positioned so as to be clear of the towing vehicle if possible. In addition one Dangerous Goods' label should be affixed to the door, and this should be fully completed with the correct technical name(s) of the substances in the container together with the U.N. number and number of packages — and any other information considered useful. This Dangerous Goods' label should be completed using a waterproof medium, e.g. a spirit pen.

All Dangerous Goods' labels should be removed from the container (or masked) as soon as the container can be considered non-hazardous.

Packaging

Packagings used for Dangerous Goods should be able to successfully withstand the tests as prescribed in IMO Annex 1. While the performance tests should be applied to all new types and designs of packaging, satisfactory practical use may be accepted as equivalent evidence in existing types and designs.

Packages of all types should be properly closed and lids, bungs and other closures be in place and tight. Although it is impossible to see the inner receptacle of the package, it should be ascertained that the outer one is in order and that this has not been damaged and that any of the absorbent packaging (if used) is not missing. Any strong smells indicating any possible leakage should be carefully investigated and if the cause is not readily found, further advice should be sought. Stains on a package particularly of a recent origin, should be investigated.

Untoward corrosion or pitting of steel or iron drums should be investigated if it appears active. Drums or other receptacles which are obviously second hand and any which have recently been painted or sprayed should be inspected for corrosion, especially at welded or soldered joints. Dented drums particularly if dented near the joints, rolling bands or spigots, should be carefully examined if the dent occurs while packing the container or loading aboard the ship and the drum concerned should be set aside and loaded last, again being examined immediately before being loaded.

Wooden barrels (hogsheads, casks, etc.) are particularly susceptible to damage and should be most carefully examined to see that at no stage have the heads sprung. Stowing on end, the bung should be specially well examined.

Plywood and fibre wood cartons with plastic interiors used for crystals and powders should not be loaded if torn — with the risk of leaking contents which are often of an obnoxious nature. This also applies to multiwall paper bags and sacks.

Cylinders and tanks of inflammable and poisonous gases should have the protective hoods for valves properly fitted, and any showing signs of damage should be refused for shipment.

Repairs — it is important that any leaking packages of Dangerous Goods are repaired, recoopered, etc., by the manufacturers who will be skilled in the handling and packaging of their own particular commodity.

Booking

Included in the documentation at the time of booking, there must be the number and kind of packages; the correct technical name of the product; the class to which it belongs; the flash point — if any; the U.N. number; weight and measurement of the goods. A statement that the goods are packed in the manner approved by the appropriate authority and adequate to withstand the ordinary risks of transport.

In the case of some goods special certificates are required stating that the product has been weathered or dried for a certain period, or that it contains or is immersed in another substance which reduces its hazard. Where such a certificate is required it is important to see that it has been issued.

A Dangerous Goods Container Packing certificate must be signed (where applicable) by the person responsible for packing a container on completion of stuffing.

Handling Precautions

Provided the correct procedures are followed and care has been taken in the handling of Dangerous Goods the risk, though present, is small. However, short cuts, rough handling of the goods and a careless attitude are a sure way to cause accidents.

Dangerous Goods must be correctly documented and handled from the time of booking until the time of final delivery.

All Dangerous Goods packages should be inspected for signs of damage, leakage, or any other unsatisfactory state liable to increase their hazard, prior to being stowed in the compartment or container.

Packages of Dangerous Goods should never be dropped or thrown down, and the use of hooks, bars, etc., kept to a minimum. Mechanical loading with fork lift trucks should be strictly controlled and any rough handling avoided.

It is dangerous to take short cuts with safety regulations, and all those persons handling Dangerous Goods should be fully aware of the hazards involved.

Dangerous Goods' packages which have been wetted by rain, and received in a wet condition with frost or snow adhering, should be effectively dried before loading. They should not be loaded unless

it is certain that the enclosures are intact and no moisture has entered the receptacle. This is vitally important in the cases of goods in Class 4.2, 4.3, 5.1, 5.2, 6, 8 or 9.

Packages which are provided with means of ventilation (e.g. certain of Class 5) should be kept upright during handling. On no account, should such commodities be rolled in the handling and stowing operations.

Fibre board kegs and plastic lined paper bags are frequently used for chemicals in powder or crystal form, often those which will taint other cargo. Some solids will liquefy or soften with the rise in temperature, increasing the risk of contamination by contact and allowing the tainting odours to be more readily released.

Particular care should be taken to see that these are not damaged during the loading. The importance of rejecting any dangerous cargo accidentally damaged is stressed. If, in the course of handling or stowing a compartment or container, any sign of leakage should be noted, particular packages should be located and rejected if of a dangerous nature. Smell or fumes should be viewed with suspicion. Odourless fumes which irritate the throat or eyes may be a warning of leakage.

Stowage

Before loading any Dangerous Goods into a compartment or container, it should be ascertained that the place is suitable for that particular cargo, and that it is in a good dry condition.

All Dangerous Goods should be tightly stowed and well secured against any movement including chafe. Securing materials used should be compatible with the goods themselves.

Drums should be stowed close and compact, bungs or closures uppermost. Rolling hoops should not override. Avoid roll tiers if possible. Adequate soft dunnage (e.g. timber) should be laid between tiers — even, in some instances, though the drums are designed to "nest". With drums of sensitive cargo, e.g. chlorates, bromates, chlorites and substances in other classes such as nitrocellulose, it may be necessary to dunnage individually between each drum.

Whenever Dangerous Goods and general cargo are stowed together within the same compartment or container, the dangerous goods should be stowed (where possible) for best accessibility and to facilitate inspection — e.g. in the doorway of the container.

The presence of even one package of Dangerous Goods in a container at once renders that container hazardous and subject to Dangerous Goods' legislation.

On Deck Stowage

All goods stowed on deck must be properly secured, having regard both to the nature of the packages and the weather conditions liable to be experienced. Adequate security can be obtained by means of temporary structures made by using bulwarks, hatch coamings and bridge bulkhead, the structure being closed by means of portable angles bolted to bulwarks and hatch stiffeners. The cargo so stowed should be further secured by means of overall lashings or nets. Unless so stowed or secured by some equally satisfactory methods bulky packages should be lashed individually, preferably with wire rope lashings.

Stowage should be such as to provide safe and satisfactory access to the crew's quarters and all parts of the deck required to be used in the navigation and necessary work of the ship, and sufficient space for the crew clear of the goods concerned. Where Dangerous Goods are stowed in the wells they should not be stowed above the height of the bulwarks, and cargo which, by reason of its nature, is liable to damage tarpaulins or hatch covers should not be stowed on the hatch if such hatchways have tarpaulin covers.

Where deck cargo of an inflammable nature is carried special precautions must be taken to prevent smoking or the use of naked lights in the vicinity of the cargo, and notices should be displayed to that effect. Substances liable to give off inflammable or poisonous vapours should be stowed away from intake ventilators. Where petroleum spirit and other liquids subject to the same conditions of carriage as petroleum spirit are carried as deck cargo on one side of a ship, means should be employed to prevent any leakage crossing to the side used for crew's access.

In ships carrying passengers, Dangerous Goods may not be stowed in any part of the decks available for passengers or near passenger accommodation.

In the case of combustibles care must be taken to avoid the risk of ignition which may arise from electrical short circuits or old electric cables.

Segregation

Greatest care should be taken to ensure that incompatible substances are never stowed together in the same compartment or container. IMO classifies such substances according to the principal hazard, but not all substances of a particular class are necessarily compatible (e.g. Class 8 where a violent reaction may take place between acids and alkalis).

Careful consideration should be given to all other commodities (also their packaging) to be stowed with hazardous substances to ensure against dangerous interaction occurring. For instance non-hazardous cargo packed with straw, wood wool or other combustible materials should not be stowed with Dangerous Goods. Substances which react with water must not be stowed with items having a water base.

Foodstuffs should not, as a general rule, be packed with Dangerous Goods.

Miscellaneous Safety Precautions

It is both illegal and dangerous to take short cuts with safety regulations. Proper care in the initial handling of Dangerous Goods can prevent accidents arising at a later stage.

Naked lights and smoking should be prohibited if in or near a Dangerous Goods' handling area at all times (particularly when inflammables are being handled or stowed).

If possible, Dangerous Goods should be handled and stowed during daylight hours; if not, adequate lighting must be provided during the operation. N.B. The colours of some labels appear to change in the artificial light.

Ambient temperatures in relation to the flash point should be taken into account — particularly in hot weather/tropical climates.

If spillage occurs it should be carefully dealt with having regard to the dangerous nature of the substances, i.e. it should not be allowed to spread via footwear, wind, etc., and spillage should not be replaced in the appropriate package without the knowledge and advice of the manufacturer. Transport drivers should be advised of the dangerous nature of the goods carried and any necessary action which may need to be taken. Information such as: IMO class; flash point, if any; whether miscible with water; whether explosive; whether toxic — and under what circumstances; whether corrosive; the effect of heat; action in case of fire, spillage, etc.; should all be given to the driver.

The ship must be equipped with appropriate safety equipment and fire fighting facilities required by the class of the dangerous goods to be carried. See IMDG Code 2000 Supplement.

OBNOXIOUS CARGOES

Introduction

Sometimes it is a requirement of law, but always it is prudent, to ascertain the correct technical name of any chemical to be transported, together with its properties. Chemicals of a hazardous nature will be subject to the Dangerous Goods' legislations operating in the country where it is packed, the country where it will be unpacked, and the countries through which it must pass (see also "Dangerous Goods").

Dirty/obnoxious cargo may be described as any cargo liable to affect other cargo or equipment by its dirty or obnoxious nature, or which may cause discomfort or raise objections from personnel involved in the handling and stowage operation.

Characteristics

Heavily infested goods (e.g. bales of rags); very odorous commodities liable to cause strong residual

taint (e.g. essential oils); cargo that gives off fine penetrating dust, thus damaging or affecting adjacent cargo (e.g. carbon black); chemicals that give off fumes — which may affect the eyes and nose, but which otherwise may have little odour (e.g. formaldehyde).

Handling and Stowage

Consideration must be given to the possibility of spillage, no matter how well the material is packaged. If the material is of an obnoxious nature then it must not be carried in the same compartment or container with substances which will take hurt if a spillage occurs. For instance poisons must never be packed with foodstuffs. It is good practice when stowing bagged powders, which may sift, to place plastic or similar material underneath the cargo (lining the floors and the wall of the container) to protect other cargo against the effects of any sifting or spillage. It also reduces the amount of cleaning required to be done at time of discharge.

Liquid chemicals in tanks, drums, or bottles, must occupy the lower portion of any mixed stow. Some chemicals require to travel and be stored under temperature controlled conditions — either to prevent the temperature of the substance rising too high, falling too low, or both. In these circumstances full consideration has to be given to the consequences of any failure in the refrigerating machinery if appropriate. Too great a rise in temperature may make a substance become obnoxious or even dangerously unstable.

Typical Dirty and Dusty Commodities

Many commodities may be objectionable to some degree — and the list below is not exhaustive. They may be dusty, or smelly or stain other cargo with which they come into contact. On no account should delicate commodities or foodstuffs be packed in the same compartment or container with any of these. Some will render the compartment or container unfit for normal use unless it has been specially cleaned. If essential oils are spilled within the compartment it may be impossible to remove the all-pervading smell without stripping and rebuilding.

Certain of the commodities listed may be a health hazard and some are Dangerous Goods (see also "Dangerous Goods").

Asbestos powder, Asphalt, Ball clay, Blood (dried), Bone meal, Borax, Camphor oil, Carbon black, Chlorides, Cement, Disinfectants, Dyes, Fertilisers, Fish meal, Fish oil, Formaldehyde, Graphite, Glass fibre, Glycerine, Greases (various), Hides, Lubricating oil, Lime, Molasses, Oakum, Oils (especially essential oils), Oxides, Ochre, Paints, Polishes, Skins, Slag (basic), Snowcem, Swarf, Sulphates, Tallow, Tar, Titanium white.

LIVESTOCK

Introduction

The transport of animals is subject to legislation in many countries. Where risk of disease may exist this legislation is rigorously enforced. In most cases the legislation not only covers the importation of animals, but also the transit of animals, through a port. For instance it may not be possible to carry certain livestock because of the national regulations of way ports that the ship may call at. A typical case in point here is the Australian requirements regarding the African horse fly; the regulations are such that if a vessel has passed within 50 miles of the coast of Africa, then any horses carried on that vessel for Australia might not be an acceptable import to that country.

Over and above regulatory requirements, there is the need for humane and hygienic treatment and conditions for animals transported by land and sea. Guidance for individual species' requirements may usually be obtained from local zoological societies and similar organisations. A large part of the ensuing recommendations has been derived from some such source.

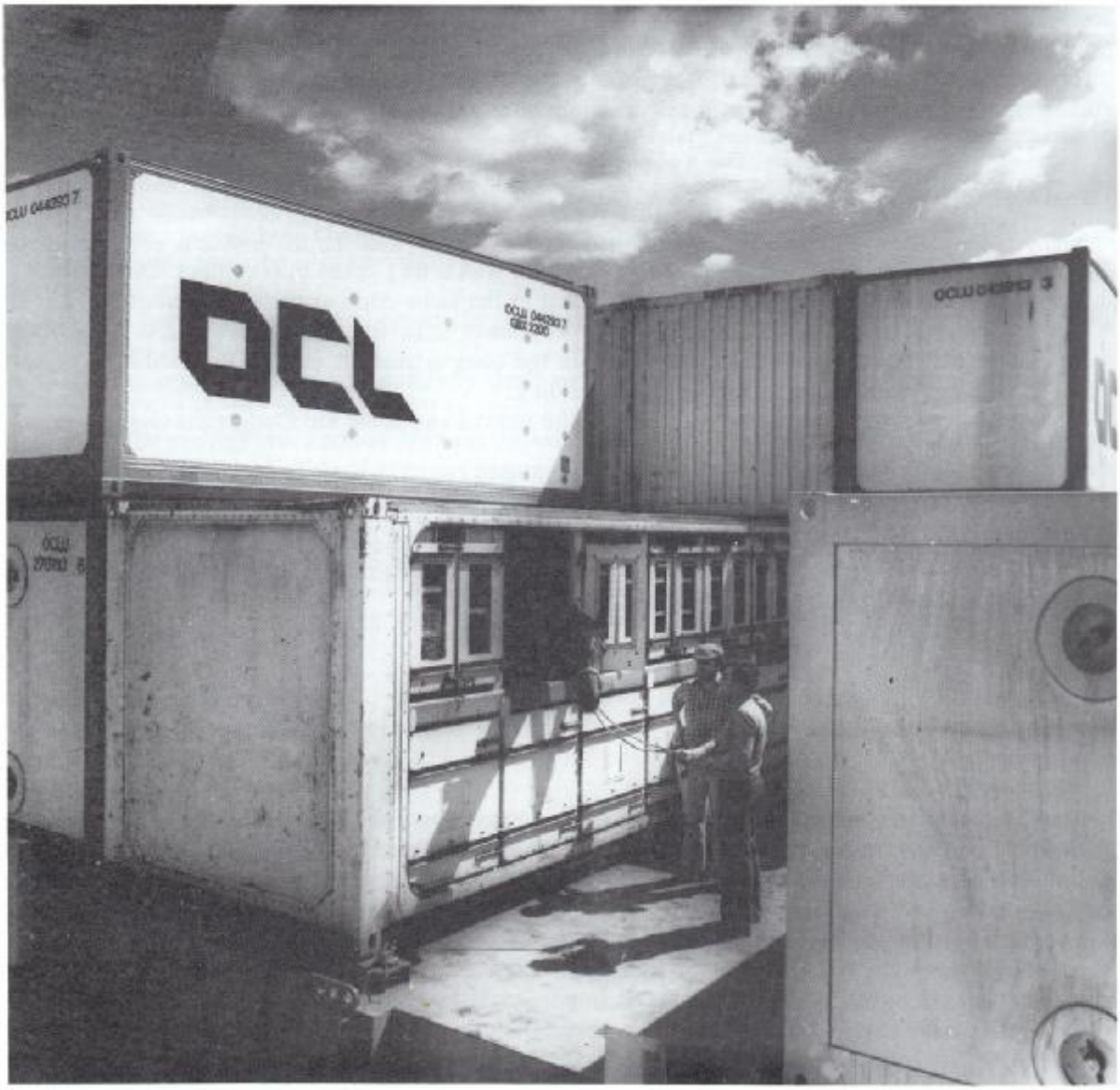
Categories of animals may vary enormously from full shiploads of, say, sheep, to a single domestic pet (e.g. a dog) which requires no more than the attention of an individual member of the crew during the passage.

Animal rights groups are exerting considerable pressure on shipowners to ban the transportation of live animals in ships not fitted for the purpose. They have been largely successful with ferry operators carrying animals in transporter lorries.

Regulations

The most stringent regulations apply to even-toed ungulates, e.g. pigs, cattle, etc. As mentioned above many countries have very strict requirements, most particularly in:

U.K. — Ministry of Agriculture and Fisheries.
U.S.A. — Department of Agriculture (Bureau of Animal Industry).
Republic of Argentina — Division of Animal Industry of Department of Agriculture.
Commonwealth of Australia — Department of Transport Marine Standards Division, etc.



(x) The carriage of livestock shown here demonstrates container versatility. *(Photo: Overseas Containers Ltd)*

Careful study of these regulations — and any that may apply from other countries — should be carried out prior to shipment of any animals from one country to another. It is also imperative that

the correct documentation is prepared, e.g. import certificates, health certificates, veterinary certificates, etc., prior to shipment.

Typical of the areas covered in the regulations over and above documentation will include: the quantity of any particular animal permitted to be carried at one time in the space available; the size of pens or cages; the strength requirements of fittings, etc.; the food requirements; fresh water services; access; ventilation; lighting; fire fighting appliances; whether animal stalls may be carried more than one tier high.

Stowage

Crates and cages should be stacked with proper protection against both heat and cold. Where possible provision should be made to set up awnings on deck to give shelter from the sun, rain and wind for those cages and animals which require it. The close covering of cages with tarpaulins in hot weather will cause undue suffering to the occupants of cages. Cages can be stacked on hatches where they are less exposed to bad weather and there is less danger of seas and spray reaching them. If, however, the ship is due to call at intermediate ports where loading or unloading will take place, enquiries must be made beforehand as to which hatches will be in use so as to avoid shifting the boxes.

Where animals are carried in freight containers, particularly on cellular vessels, care must be exercised to ensure that those particular containers are protected from extremes of heat, cold, rain and spray. Where animals have to be taken out for exercising — e.g. dogs — stowage positions should be such that this may easily be achieved. To provide adequate ventilation it is almost certain that adjacent container slots will need to be left vacant. This vacant space may under certain circumstances be utilised partially as storage area for food and equipment, and access for the handlers.

In the case of larger animals the stowage position (whether in containers, or as general cargo in crates) should be such that access can be achieved should the animal need veterinary attention during the voyage, or for removal of the carcass should the animal die. This last is most important on vessels without gear, and could mean the butchering of the animal to dispose of the carcass.

It is important to make allowances on cellular container vessels, when animals are carried in freight containers, to allow sufficient container space for the carriage of the necessary food and bedding. Such containers should have their doors readily accessible at deck level, unrestricted by lashing arrangements.

Food, Water and Bedding

An ample supply of food and bedding for the voyage must be placed on board at the port of embarkation, unless firm arrangements can be made to replenish supplies en route, and a margin should be allowed for delay. Proper arrangements should be made for stowage of food on board, where it can be reached easily during foul weather. Only sound food should be given and this, as well as bedding, must be stored in a dry place on board.

Full written instructions for feeding, watering and cleaning should be fixed to the front of each box and full power should be given to the man in charge to replenish stocks of food if necessary at ports of call.

All drinking vessels should be kept carefully scoured, and only fresh water used.

Suitable food for ruminants consists of lucerne, or clover hay, meadow hay, grain, chafe, crushed oats, maize, or other grain. Also appropriate food concentrates in the form of pellets or cake supplied under proprietary brand names.

In the case of carnivorous animals it may be possible to store the frozen meat in the ship's stores, if there is appropriate separation or barriers for hygiene requirements. Where this is not possible a refrigerated container capable of carrying at correct temperature would be ideal.

Refrigerated carriage may also be necessary for fruit, eggs, milk, etc., for the animals. Milk can most probably be carried as condensed tinned milk.

Carnivores need be fed only once a day, preferably in the late afternoon. Ruminants and all other animals should be fed twice a day — early morning and early evening.

Animals should, as a general rule, be watered two or three times a day, but more frequently in hot weather. If the drinking vessels are removed after the animals have drunk, there is no risk of the water being fouled nor can the animals knock against them and be frightened. Carnivores should be provided with shallow metal receptacles. Ruminants should be watered in the same manner as horses, small donkeys or goats, according to size.

Straw or hay makes suitable bedding for most animals, and it should be removed every morning. For kangaroos, oat-chafe is most suitable. Soft hay should be used for all animals provided with sleeping boxes. Bedding should be changed as required, and careful attention paid to the possibility of livestock eating the bedding and suffering accordingly.

In the case of ruminants the container space used for food and bedding very often exceeds that required for animals and should be planned accordingly.

Ventilation

It is most important that all animals have adequate ventilation — except in the case of some reptiles. Ventilation must be such that the animals are not exposed to strong winds and spray in the process of being ventilated! In some cases, e.g. 'tween deck stowage, and some container stowage, mechanical ventilation may have to be provided.

Lighting

Adequate artificial lighting will have to be provided particularly in 'tween decks and possibly in containers. Lighting will allow the handlers to better attend to their charges, and may also provide a soothing effect on the animals themselves. More careful attention to lighting and heating maybe required in the case of small animals, birds and reptiles.

Cleaning

The type and size of animal will dictate the frequency of cleaning of pens and cages and containers that is required. Adequate services should be provided in the vicinity of animals to allow proper cleaning to take place, e.g. hose connections, power points, etc. It is important too that adequate drainage is available and such that any cleaning water does not blow back on board in the process of draining.

All boxes and cages should normally be cleaned out at least once every day. As salt water is injurous to many animals it should be used with discretion for washing out large cages. Disinfectants if used at all, must be used very sparingly, with great care. All the smaller cats should be provided with shallow trays containing earth or sawdust, which must be changed daily.

Equipment

Appropriate medical supplies for each type of animal and length of voyage should be placed on board prior to departure from the port of loading. Appropriate humane killers — as prescribed by regulations, and the type and size of animals — should be placed on board at port of loading. Other equipment such as buckets, brooms, shovels should be supplied in adequate quantities to avoid having to use ships' supplies. In many cases ships do not carry sufficient of this type of equipment to allow their use for other than ships' work. Stowage for this equipment should be supplied and, in the case of medical supplies, humane killers, etc., should be safe from unauthorised access.

Handlers

Where ten or more head of large animals are carried, a handler (or handlers) may need to travel with the animals. This should be adequately investigated in advance, with handlers of suitable expertise

and experience, and the appropriate arrangement made for transfer from the vessel at the port of final destination. It is important, too, that the necessary accommodation is available for such handlers — and of course victuals, bedding, etc. For small animals, and small quantities of animals, members of the crew might reasonably be expected to act as attendants. For hygiene purposes such animals should not be allowed into the accommodation.

Mammals

Small animals such as dogs, cats, monkeys, etc., may be a subject of interest to crew and passengers. Precaution should be taken to prevent any teasing taking place or ad hoc feeding with titbits, etc. Some individual animals become extremely nervous if peered at by a procession of strange human beings.

Crates, pens, stalls, etc., must allow adequate room for the animals to move, while providing appropriate support against the rolling and pitching effects of the vessel. Adequate head room, particularly with regard to horses, is most important. Typical height for that requirement would be:

Minimum Head Clearance

cattle	1,981 mm (6′ 6″)
Horses (not ponies)	2,286 mm (7′ 6″)
large dogs	1,220 mm (4′)
medium sized dogs	915 mm (3′)
small dogs and cats	610 mm (2′)

Other dimensions can also be extremely important; certain species of antelope when taking fright exhibit the reflex action of trying to bound away, and it has been known for these animals to break their neck if restricted by, for instance, the wall of a cage.

Heights, lengths and widths of stalls, crates or pens with regard to mammals are frequently governed by legislation in countries of origin or destination.

Certain animals are dangerous if approached too closely by those who are not their regular handlers. Appropriate notices should be displayed for crew, passengers, etc., where this applies.

Different types of mammals have different requirements:

1. Camels — may weigh from 810 kg (16 cwt) to 1,270 kg (25 cwt). Carried on deck at shipper's risk, clause Bill of Lading "ship not responsible for mortality". For short passages in fine weather latitudes they are just tethered to a line spread fore and aft along the deck. Some of these animals are very vicious and given to biting any stranger within reach. Wounds so inflicted are very apt to become septic, and however slight, should be given early and careful treatment. Camels should be well watered before embarkation. For other than short passages, allow ten gallons of water, three or four pounds of grain, in addition to green foodstuffs per day.
2. Cattle — the voyage itself may form part of the quarantine period for the country of destination. It is important therefore that no contamination, e.g. from personnel, etc., should take place at way ports during the voyage. Vessels are usually exempt from all claims with respect to mortality, and bills of lading should be claused accordingly.

   Attendants are usually supplied and their wages paid by the shippers. Charter party or contract should embody a provision to enable the owner to recover all expenses incurred in respect of these men — usually the victuals are provided free of charge by the ship — including expenses for repatriation which may amount to a large sum. They sign on ship's articles and are in all respects to be subject to the discipline of the ship to the Master's authority.
3. Horses and Mules — usually subject to statutory regulations of the country of origin and/or destination. The average weights of horses: heavy horses, 712 kg (14 cwt); cavalry, 560 kg (11 cwt); light horse, 406 kg (8 cwt). Animals suffering during the voyage from broken legs or other serious injury must be slaughtered by direction of the Master, hoof or other marks noted and the incident recorded in the log. Slaughter should be carried out using an approved humane killer. The vessel is usually exempt from all liability in respect of mortality or injury to animals, and the bill of lading should be claused to that effect. Wet, mouldy or loose hay should never be accepted, no matter by whom supplied, and the bales should be sufficiently well bound to keep them intact while being handled. Times of feeding and watering are usually prescribed by

the shipper whose representative generally proceeds in the ship. Usually horses and mules are fed and watered three times a day — morning, noon and evening. Owing to their heating properties it is not customary and neither is it wise, to feed oats until the voyage is well advanced and then not heavily. Dead animals should be got overboard as soon as possible, as they quickly fill with nauseous gas offensive to both man and beast, and every effort should be made to avoid entering port with carcasses of animals recently dead on board. Where a choice exists, horses should not be positioned facing over the side of the vessel.

No attempt should be made to reduce the scantlings of fittings to horse boxes, stalls, pens, etc., below those recommended or required by law. The weight of an animal such as a horse or cow in a heavy seaway can put enormous pressure or battering ram effect on all such fittings.

4. Sheep — until recent years sheep were carried in small numbers in essentially similar conditions to other agricultural stock. However, the carriage of sheep, particularly from Australasia to the Persian Gulf, has become a major trade and in the main converted vessels now carry as a specialist operation live sheep of up to and in excess of 100,000 head.

   This clearly requires different techniques in feeding. Prior to the vessel's arrival, sheep are transported close to the loading place and their feeding is converted until they are able to thrive on pellet food. Once this has been done, they are ready for loading. Mortality rates of under 1–2% have been frequently achieved during the passage.

5. Elephants — carried on deck at the shipper's risk. Bill of Lading to be claused "Ship not responsible for mortality". They may also be tethered in a suitable position on appropriate vehicle decks on Ro-Ro ships. A fully grown animal is three tons and over and varies from 2,286 mm (7' 6") to 2,743 mm. (9') in height. Special slings must be used for lifting these animals. Allow 115 litres (25 gallons) of water and 270 kg (600 lbs) of green foodstuff per day for each full grown animal.

UNITISED CARGOES

Definition

A grouping together of two or more items (usually of a homogeneous nature) and securing them with banding, glue, shrinkwrap, slings (e.g. clover leaf), to form a unit which, together with a base (skids, pallets, etc.) or permanent slings, allows mechanical handling equipment (e.g. tynes of a fork lift truck) to lift and transport the unit.

N.B. While ISO containers are a form of unitisation, they are dealt with separately in this chapter.

The advantages of unitisation may include:

Ease of tallying.
Reduced breakages.
Reduced pilferage.
Faster speed of working between ship and shore (and on ship or shore).
May make more effective use of vertical storage space in sheds and holds by stacking units 4, 5 or 6 high (possibly with the need to incorporate shelves or racking).
Reduced labour requirements when handling between interfaces.

The disadvantages of unitisation may include:

Loss of space below decks where the shape of the vessel is not compatible with the shape of the unit.
Loss of space caused by the shape of the package being unitised, e.g. drums on pallets.
Collapsed or crushed units require labour intensive efforts to rectify, handle and store.
An element of extra cost involved in the pallet; slings; skids; shrink-wrap; strapping, etc.

Pallet Sizes

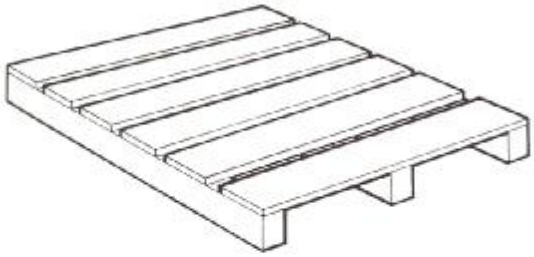
The overall height of a pallet may be from 100 mm (4") to 150 mm (6"), depending on the construction (single-deck, double-deck, etc.) and the use to which it will be put (single trip, pallet racking, etc.).

The deck (or plan) size depends on a number of factors:

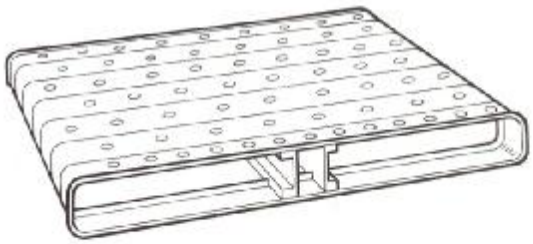
Size of cargo to be palletised.
Type of cargo to be palletised (e.g. drums, bags, etc.).
The use to which it will be put: e.g. closed circuit pool, one trip only, inland/ocean transport requirements, etc.

ISO have set some standard sizes:

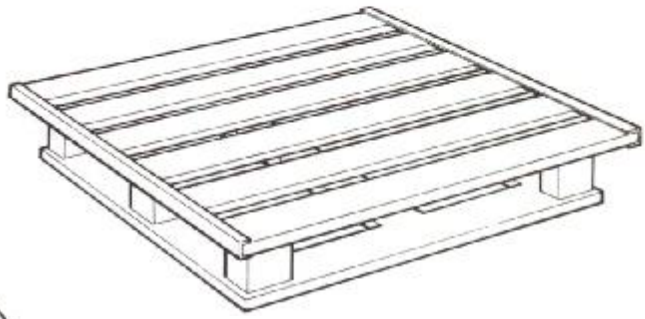
1,000 mm × 800 mm (40″ × 32″)
1,200 mm × 800 mm (48″ × 32″)
1,200 mm × 1,000 mm (48″ × 40″)
1,200 mm × 1,600 mm (48″ × 64″)
1,200 mm × 1,800 mm (48″ × 72″)



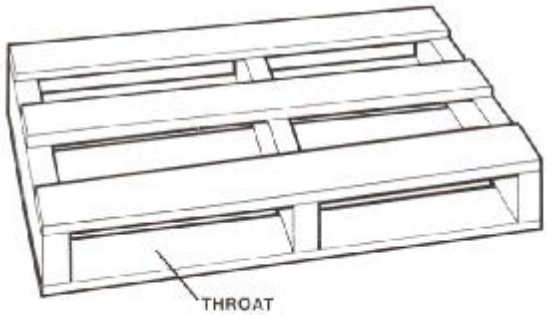
SINGLE FACE PALLET



DOUBLE FACE PALLET



FOUR WAY PALLET



TWO WAY PALLET

British Standard sizes which are recommended as being suitable for ISO containers (from BS2629, part 2) include:

1,000 mm × 900 mm (44″ × 35.5″)
1,100 mm × 1,100 mm (44″ × 44″)
1,100 mm × 1,400 mm (44″ × 55″)

Other sizes in common use, particularly in "closed circuit" systems such as stevedoring and warehouse operations:

1,500 mm × 1,200 mm (60″ × 48″)
1,170 mm × 1,170 mm (46″ × 46″)
(particularly Australasia)

Typical pallet sizes to suit sizes of bags, filled:

Bag Sizes	*Pallet Sizes*
762 mm × 380 mm (30" × 15")	1,140 mm × 1,140 mm (45" × 45")
800 mm × 400 mm (32" × 16")	800 mm × 1,200 mm (32" × 48")
609 mm × 400 mm (24" × 16")	1,200 mm × 1,000 mm (48" × 40")

Slip Pads

Sometimes known as slip sheets. These may be made up of a single sheet of fibre board or plastic, of the same plan dimensions as a pallet, but with an exposed "lip" which allows the special fitting on a fork lift truck to grip and pull the slip sheet onto a flat "spade" attachment. Thus the unit — made up on the slip sheet — is handled in all respects as a pallet, except for the special FLT attachment necessary.

The advantages of this system include:

Saved space; as against pallets or skids. Sometimes particularly important, e.g. low 'tween decks, containers, etc.
Pads may be less expensive than pallets.
Less storage area required when not being used.

The disadvantages include:

Pads may be easily damaged; if the "lip" is ripped off then the mechanical handling equipment has nothing to grip.
Requires a flat surface without obstructions on which to operate.
Requires special equipment to operate and handle.
May (usually) only be approached and handled from one side; i.e. the side on which the lip protrudes.

Making Up the Unit

The cargo should, as nearly as possible, exactly fit the pallet or slip sheet. Cargo overhanging the deck of a pallet may cause the following problems:

Put excessive pressure on the lowest tiers of cargo, particularly that which is in contact with the edge of the pallet. The *g* forces generated during transport can force the edge of the pallet deck to penetrate the cargo — particularly bags and cartons — with resultant damage to the contents.
Make the securing of the load to the pallet difficult or even impossible.
Risk the pallet load fouling adjacent cargo or units, with the load becoming wedged or jammed in the stow.

Similarly a unit module which is too small for the deck of the pallet will make the securing of the cargo to that pallet less effective, and reduce the ability of ship's bulkheads, container walls, or other cargo to support the pallet loads laterally in the stow.

The height of a pallet load should be such that the pallet and cargo combined leaves a clearance of at least:

50 mm (2") between top of cargo and door header (or ceiling) of a container.
150 mm (6") between the top of the uppermost pallet and the lowest deck-head obstruction in a 'tween deck or hold.

Method of Securing

The cargo should be secured onto the pallet by one or more of the following methods:

Strapping: Man-made fibre or steel. Banding should pass under the top deck of the pallet, to remain clear of mechanical handling equipment requirements. Some cargo may require protection from the point loading of the strapping, which may be achieved with scrap dunnage, waste cardboard, etc., or using proprietary equipment specially designed for the purpose.

Steel strapping may not be suitable for securing cargo that may alter shape or contract, e.g. bags, telescopic cartons etc. Man-made fibres, particularly nylon, may stretch and allow rigid items to move in some instances.

Nets: Usually of polypropylene, and used to secure awkward shaped packages onto a pallet.

Glue: For securing regular stows of cartons or bags. Should be strong in sheer strength, but with little resistance to a vertical force when dismantling the pallet load. A 5 per cent dextrine solution can be a suitable mixture for this purpose.

Shrinkwrap: A plastic (transparent) cover over the pallet load which is heat shrunk into place. Certain types of plastic wrapping may be put around the cargo without the need of heat. May be used for most goods and provide protection against dirt, pilferage, etc.

Locking Pattern: Unit loads may be built up on pallets with plan dimensions suited to the modules being handled. In this way layers may be built up each differing from its neighbours and providing restraint in a similar manner to a brick wall. Alternate layer patterns are reversed to "tie in" the layer beneath.

The Effect of the Pallet

The pallet, because it raises the cargo approximately 150 mm (6") off the deck of the hold, has the effect of raising the centre of gravity of the cargo which may, in certain circumstances, have to be allowed for.

Pallets use more space than conventional dunnage, perhaps 10 to 14 per cent.

Some overhead space may be lost if the height of the pallet load does not form a module of the height between decks or in the holds of the ship — or the internal height of the container. If the pallets are being made up on the quay this height may be adjusted (in some instances) to suit the particular height requirements of the ship. 'Tween decks may be designed for "user friendly" palletised cargoes.

While pallet loads may be made up in such a way that the units are suitable for carriage under refrigeration, the following will need to be taken into consideration:

The air-flow through the cargo (if required) or around the cargo is not impeded by securing materials or the positions of the pallet loads.

If two-way entry pallets are being used, then the pallets must be so positioned that the correct air-flow is not blocked by the supporting members.

The deck of the pallet may have to be slatted or perforated to allow free movement of controlled temperature air. This is particularly important for cargoes (e.g. fruit) in packaging designed to allow vertical through-movement of air.

Handling and Stowage

A flat unobstructed area, e.g. deck space, is best suited for positioning and stowing pallets. They should never be dragged into nor out of the stow — such treatment will collapse the pallet (particularly one-trip pallets) and make subsequent handling and storage difficult if not impossible.

Vessels which have not been built with pallet handling in mind, e.g. without flush 'tween deck hatch coamings, etc., may need extensive preparation work carried out before loading commences, e.g.:

Temporary wooden ramps to surmount hatch coamings.

The removal of deck obstructions, e.g. ring-bolts, stanchions, etc.

The bridging and squaring off of rounded bilges, excessive shear, etc.

Temporary strengthening of hatch covers, tank tops, 'tween decks, etc., with metal plates to allow for axle loading of fork lift trucks.

Point loadings may be very high when a fork lift truck is under load, and considerations should be given to the Classification Societies' point loading figures (usually expressed in tonnes per square metre).

A table of truck weights and loadings is given below:

Type of Truck	*Total Weight of Truck and Load (tons)*											
	3	4	5	6	7	8	9	10	11	12	13	14
	Minimum Deck Thickness (irrespective of beam of longitudinal spacing) (inches)											
Two wheels at Fork end	0.30	0.35	0.40	0.44	0.47	0.50	0.53	0.55	0.59	0.61	0.63	0.65
Four wheels in pairs at Fork End	0.26	0.30	0.32	0.35	0.38	0.41	0.44	0.46	0.47	0.50	0.51	0.53

The stowage of the ship has to be planned with the strength and size of the units carefully considered. Two-way entry pallets and skidded units should be stowed so that the truck always has an entry to the cargo available. This is particularly important where the vessel is discharging at more than one port, and is often referred to as the "flowline" of the pallets. This "flowline" should be marked on the cargo plan with arrows.

If a solid stow is obtained immediately beneath the hatch square it is necessary to have key pallets clearly marked on the stowage plan to indicate which have to be lifted out first to allow access to the remainder of the stow and introduce the appropriate mechanical handling equipment. These pallets may with advantage, under most circumstances, be left with slings in place at time of loading to aid the process of discharging.

Any dunnage used with palletised (or other unit) loads should be limited, and lengths kept short to prevent obstructing or fouling mechanical equipment, cargo in the stow, and handling operations. Sometimes it is necessary to place sheets of plywood, chipboard or fibre board on edge in the stow to prevent the cargo on one pallet "locking" with the next and so obstructing the unloading operation. It is important when operating below decks with mechanical handling equipment that the decks are free of obstructions: loose dunnage, rubbish, etc.

Making up Dockside Pallets

Where pallet loads are made up on the dockside for unit loading aboard ship, care must be taken that bills of lading are not mixed on the pallet. Labelling of the pallet load should be carried out on at least two sides.

The mixed loading (or discharging) of breakbulk cargo and unitised cargo will completely negate the purpose of mechanised working, i.e. the fast handling of cargo with mechanical equipment and reduced numbers in each gang. It is also more likely to result in cargo becoming jammed and damaged.

Cargo into Units

When cargo is not suitable, because of size, shape or other reason, to be palletised, it may sometimes be made up into a unit load suitable for handling with mechanical equipment. This could be achieved in a number of ways, e.g.:

Securing skids or bearers to the bottom of a suitably sized package or case. This would require at least two such "skids" spaced to allow fork lift tynes entry. The minimum depth of the skids should be 50 mm (2"), but more suitable 65 mm ($2\frac{1}{2}$").

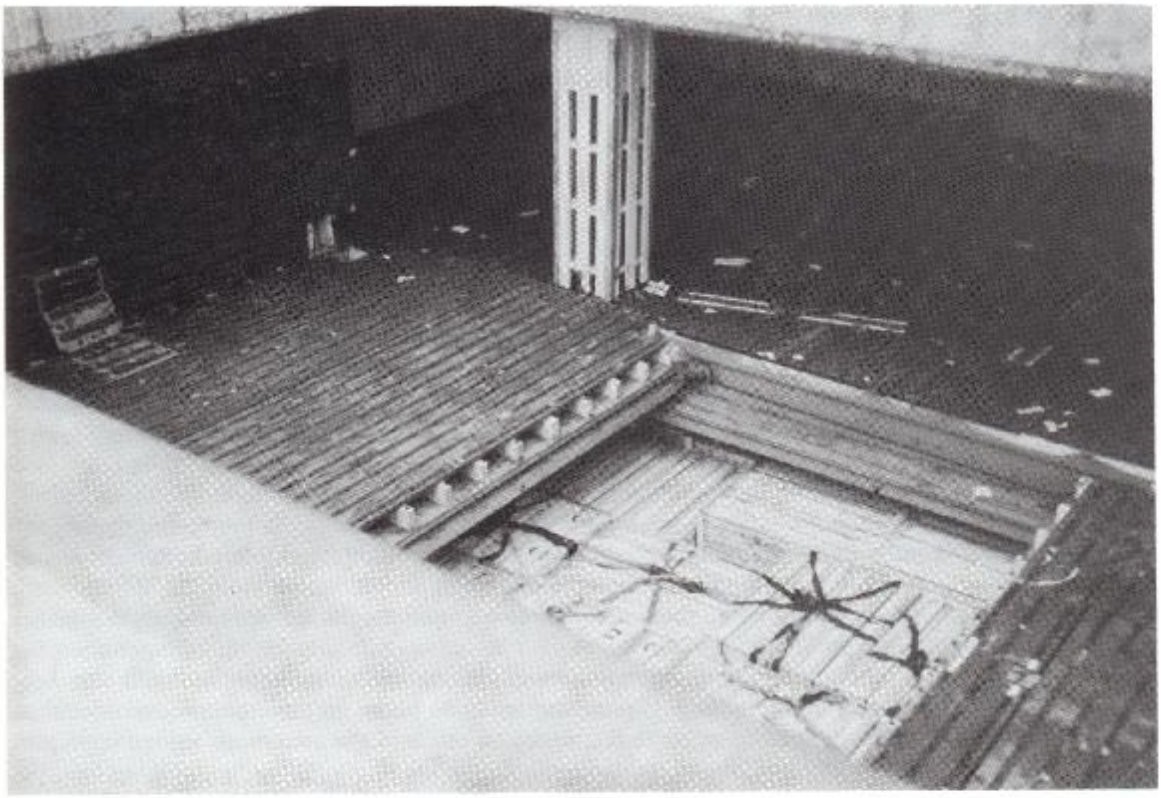
Making up the packages that form the unit in such a way that space is left between the packages themselves for fork lift tynes to gain access. Typical commodities that are suitable for this treatment are ingots, bricks, etc.

Pre-Slinging Techniques

Pre-slinging is normally used to facilitate the speed of cargo loading and/or discharging. Also to open up the stow in way of the hatch square (see over).

Multiple sling discharge.

Pre-slung reefer cargo.



It necessitates the positioning of sling loads of cargo in the stow at time of loading, leaving each unit with the sling still encompassing the load so that the port of discharge has only to hook on and lift out.

With open hatch ships and twin hatches, the advantages to be gained by using pre-slinging techniques can be great. Traditional hatch arrangements with deep wings are not so suitable since the sling load cannot be landed directly from the hook to its stowed position.

A certain amount of space is lost (perhaps 10 or even 15 per cent), but this is usually more than made up for in the speed of cargo handling obtained. The space lost is less than that for palletised or skidded cargo, and the cost of slings is probably competitive with the cost of pallets.

Materials

Any normal sling material may be used for a pre-slinging operation:

Chain slings.
Fibre rope.
Steel wire rope.
Flat synthetic fibre.

Also, under certain circumstances, nets, baskets or trays.

It is common for the following types of commodities to have the following types of sling:

Bagged Goods

Clover leaf slings, of natural or man-made fibre ropes and strops.

Reels of Paper and Newsprint

Flat synthetic strops, or endless slings often used in pairs.

Sawn Timber

Wire or flat synthetic choker strops. N.B. Bearers and dunnage must be used between units when using flat synthetic slings to avoid severe chafing damage in bad weather.

Cartons and Cased Goods, Bales and Pulp

Flat synthetic slings — also rope or wire slings.

Steel Products

Various, depending on weight, unit shape, and number of potential lifting points. Round steel piping is often pre-slung using two flat choker strops in a bridle. Steel plate, on the other hand, will usually require wire or chain slings.

Handling

When loading it must be ensured that the sling eyes are left in an accessible position on top of the load ready for immediate hooking on at time of discharging.

When discharging care must be taken that eyes from two adjacent units are not hooked on together in the belief that they are from the same unit.

It is important that during handling operations a pre-slung load remains intact and does not become broken up due to careless handling. If pre-slung loads do break up then there is immediately a labour intensive operation required to move that cargo, and much of the advantage gained from pre-slinging is lost due to higher costs in labour and time.

It is important that a series of pre-slung units be made up of the same number of bags, cartons or whatever, so that tallying is made easier. Bills of lading should not be mixed in one pre-slung load.

The drift of the sling, when handling fragile items such as cartoned goods and small crates, etc., should be sufficient to prevent pinching and crushing of the sling loads.

Slings should be of adequate strength and colour codes checked so that safe working loads and limitations may be observed.

Small bags, e.g. of salt, may be made up into loads contained within large specially constructed bags. This pre-slinging technique is practised widely in the West African trade. It should not be confused with mini-bulk (but see also that section).

CONTAINERS

Introduction

Although there are many earlier examples of "containers", the maritime container which is so familiar today first began entering deepsea service in the mid 1960s. The U.S. company Sea-Land Service introduced the first genuine containerships onto the North Atlantic trade in 1966 and by the end of the decade, there were purpose-built container vessels operating on most of the world's prime trade routes. Very soon, the major trades between developed countries were fully containerised, i.e. breakbulk vessels were withdrawn almost completely and what non-container capacity remained tended to be provided aboard roll-on, roll-off/container ships.

Trades to/from developing countries began to containerise in the 1970s, firstly by carrying some containers on conventional vessels, then with the introduction of multipurpose roll-on, and roll-off/container vessels, and ultimately with cellular and non-cellular full container vessels.

Amongst the advantages cited in favour of containers are:

(a) Reduced ship time in port.
(b) Better berth utilisation.
(c) Improved trans-shipment and intermodal operations.
(d) Reduced time between producer and consumer.
(e) Less physical handling of cargo — less damage.
(f) Good security — less pilferage.
(g) Protection against weather and detrimental atmosphere.
(h) Quality control to improve shelf life of perishables.
(i) Improved safety to personnel, cargo and equipment.
(j) Reduced tallying costs.

The relative importance of each varies according to particular circumstances. For the shipowner, the increased efficiency compared with breakbulk operations soon rendered the conventional cargo vessel uneconomic, except in specialist areas of employment. It was not simply a matter of higher vessel operating costs; also to be considered was the fact that higher value cargoes, paying better freight rates, gravitated towards containers, leaving the breakbulk vessels with only the low value, low rated cargoes.

For the shipper, the shipowner's customer, the advantages were even more significant. The attraction of the customer towards a system which conveyed cargo from door to door with minimal risk of damage or loss has proved to be the real driving force behind containerisation. Consequently containers today are to be found in considerable numbers all over the globe, even in countries where the landside infrastructure is clearly inadequate or where stevedoring charges are still modest.

The elimination of the breakbulk vessel from the volume trade routes explains why, today, cargoes which, on the face of it, are ill-suited to transport within closed boxes are nevertheless being containerised. There is no alternative shipping method available.

To distinguish between the loading of a container on to a ship or unloading of it from a ship, or the packing and unpacking of that container with cargo, the words stuffing and stripping are used with regard to the actual cargo work (sometimes known as vanning and de-vanning).

Cargo in a container very often has the same requirements and same characteristics as a cargo loaded into a locker, 'tween deck, or hold of a ship. For this reason many of the remarks on general stowage apply equally well to containers.

The ISO Container

The first container shipping lines took into account various factors when choosing the dimensions of their containers but the most important consideration was always the regulations governing road transport in the countries where the containers would be used. Next in importance was the nature of the cargo to be carried on particular trade routes, especially the relationship between weight and volume. So it was that the U.S. shipping companies who pioneered containerisation developed 20 ft, 24 ft, 27 ft, 35 ft and 40 ft containers.

To meet the industry's needs for some degree of uniformity, the International Standards Organisation now recommends a series of external and internal dimensions for containers, together with gross maximum weights which the containers may achieve (complete with cargo). Under normal circumstances these sizes and weights are adhered to, but there are exceptions, the most common of which are:

Length: The U.S. company Matson Line still operates 24 ft long containers but Sea-Land's 35 ft containers have now disappeared. Today the deepsea trades are dominated by containers either 20 ft or 40 ft in length. Recently some lines have begun the introduction of 45 ft containers but these are still restricted to the major trade routes such as those across the Pacific and North Atlantic.

In North American domestic traffic, 48 ft and even 53 ft long containers are being employed but, given current road regulations elsewhere in the world, these overlength containers are unlikely to spread into the maritime sector.

In Europe, the 30 ft container is still found in North Sea trades but the intermodal metric "swapbodies" — 7.15 m/7.45 m/7.82 m/13.6 m in length — are not suited for carriage by container vessel.

Width: The dominance of the 8 ft wide container was unchallenged until the later half of the 1980s when the emergence of the 2.5 m (8′ $2\frac{1}{2}$″) wide container began.

In Europe, the standard container had always been at a disadvantage when competing for traffic with road vehicles in that its internal width was insufficient for two standard Euro-pallets to be stowed side by side. The 2.5 m wide box addresses this problem and has proved extremely popular with European shippers.

While early "pallet-wide" containers could not be carried in cellular vessels, most newer designs do permit loading into cellular holds and this has resulted in 2.5 m wide boxes being ordered by some deepsea carriers. As with the 45 ft container, it remains to be seen whether their use will become more widespread.

Height: 8 ft 6 in has become the standard container height and early 8 ft high containers have now almost disappeared. However, to meet the needs of certain shippers, some carriers introduced 40 ft long, 9 ft 6 in high containers and these "hi-cubes" are now very common, especially on the East-West trades linking North America, Europe and the Far East. In many countries though, the overall height of a 9 ft 6 in container on a road vehicle or rail wagon creates difficulties and in the European shortsea trades for example, a compromise height of 9 ft is often preferred for hi-cube requirements.

Weight: ISO recommended maximum gross weights of 20,320 kg/25,400 kg/30,480 kg provide an easy to remember 20 tons/25 tons/30 tons approximation for the maximum permissible loaded weight of 20 ft/30 ft/40 ft-containers. In the 1980s though, the 24-tonne 20 ft container became the norm and 20,320 kg 20 footers are fast becoming rare.

Table 1. — External dimensions, permissible tolerances and ratings for series 1 freight containers.

Freight container designation	Length, *L*	tol.		tol.	Width, *W*	tol.		tol.	Height, *H*	tol.		tol.	Rating, *R* (gross mass)	
	mm		ft	in	mm		ft	in	mm		ft	in	kg	lb
1AAA	12 192	0 −10	40	0 −38	2 438	0 −5	8	0 −3/16	2 896[°°])	0 −5	9	6[°°]) 0 −3/16	30 480[°°])	67 200[°°])
1AA									2 591[°°])	0 −5	8	6[°°]) 0 3/16		
1A									2 438	0 −5	8	0 −3/16		
1AX									<2 438		<8			
1BBB	9 125	0 −10	29	11¼ 0 −38	2 438	0 −5	8	0 −3/16	2 896[°°])	0 −5	9	6[°°]) 0 −3/16	25 400[°°])	56 000[°°])
1BB									2 591[°°])	0 −5	8	6[°°]) 0 −3/16		
1B									2 438	0 −5	8	0 −3/16		
1BX									<2 438		<8			
1CC	6 058	0 −6	19	10½ 0 −1/4	2 438	0 −5	8	0 −3/16	2 591[°°])	0 −5	8	6[°°]) 0 −3/16	24 000[°°])	52 900[°°])
1C									2 438	0 −5	8	0 3/16		
1CX									<2 438		<8			
1D	2 991	0 −5	9	9¾ 0 −3/16	2 438	0 −5	8	0 −3/16	2 438	0 −5	8	0 −3/16	10 160	22 400
1DX									<2 438		<8			

In certain countries there are legal limitations to the overall height of vehicle and load (for example for railroad service).

Table 2 — Minimum internal dimensions and door opening dimensions for series 1 freight containers.

Dimensions in millimetres

Freight container designation	Minimum internal dimensions			Minimum door opening dimensions	
	Height	Width	Length	Height	Width
1AAA	Nominal container external height minus 241 mm	2 330	11 998	2 566	2 286
1AA			11 998	2 261	
1A			11 998	2 134	
1BBB			8 931	2 566	
1BB			8 931	2 261	
1B			8 931	2 134	
1CC			5 867	2 261	
1C			5 867	2 134	
1D			2 802	2 134	

The strength of a container relies mostly on the floor and corner posts. The walls, doors and roof do supply some strength but are very susceptible to damage from point loading — e.g. cargo stowed hard against it. The strength and weaknesses of a container must be borne in mind when stowing with other types of cargo, and particularly when securing.

Materials used may be steel, aluminium, grp/plywood, or a combination of these three. The inside floor of the container, supported by the cross bearers, is usually of timber construction. Aluminium containers usually have the walls lined partly or totally with plywood. Nearly all containers have securing points for the cargo in the floors and on the walls.

Many containers are built with fork lift pockets to ISO dimensions. Depending on the size and type of container there will be a standard distance between the pocket centres, width of pockets, clear height of opening and height of pockets above lowest point of container.

Types of Container

Of the many different types of ISO container the most common is the Dry Box (or General Purpose) container. This usually has doors at one end only, has a relatively low tare weight, a relatively low capital cost, and can carry a surprising variety of different commodities.

There are however many other types of container, generally known as specials.

In the deepsea trades, early experience showed that specials suffered from low utilisation rates and high re-positioning costs leading most carriers to restrict their operation of specials to only three categories: the open top and half-height; the platform and flatrack; and the refrigerated container or reefer. A fourth type, the tank container, is generally shipper-owned or leased; very few shipping lines now provide tanks except where there are dedicated traffic flows.

The open top container has doors at one end, portable roof supports (roof bows) and a tilt or cover for weather protection. Some open-tops have a rigid removable roof rather than a canvas tilt. This type of container is principally used for very heavy cargoes; cargoes that can only be loaded with an overhead crane; or for over height cargoes.

Although the open top can be used as an alternative to a dry box container, perhaps for positioning purposes, many shippers are reluctant to load them in case the tilt should prove not to be watertight.

The half-height container, like the open-top fitted with a tilt cover, is intended for the carriage of high density cargoes such as ingots but since such cargoes can easily be loaded into dry boxes or onto flats, many operators have ceased to offer this limited-use special.

The platform flat or the flatrack will be used for cargo which cannot be accommodated within a dry box or an open top.

The platform is basically the floor of a container with container fittings at each corner but not corner posts. 20 ft × 8 ft platforms are commonly used on ro-ro vessels as large pallets to unitise breakbulk cargo but they are rarely employed for door-to-door movements involving cellular ships since they cannot be stacked or top lifted by a conventional spreader when loaded with cargo. Container operators prefer the flatrack, a platform with either fixed or folding end walls.

The flatrack, when loaded with "in gauge" cargo can be handled as a standard box and be incorporated within container stacks ashore and in cellular and non-cellular holds. With out-of-gauge cargo, either overwidth, overheight or both, special care needs to be taken regarding the stowage location.

Unlike a standard box container, the flatrack is designed for heavy cargoes producing concentrated floor loadings. Usually heavy-duty lashing points and slots for side stanchions are provided.

Sets of folding flats may be locked together for empty handling as a single "container". This provides economic advantages over fixed end flats but first cost and maintenance costs are higher.

Flatracks and platforms may also be used in cellular vessels grouped together to provide 'tweendecks for the underdeck stowage of items too large to be conveyed on a single unit.

The reefer. Refrigerated containers fall into three categories: those with an integral diesel generator to power the refrigeration unit; those reliant on an external source of electrical power; and port-hole insulated containers.

When used to carry temperature-controlled cargo, the electrically powered container is connected to the ship's own power supply and usually carried on deck. The diesel generator is also normally carried on deck or in a well ventilated area on ro-ro ships.

Port-hole containers are carried below deck connected via air ducts to the ship's central refrigeration plant. It is possible to fit "clip-on" reefer units to port-hole containers in which case they can be treated as per the standard reefer type. This is particularly important when pre- or on-carriage can not be effected quickly.

It is important to note that reefer containers are designed to maintain temperatures and that cargo should be pre-cooled to the appropriate temperature before loading. They are not designed to "pull down" cargo from ambient temperatures.

Tank containers are used for the carriage of a wide variety of liquids ranging from edible products — e.g. fruit juice, wines and spirits — to hazardous and non-hazardous liquids including liquefied gases. They may be heated or non-heated.

Most tanks are owned/operated by shippers and/or specialist tank operators and are carried by shipping lines as shipper-owned equipment. However some carriers do provide tanks for certain traffics, e.g. Scotch whisky or rum.

In the shortsea trades, a wider variety of equipment is offered to shippers reflecting the need to compete with road transport for specialist traffics. The following specials may however be found being operated in some deepsea trades too.

The open sided container is ideal for cargoes that need to be loaded from the side — e.g. long lengths — and for cargoes that need ventilation — e.g. fresh vegetables or livestock. Cargo side restraint may be provided by bars or a metal grill and usually a canvas tilt cover provides weather protection.

The side-door container carries both a weight and cost penalty but is favoured by shippers who require both side access and the security of a box container. Popular with rail operators since it can be loaded whilst still on a rail wagon.

The coil carrier is a derivation of the flatrack with special fittings designed for the carriage of steel coil.

Finally, there are a group of container types which are derivations of the dry box. They can be found in both deepsea and shortsea employment.

The dry bulk container resembles a dry box but will have loading hatches in the roof, doors at one end, and a discharge hatch either in the wall opposite the doors or in the doors themselves. It may be used for dry bulk cargoes and for general cargo. N.B. Requires tipping trailer to operate it for discharging bulk.

The ventilated container has been developed for the carriage of hygroscopic (high moisture) commodities such as coffee or cocoa beans. The full ventilation galleries along the top and bottom side rails are designed to prevent the ingress of water and so these boxes can also be used for general cargo.

The fantainer or fan box is intended for cargoes prone to condensation problems. It may be purpose built but it is just as likely to be a converted dry box. A circular ventilation hatch, which can be sealed when not in use, is fitted with an electric extractor fan.

The garmentainer is usually a hi-cube 40 ft fitted with internal rails for carrying hanging garments. Care should be taken that the rails are not overloaded or collapse may occur.

The Stowage of Containers on Board

It is usually the practice in full container vessels for all pre-planning of the stowage positions of containers to be undertaken ashore. With the short turn round time of a ship, constantly changing information, containers arriving up to the last minute, and the requirement for an overall knowledge of future container movements (particularly empties), a centralised unit which has information available for the whole round voyage can often provide more effective planning. This stage of the planning usually gives guidelines for local planners at terminals and ports so that they may position individual containers. These guidelines would have due regard to stability, dead-weight, rotation of ports, movement of empties, forecasts of future cargo, the requirements of special cargo such as dangerous goods, over-heights (or other out-of-gauge cargo), uncontainerisable, refrigerated. As mentioned in the preamble to Part 1, such activity does not detract from the Master's responsibility for the safety of his vessel. It is important, therefore, that Ships' Officers pay particular attention to the condition of containers coming aboard, noting any damage; also the stowage positions and labelling of Dangerous Goods containers, the securing of cargo (where it can be seen, e.g. on flat racks), the declared contents of refrigerated containers so that the correct temperature setting may be checked and/or set. Tank containers should be scrutinised for any sign of leaks or damage to valves. Ships' Officers should liaise closely with shore planners to obtain the latest information on container stowage positions, their weights and where applicable their contents, so that stability and other calculations can be monitored and checked prior to putting to sea.

Containers of cargo that come aboard without seals (or locks) on the doors should immediately be queried with the shore staff; a fresh seal put on and a note made of the number and the circumstances.

If containers are loaded on to ships with other cargo types, such as unitised cargo or break bulk cargo, great care must be taken to prevent undue strain being put on the sides, ends or roofs of the containers. If a container has to be over-stowed with break bulk cargo (not a recommended practice) only the very lightest of cargo should be used for this purpose. The stowage of Ro-Ro ships sometimes requires that a container is blocked in and used as a natural break, or separation to other cargo. In this case it is often possible to leave the container unsecured, relying on the surrounding cargo to restrain it. Again it must be emphasised that the cargo should be of such a nature that it cannot damage the sides or ends of the container.

Containers are best stowed in the fore and aft line so that the cargo inside them gets the benefit of the restraint of the side walls. Containers stowed athwart ships will possibly result in the face of the stow collapsing and being thrown against the doors, when the ship rolls, with resulting danger or damage when the container comes to be unstuffed.

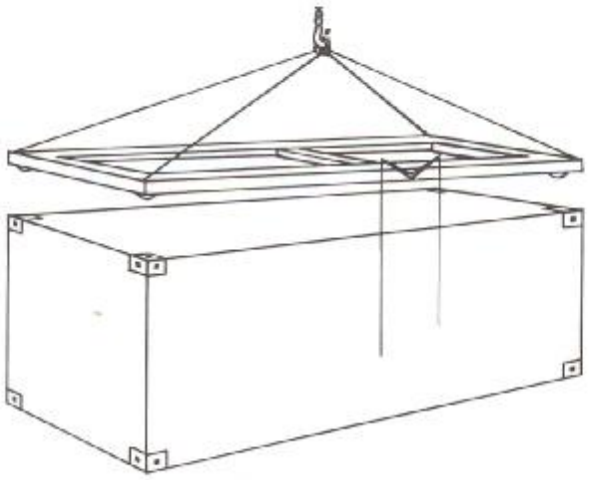
Where containers are stowed more than one tier high, the planner must endeavour to achieve homogeneous blocks of containers, e.g. avoid mixing 8 ft 6 ins and 9 ft 6 ins high containers indiscriminately in the stow. In any case the stowage arrangement must be such that adequate securing of the containers may be achieved. Where it may be possible to stow a 40 ft container on top of two 20 ft containers (if position and securing arrangements permit), however two 20 ft containers should never be stowed immediately over one 40 ft unit — unless a specially constructed frame or platform takes the weight.

The weight of a container is supported through its four lowermost corner castings. Calculations of deck loadings must take this into account. Some vessels — e.g. certain Ro-Ro vessels — have specially strengthened points on deck or tank-top to support loaded containers. Care must be taken to ensure that loaded containers are properly positioned in respect to these strengthened areas and do not exceed maximum weight limits.

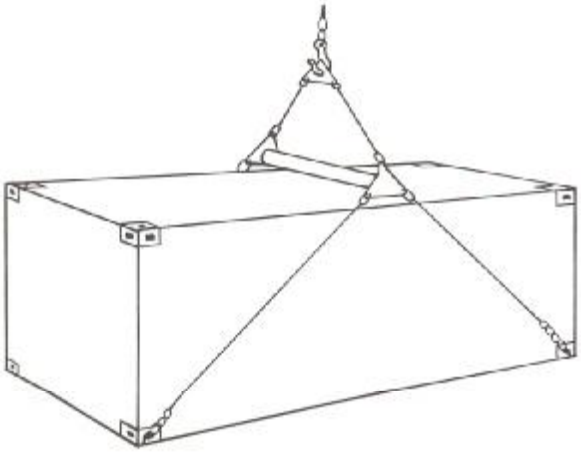
Containers, with side canvas tilts which can be damaged by high winds or heavy spray, should not be stowed on the outboard side of the stack on deck. When animals are carried the stowage position should be such that the crew can gain easy access to them for feeding or watering or, if the worst occurs, for removing the animal carcasses at sea (see "Livestock").

Container Handling

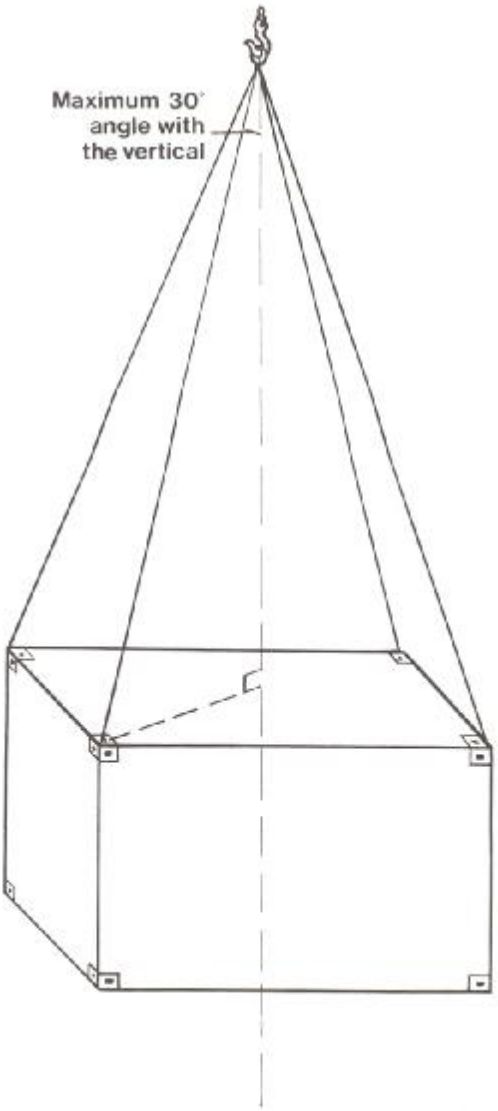
Cranes and derricks — These require an overhead connection to the container usually supplied by a "spreader". This is necessary to supply vertical lift at each corner casting to prevent damaging the container. Twist locks enter the appropriate apertures in the corner castings and when turned 90 degrees they engage. Spreaders may be operated by the crane driver direct or they may be



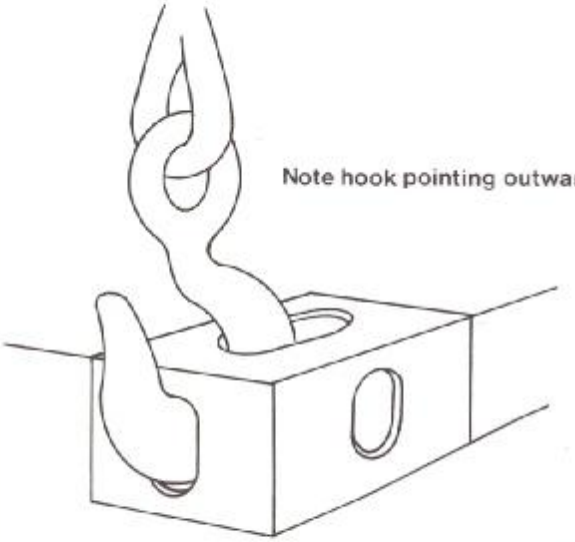
Semi-automatic, manually operated 'twist-locks'

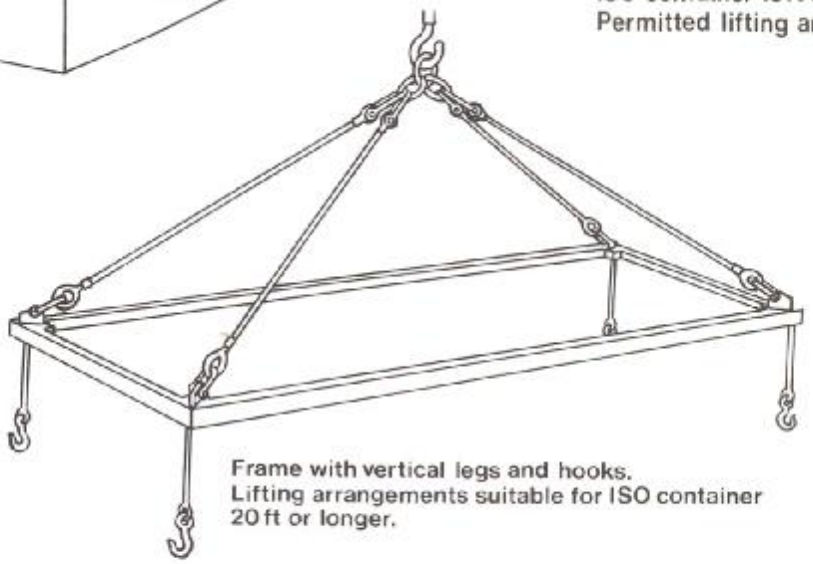


Bottom lift by means of transverse spreader, sling and hooks, shackles or lugs. Slings should be angled at not less than 45° nor more than 60° to the horizontal.



ISO container 10ft or smaller.
Permitted lifting arrangement.





Frame with vertical legs and hooks.
Lifting arrangements suitable for ISO container 20 ft or longer.

"semi-automatic" and operated by a lever on the side of the frame (often with a line hanging down for ease of access). A frame may be used with four hooks hanging vertically which are manually inserted into the correct corner castings, in which case the hooks should be pointing outward from the ends of the container to gain maximum support from the seat of the hook and make for ease of unhooking when the container is in position. 20 ft containers and above should never be lifted by direct wire slings from top corner castings without some spreader device to prevent the wires pinching and therefore damaging the container.

Fork lift trucks — These must be of sufficient capacity to handle the container if it is loaded. Mast heights must be suited to operating with overhead obstructions in the case of Ro-Ro vessels. Smaller capacity fork lift trucks may be used for empty containers. If the container has fork lift pockets then the tynes of the fork truck may be used for direct lifting. Spreaders may also be fitted for top lifting containers as also may be side frames. Side frame operation may not be suitable over uneven terrain, and care must be taken to select frames suitable for the containers to be handled, e.g. with bearing points at or near the side rails or corner castings. Empty containers may be lifted by end frames; but this is only for empty containers as it puts a great strain on the container itself.

Container terminals usually employ sophisticated equipment such as straddle carriers, gantries, etc., for movement of containers into and out of the stack. Low profile straddle carriers may sometimes be used to carry containers on and off Ro-Ro vessels.

There are certain makes of self levelling spreaders and spreaders that maintain a parallel line to the ship as a swinging crane or derrick puts the container on board. Some spreaders are able to rotate a container through 360 degrees; these being of greater weight usually detract from the maximum load that the crane is able to lift.

Certain terminals have spreaders capable of twin-lifting 20 ft containers. Such equipment can usually only operate if containers of the same height are paired. Two containers at a time, one on top of the other, may be lifted by fork lift truck (if of adequate capacity) in certain circumstances (e.g. the weather deck stowage on board Ro-Ro vessels with no overhead gear) to obtain a three-high stow. However, the lifting of two containers, coupled together by twist-locks or similar, by overhead gear is dangerous — unless the system has been properly tested and approved.

Container Securing

Care should be taken by ship's staff to ascertain the point loading on deck and heavy containers are given adjacent deck stow. There may be occasions where planners seeking to minimise moves may give heavy containers top stow. This may cause stability problems and excessive lashing strains when rolling, pitching, or working in a seaway.

The securing of containers on (or if applicable below) decks is the responsibility of the ship's staff, though not necessarily carried out by them. It is important that all rod and wire lashings are sufficiently tight but not too tight to strain fittings, containers, etc. The correct bridging pieces, twist locks, etc., should be checked in position between tiers. It should be clearly ascertained and understood which way twist lock handles are put for the locking position, i.e. the locking position should be in the same direction for all twist locks on the ship so that a quick glance is all that is needed to ensure that the locks are indeed engaged.

In cellular vessels containers are put down cell guides and landed one on top of the other. No further securing is required in these circumstances. Some ships exist with guides above deck for similar purposes. Containers stacked one above the other without the benefit of cell guides must be secured one to the other with twist locks, and/or a combination of locating cones, bridging pieces, lashing rods, wires and shores as specified by builder or supplier, to prevent any form of shifting.

The blocking in of containers in a stow with unitised or general cargo has already been mentioned. To facilitate this and to spread the load on the container sides or walls large inflatable dunnage bags might be used to advantage.

Containers that are not blocked in as above must be properly secured with wire rod or chain lashings to prevent any movement and to reduce the strain of racking on the container. When lashing containers in conventional stow or on deck, particular attention must be paid to securing the *bottom* of the container as well as the top corners. This is particularly important if two or more containers are stowed in a vertical height. It is also important that only the corner castings are used to secure the

container. A wire lashing for instance passed over the top middle section of the container does not secure it adequately, and can only damage the container should it move. Ships that have been designed to carry containers either below or on deck, and do not have cell guides, will have deck fittings suitably placed for corner castings to be held. It is essential that container shoes, stacker cones, and twistlocks are properly maintained. Twistlocks must be correctly engaged, normally by rotating the locking mechanism through 90°. These must be used to full advantage, and any recommended lashing pattern provided by the builders or architects should be strictly adhered to particularly where containers of mixed heights are concerned. Ro-Ro ships that may carry cargo either on wheels or landed on the deck will often have securing points that can be used for either type of cargo. Proprietary products are on the market that will allow a deck fitting to be used one voyage for Ro-Ro lugs, and on the next voyage to insert container securing cones.

Container Stuffing

The stuffing of the container may take place at:

The customer's premises.
An inland terminal or depot.
A groupage agent's premises.
The sea terminal or port.
On board ship (in special circumstances).

Prior to stuffing the container, it should be checked for fitness, i.e. that it is suitable with regard to type, cleanliness and repair, for the cargo it has to carry and the voyage to be made. These checks will include:

External

No holes or tears in the walls or roof.
No broken or distorted door hinges or locks.
The roof closures of open-top containers to be sound (e.g. no tears in tilts) and well fitting.
All out-of-date labels removed.
The temperature setting (of mechanically refrigerated containers) correct for the cargo to be loaded, with recording chart in place.
Loading, discharging and relief valves on tank containers operating correctly and properly shut where necessary.

Internal

Cleanliness: there should be no remnants of the previous cargo, e.g. no dust, sweepings, grease, liquid, etc.
Dryness: the interior should be free from any sweat, frost, etc., which might adversely affect the cargo to be packed.
Infestation: the container should be free of any signs that vermin or pests are present or have been present.
Taint: particularly if delicate goods or foodstuffs are to be put in the container, there should be no residual taint, also free from odour of disinfectants or fumigants.
Watertightness: this may best be tested with the "light test", i.e. entering the container, shutting both doors, and looking for any ingress of light.

The degree of fitness that the container has to achieve is largely dictated by the type of cargo to be carried. The alphabetical list of commodities in Part 3 will indicate the requirements for each type of cargo, and where possible the most suitable types of container.

Particular care must be taken in the case of Dangerous Goods, to which the IMDG Code Section 12 refers (see also "Dangerous Goods").

It is most important that the cargo inside the container is restrained from any movement. Proper restraint will prevent:

Damage to the cargo from falling or sliding around during the container's movements on land or sea.

Damage to the cargo or packaging from chafe — usually caused by vibration on road or rail.
Damage to the container floor or walls.
Danger to personnel opening the container doors at time of unpacking or for the customs inspection.

In extreme cases very heavy cargo, which is not adequately restrained, might break through the container walls and affect adjacent cargo or even the safety of the ship itself.
Restraint can be provided by:

Using an appropriate interlocking stow of the packages.
Pre-planning the stow so that if it does not fill the container it fully covers the floor and is level in height throughout.
Where possible and appropriate leaving void spaces down the centre of the stow so that cargo may be restrained by being supported hard up against either side wall, and filling the appropriate void spaces with dunnage or waste material, e.g. spare packaging material, old tyres, inflatable dunnage bags (which must be compatible with the cargo carried, e.g. with respect to taint).
Shoring and blocking the "face" of the stow (near the doors) with timber or inflatable dunnage.
Using the floor and wall securing points to lash with rope, wire or nets. N.B. If nails are used to secure timber shoring to the container floor, the nails must not penetrate the full depth of the floor, and they should be easily removed.
The cargo may damage itself or adjacent cargo, if not properly stowed, by:
Mechanical damage, e.g. crushing, etc.
Cross-contamination, e.g. taint, spillage or leakage, migration of dust or debris, infestation, movement of moisture, i.e. condensation.

Such damage may be guarded against by:

Stowing light items (of low density) over heavy items (high density).
Keeping items such as crates separated from cargo such as paper sacks.
Providing dunnage (timber, hardboard, etc.) between tiers as required.
Stowing liquids on the floor, dry items above. N.B. Drums and barrels should be stowed with bungs or closures uppermost.
Stuffing moisture inherent items in separate containers to those requiring dry stowage.
Stuffing items with a strong odour in separate containers to those susceptible to taint damage (or which might affect the packaging). N.B. Commodities with properties that might leave long-lasting residual taint (e.g. Phenolic based substances) may have to be stuffed into special containers that are reserved for dirty cargoes (see "Obnoxious Cargoes").
Strict observance of Dangerous Goods rules and regulations (see "Dangerous Goods").

Other areas of damage that have to be guarded against at time of stuffing or during transit include:

Uneven weight distribution; the cargo weight should be so distributed that the centre of gravity remains as low as possible and near the centre of the container. No more than 60 per cent of the weight should be in one half of the container.
When very heavy high density cargo is stuffed (e.g. lead ingots) the cargo should be positioned hard up against the side walls, and the weight distributed as extensively as possible to obtain full benefit from the inherent floor strength. Some such cargoes may require dunnage or similar to support the weight and spread the load.
Cargo susceptible to damage from fluctuations in temperature may have to be carried in insulated containers under temperature control conditions, or given stowage and stacking position adequately protected from direct sunlight (see "Refrigeration").
Cargo requiring ventilation may have to be carried in containers fitted with mechanical ventilation, or in open-sided or open-top containers. The stowage pattern of such cargo should be arranged to allow the proper movement of air through the cargo to achieve the ventilation required (see "Ventilation").
Refrigerated cargo must be stuffed in such a manner that the air or gas may move around and/or through the cargo sufficiently freely to maintain the required temperatures (see "Refrigeration").

Before stripping (de-vanning, or unpacking) a container, the following should be carefully checked:

Any notices or labels (e.g. Dangerous Goods labels), or notices concerning the contents specially if bulk has been loaded.
Where there is risk of gas being present (e.g. when using liquid nitrogen as a refrigerant) then doors should be left open for some minutes to allow any gas to dissipate before personnel may enter the container.
The right hand door should be opened — cautiously — first. This is to guard against the risk of improperly secured cargo falling out and injuring personnel.
The seal should be intact and not have been tampered with. A note should be made of the number for future reference.
The external condition of the container should be apparently sound. Any damage that may have affected the contents should be noted.

When the container is empty of cargo the interior should be checked and any residue removed.

Modification of G.P. Containers

The use of "specials" adds extra cost in capital outlay; maintenance and positioning. Advantage may be gained, therefore, by the operator able to use General Purpose (Closed Box) containers for specialised cargoes.

Techniques in this direction have been developed for the carriage of dry bulk and liquid bulk using General Purpose containers.

The principle requires the installation of a temporary bulkhead in way of the doors to support the load, and, for some types of dry bulk, the lining of the container with plastic or similar. Liquids are contained in a bag made of Polyurethane, Nitrile, Butyl, Platilon, Hytrel, Hyperlastic or Nylon Film depending on the compatibility with the product to be carried. Some of the products that have been carried in bulk, using a General Purpose container include: Malt, Grain, Seed, Polythene Granules, chemically inert powders, Brake Fluid, Detergents, Fruit Juice, Wine, Oils (non-hazardous), Sodium Silicate, Fatty Acids, Maple Syrup, etc. (See also Appendix 7).

Where bulk is being loaded in a General Purpose container, it must be ascertained that the container is structurally fit for this type of treatment. Some plywood sided containers, for instance, may suffer such extreme side wall deflection that the container may foul adjacent units or even the cell guides. In severe cases the container may rupture.

When to Clean

One or more of the following circumstances may make it necessary to consider cleaning the interior of a container between cargoes:

In the event of spillage — of either liquids or solids.
To remove a source of taint — which might affect future cargo.
To remove infestation — which may not always be apparent at time of inspection.
To remove the residue of a previous cargo, e.g. bulk, for quarantine or other reasons.
As a safety or good operating practice to remove old dunnage, packing materials, residue from chafed packages, etc.

N.B. Some of the cargoes which might permanently affect the interior of a container are listed in the section on "Obnoxious Cargoes".

Different types and levels of contamination from residues or spillage require different methods of cleaning. As mentioned above, the degree to which the interior is cleaned must depend to a certain extent on the commodities likely to be carried — and even on the trade.

Removal of loose solid residue by means of a simple sweep with a broom.
Cold fresh water wash, using soap or detergent.

Hot fresh water wash, using soap or detergent.
Steam clean.
Replacement of highly contaminated parts (e.g. the wooden floor) which involves repair rather than cleaning methods.

Fumigation

Containers may be fumigated for the following reasons:

When empty of cargo — to destroy residual infestation from previous cargoes.
When stuffed — to fumigate a particular cargo, e.g. malt.
To comply with quarantine requirements, e.g. Australian Plant Quarantine Regulations.

Normally carried out by specialist Companies well experienced in fumigation requirements, containers are usually shipped after having been cleared of any residue of fumigation. Special occasions may arise, however, when containers have to be shipped while under fumigation. In such instances full agreement and understanding must be reached between ship and shore staff; correct stowage — with appropriate ventilation — provided; warning notices, labels and restriction of access to unauthorised persons must be clearly marked. Containers under Methyl Bromide or Phosphene gas fumigation are dangerous, and must be carried strictly in accordance with appropriate legislation and reference to the authorities.

Fumigation methods:

(a) Methyl Bromide may be injected into the container via special inlets on the top side rails or other suitable point. Alternatively it may be introduced via the doors. In any case it should be carried out by authorised and experienced personnel, with proper protective clothing and breathing apparatus. The containers should have warning labels clearly discernible and should be fenced off from all unauthorised approach.
(b) Phosphene may be introduced in the form of pellets, which emit gas as a result of reaction with the moisture in the air. This gas is even more dangerous than Methyl Bromide, and residue of pellets must be removed from the container before cargo handling personnel are permitted to enter.

See also "Pests and Vermin".

ROLL ON-ROLL OFF

Introduction

Roll-on Roll-off (Ro-Ro) techniques include the handling of cargo on to or off a ship primarily by horizontal (or near horizontal) movement. This means that the cargo may be handled on vehicles or trailers which remain with the cargo during the sea passage, or alternatively may be taken on board by wheeled vehicles and the cargo itself stowed as General or Unitised cargo. (Sometimes, in exceptional circumstances, e.g. the movement of very heavy loads, the use of air or water skids may be adopted). The reverse procedure is used at the port of discharge.

Ro-Ro operations may be divided into three broad groups:

1. Short-Sea — With the sea-leg of transport chain of short duration, cargo usually remains on the trailers or vehicles.
2. Medium Sea — Medium length voyages, where cargo may remain on trailers or be lifted off and stowed without its wheels for the sea leg of the voyage, or a combination of both.
3. Deep Sea — Long ocean passages, Ro-Ro cargo is usually delivered on board, removed from its wheels, and stowed in a similar manner to a general cargo vessel — space requirements taking preference over speed of operation.

Operational Efficiency

Good planning and proper supervision are of a paramount importance.

Since the time taken to manoeuvre the load into position on a Ro-Ro vessel can take up to 50 per cent of the vehicle cycle time, it is important that proper means and techniques are provided to allow vehicles or their cargo to be manoeuvred into position with the least possible delay or complication. The loading time of a Ro-Ro vessel is very often dependent upon the time taken to manoeuvre and secure the cargoes, trailers, and vehicles.

The speed with which a vehicle can complete its cycle (and sometimes its ability to operate at all) is affected by:

(a) the gradient of each ramp;
(b) width of each ramp;
(c) bends and turns to be negotiated, and blind corners;
(d) the speed of operation of elevators or other similar handling equipment;
(e) the "vehicle envelope";
(f) the change in gradient;
(g) the organisation and traffic flow.

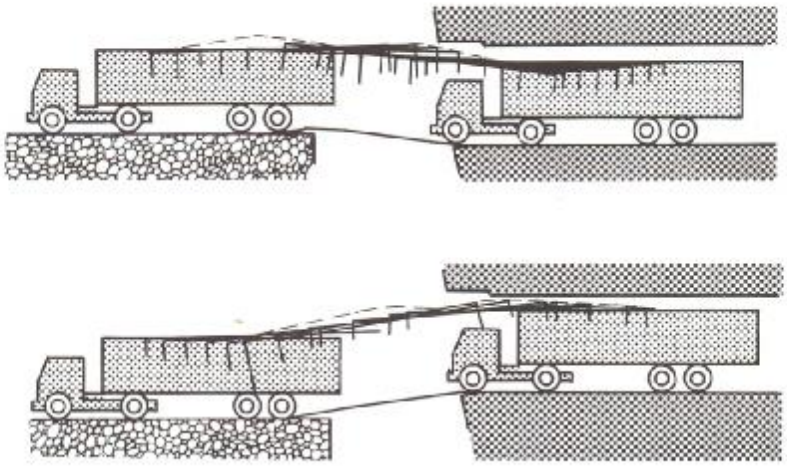
The angle of the ramps — particularly the ship to shore ramps which are subject to a greater flow of traffic as well as to external weather conditions — can affect the speed and sometimes even stop operations. A gradient of one in ten may reduce the cycle time of vehicles by up to 8 per cent when measured against the speed obtained with purely horizontal access. It is important therefore that where possible vessels use the appropriate trimming tanks to adjust the threshold heights of their ramp to enable the latter to have the least gradient possible. Too steep a change in slope (e.g. in excess of 7 degrees) may sometimes cause the towing unit to become uncoupled from the trailers that they are pulling.

Where the width of a ramp may seem sufficient for two lane vehicular traffic, cycle time may be affected adversely if too many vehicles have to pass each other on the ramp. Traffic flows can sometimes be improved to reduce this.

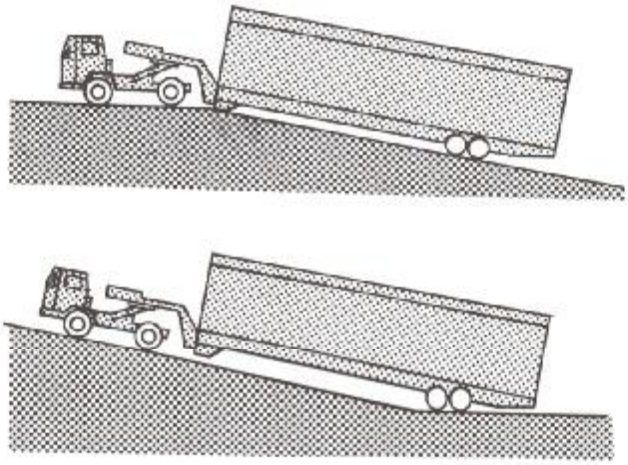
The "vehicle envelope" is the total space required by the whole vehicle and its load as it negotiates a change in gradient, without fouling any obstructions above, e.g. entrance, deckhead, trunking, etc.

A change of slope if too severe, can ground vehicles either at the centre or at their extremity. Vehicles thus grounded may suffer damage themselves and cause damage to the ramp. Typical maximum angles when setting up equipment that involves a change of slope, would be 6 to 7 degrees, and about 6 metres between each such change of slope.

The use of good experienced drivers can greatly improve the speed of cargo handling in a Ro-Ro vessel. This is particularly apparent if vehicles have to be reversed up the ramp because of insufficient



'Vehicle envelope' – the extra vertical space required by a vehicle negotiating a change of slope.



Excessive change of slope (e.g. between ship's ramp and quay) may cause grounding problems.

manoeuvring space on the vessel, or to position the trailers so that they may be pulled out directly at the port of discharge.

Where extreme tidal ranges may affect the gradient of the ramp, or even prohibit it from being landed on the wharf, Ships' Officers should make trim and draft calculations before arrival in the port of loading or discharging to ascertain the periods during which cargo may be worked, or in extreme cases periods when very heavy lifts may be handled over the minimum gradients. This information should be available to stevedores, planners, etc., so that maximum speed of operation may be achieved. Occasions have arisen when cargo has been presented to the ship, but, because of the angle of the ramp, the change of angle between ramp and quay, and the "vehicle envelope" requirement, the cargo has had to be turned away and the ship owner presented with the costs.

Stowage

Many Ro-Ro vessels have a predominance of the weight (e.g. ramp system) aft. This may require that tanks are used to maintain an acceptable trim during loading operations, and may also require that cargo is first in and last out to the forward lower decks.

Cargo may be taken on board the Ro-Ro vessel in one or more of the following ways:

(a) road vehicles with integral haulage power which will also remain with the vessel;
(b) road trailers which will remain with the ship throughout the sea transport leg;
(c) roll trailers which are not suitable for road haulage but which will remain with the ship during sea transport;
(d) cargo towed on board using roll trailers (or occasionally road trailers) and then cargo removed and stowed without its wheels.
(e) cargo secured on flats and carried on board either using roll trailers or by other mechanical handling equipment; both the flat and its cargo being stowed as a unit;
(f) pallets either singly or in groups (e.g. four at a time) carried on board using roll trailers or fork lift trucks;
(g) individual items of cargo brought on board by fork lift trucks.

Each of the systems described above have their own part to play in particular trades or environments. For instance short sea trades nearly always keep the cargo on its wheels for the short sea passage, the increase in cargo handling speed outweighing the loss of space.

Vehicles are usually close parked (and this includes trailers) in lanes of about 3 metres wide. This

should allow access for lashing gangs to secure each vehicle properly. Australian waterside workers, for instance, require a minimum of 40 mm between vehicles when discharging car carriers.

Containers may be stowed fore and aft or athwartships, but care must be taken to ensure that suitably strengthened areas of the deck (usually with pads and locating cones) are in way of the corner castings.

As mentioned above trailers may be backed up the ramp and positioned so that at the port of discharge towing vehicles may have direct access to the coupling point of each trailer, and be able to tow straight off the vessel without the need to turn round.

It is important that different types of cargo, e.g. containers and pallets, are properly separated to prevent the one causing damage to the other. This separation, which in many cases also provides restraint, may be by means of timber dunnage, dunnage bags, sheets of plywood or hardboard, other cargo, e.g. tyres, etc.

Where containers with air cooled integral refrigeration units are stowed below decks, it must be ensured that adequate ventilation can reach these containers to allow the proper air cooling to take place, as well as sufficient space, c. 600 mm (2'), in way of the equipment end of the container, so that maintenance may be carried out and temperatures monitored.

Appropriate Dangerous Goods' regulations apply to all Dangerous Goods' cargo (see "Dangerous Goods").

Securing

Securing of vehicles on board Ro-Ro vessels must be in accordance with an approved system, making full use of trestles, pedestals, deck securing points, as are recommended by the builders. Securing points and appropriate trestles, etc., should be used to by-pass the springing system of vehicles, so that during the movement of the vessel at sea the vehicles remain rigidly secured (see also Part 1 — "Safety").

Containers should be lashed and secured in accordance with an approved system, preferably to locating cones and securing pins. Wire, chains, hooks and levers must be set up so as not to take undue strain and thereby rack or distort the container.

Equipment

When mechanical equipment, towing vehicles and road vehicles are operating on vehicle decks, proper and adequate ventilation must be used to remove excess exhaust fumes.

Using fork lift trucks to handle cargo direct from shore storage to ship stowage may be uneconomical in certain circumstances. The table below indicates suggested maximum operating distances for fork lift trucks:

Speed of FLT km per hr	*Max. Economical Distance metres*
7	64
8	74
9	83
10	92
11	102
12	111
13	121
14	131
15	140
16	150
17	159
18	169
19	179
20	188

NEOBULK

A term used where large quantities of homogeneous or even similar cargo is loaded into one bottom, often with specialised facilities or specialised handling equipment to do so. While these types of cargo do not fall within the category of bulk cargo, they are of a sufficiently special nature to require techniques applied over and above those required for general cargo and bulk cargo. Neobulk carries no hard and fast definition with it and in fact the types of cargo loaded as Neobulk are classified and treated as general cargo in small parcels. Such cargo might include: steel, timber, forest products, motor cars.

Specialised ships may be employed for some of these items: specialised car carriers, specialised timber carriers and in some instances specialised steel carriers.

IRON AND STEEL PRODUCTS

Typical examples: ingots, billets, slabs; steel sheet in hot rolled coils and cold rolled coils; rolled sections and constructional steel; small section material, rods and wire; pipes and tubes of all dimensions; reinforcing bars; packs of sheet steel; individual steel sheets.

Characteristics

Nearly all steel — including some stainless steel — can suffer from rust development to some extent. This affects the products to a greater or lesser degree depending on (a) its state of production, and (b) its proposed end use. All steel can, to a greater or lesser extent, suffer from mechanical handling damage. This may occur on the quay, on the ship, at some inland point of transport, or while in the stow and subject to external forces of ships' movement and other cargo.

Steel may be packaged, that is protected with a cover of cardboard sheeting or crated or parcelled, e.g. packs of steel sheet wrapped in metal envelopes. Steel may be coated with oil or other protective against moisture. A great deal of steel is transported and stored without any protection at all, e.g. structural steel, reinforcing bars, pipes, etc. The degree of protection provided does not necessarily reflect the degree of care needed during transport.

Handling

Where steel is carried in large quantities, specialised handling and slinging equipment is almost certain to be available, and this will vary from country to country and from berth to berth.

Slings and strops are normally constructed from wire rope, braided wire, and chains.

Slings, hooks, shackles, strops and chains must all be of sufficient robustness to provide adequate factors of safety when lifting the proposed loads. Chains are normally stronger than wire ropes or other slings (size for size) but may be unsuitable on account of possible damage to the cargo itself. When a load is lifted by a pair of legs or slings the angles subtended at the lifting hook should be small enough to ensure the cargo is not distorted or damaged by "pinching". This is particularly important when manufactured pieces are lifted which could be severely damaged if bent. A spreader or beam may need to be provided to prevent such damage. Sufficiently robust bars through the centre of steel coils, slung at the ends, may serve the same purpose. Steel should never be lifted by its own strapping unless it has been specially designed and approved.

Certain types of steel, e.g. pipes, coils, tubes, may have their own purpose built lifting equipment, e.g. pipe hooks, bars and spreaders.

Pallets, skids, bins, all may be utilised in the packaging of certain types of steel particularly coils of wire. Packages and units made up in this manner may be handled by mechanical equipment (see "Unit Loads"). "C hooks" are the safest way of lifting and handling coils. This is a counter-balanced support arm which is put through the centre eye of a coil, and as the weight is taken the arm remains horizontal and supports the load. It is only suitable for handling and storing cargo that has plenty of access space — i.e. to put the arm (or bar) of the lower part of the "C hook" through the coil requires an equivalent amount of space adjacent to it so that the arm may enter.

It is important that the handling equipment used at the port of loading can be matched at the port of discharge. Instances have occurred of sheet metal being loaded by electro magnet, and the stow made so tight that it is impossible for conventional gear to gain access to the sheets at the port of discharge.

Damage

Steel products, usually unwrapped, which are shipped in a partly processed condition are referred to in the industry as semi-finished products, i.e. for further processing at place of destination, are less susceptible to handling and stowage damage than finished items. They may consist of hot-rolled bars, bar-sized shapes or coils, ingots, billets, slabs. Some of these can be seriously damaged by bad handling. Damage to coils may be caused by the edges being cut or dented. This can effectively reduce the width of the coiled sheet when it is offered for processing. Coils that become unstrapped may telescope or become kinked, and they may also be unsuitable for further processing or require re-securing for on carriage.

Finished products, usually wrapped, which might sustain damage from careless handling or bad stowage include:

Rolled sections, i.e. constructional steel. These may be damaged if distorted or bent.

Steel sheets or packages may be subject to damage by mechanical handling or by rust. The edges of these packages may be particularly vulnerable, and unacceptable point loading may cause further damage.

Coiled finished carbon alloy and stainless steel bars, coils, etc., may be damaged by weather, and/or physical and/or chemical damage.

Pipes and tubes may suffer unacceptable damage if the packaging or coating is damaged — i.e. to allow the ingress of moisture laden air.

In general, all wrapped material must be kept dry as it is invariably sensitive cargo and may be ruined through contact with moisture caused by condensation, exposure to fluctuating ambient temperatures, rain etc.

STOWAGE AND SECURING

(A) Coils Steel Sheeting

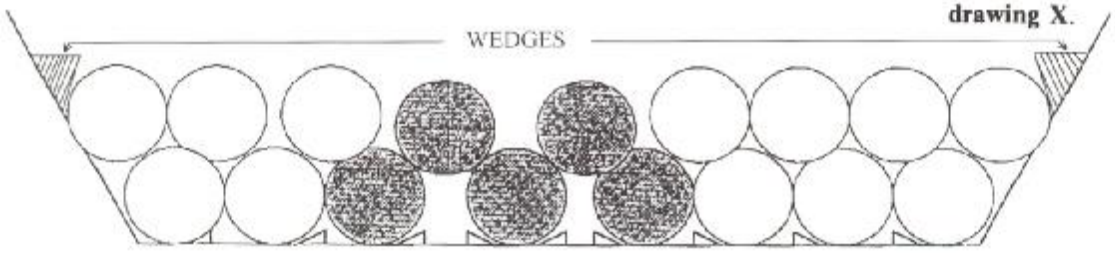
Appearance

Hot rolled coils are usually not wrapped and can appear wet and rusty when shipped. Cold rolled coils, also coils of galvanised sheet steel, are wrapped and highly susceptible to claims. Coils are either packed or non-packed and the type and quality of the packing material, whether metal envelopes or just paper wrappers are involved, appears in a wide range of types and colours. The packing components are secured in place by applying a number of circumferential and radial steel strapping bands.

Without going into detail about the various types of material within these two categories one can take it as a general rule that the carrier should at least care for the cargo in the same manner as the shipper does. Cargoes which are protected against humidity prior to shipment, either on trucks in barges or in warehouse, should never be exposed to rain during loading. In fact it is only non-packed hot rolled coils which may possibly be loaded in rain providing these are stored in the open and appropriate remarks as to its condition can be inserted in the relevant shipping documents. Further to this, consideration for cargo already loaded and/or to be loaded must be kept in mind.

Handling and Stowage

Coils should always be handled with braided wire slings or by means of special designed lifting gear in order to avoid lifting marks to the core packing and possible bending damage to the core windings. Forklifts should always be equipped with a round ram without any sharp edges.



drawing X.

Stowage of steel coils is to be performed with the utmost care and should comply with a number of rules which after many years of trial and error have eventually proved key elements in the safe carriage of this type of cargo.

Steel coils are to be loaded on a sufficient number of lines of flat dunnage, usually two or three lines depending on the width of the coil, with the centre cores placed in a fore and aft direction. The stowage is usually started in both ship's sides and is extended towards the middle of the hold taking care that at least two wooden wedges are properly placed against the base of the coil, always pointing towards the ship's side. The empty space which unavoidably remains in the centre of the stow should be provided by a so called locking — or key coil which is intended, by its own weight, to apply pressure to units in the sides in order to compensate for any slackness which might exist. This coil should be placed within the cantlines of the adjacent units and should sink down to at least one third of its diameter. In case the space is not sufficiently large two locking coils are to be provided as shown in **drawing X.**

Coils should, for reasons of safety, if possible, always be stowed at least two units high as it is obvious that in this case any of the coils in the second layer are serving as locking coils and sink down whenever slackness would occur in the stow. A two or three high stowage nevertheless does not overrule the key coil system as described above.

In case a one high stowage (single tier of coils) is performed, as for instance in smaller sized vessels where the tanktop strength does no allow a higher stowage, additional securing is to be performed as described under the following heading. Single tier stowage is often performed in all sized vessels.

In a multi layer stowage the second and possibly further layers of coils are loaded in the cantlines of the previous loaded coils. Care is to be taken, in case of different diameters and sizes of coils, that all coils are properly resting on the cantlines of the understowed units which involves a selection of the coils prior to shipment.

In connection with the stowage of coils on vessels equipped with side tanks it is common practise to stow coils by means of forklifts, equipped with a special designed hook on the ram, on the side tanks. Pyramid stowage is often performed to avoid the difficulties of manoeuvring heavy coils into the wings and reducing the use of handling equipment. However, such stowage, customarily resorted to in the industry, is contrary to all principals of good and safe stowage, which demands that all tiers of cargo be winged out to the ship's sides as a maximum precaution against shifting.

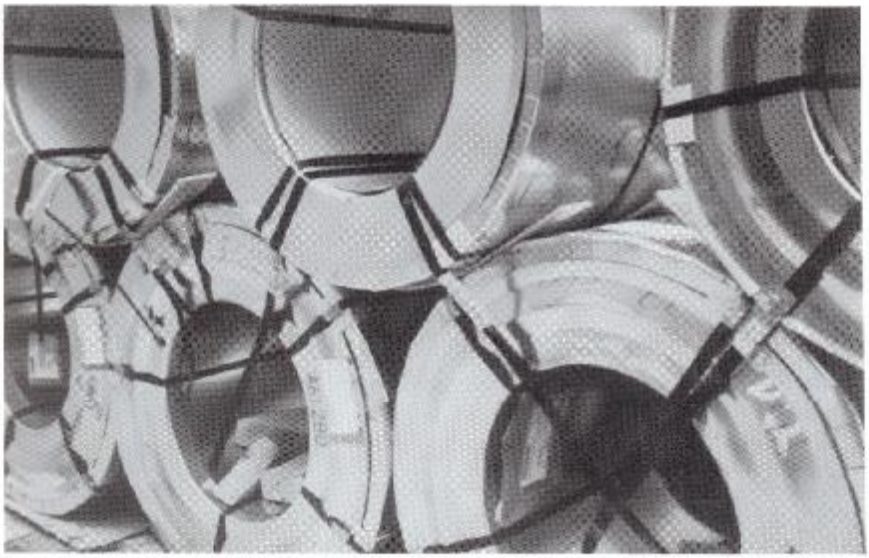
Lashing and Securing

(1) Coils in one high stowage

Coils in a one high stowage are not desirable but cannot always be avoided as it is sometimes necessary in smaller vessels for reasons of tanktop strength, or in larger vessels where individual coil weights are in excess of 15 tons. With this type of stowage it is advisable to perform a double lashing of the locking coil by means of steel wires or metal strapping bands. It is preferable to perform a short lashing through the eye of the locking coil towards the eye of the understowed coil rather than to lash the coil over its circumference. In any case, the method of securing should involve lashing the locking or key coil to adjacent coils below through the cores of the individual coils.

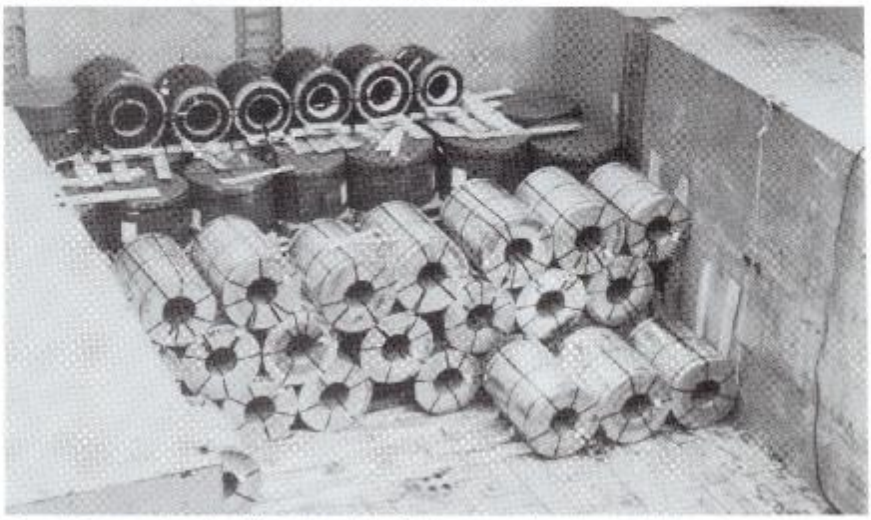
(2) Two or more high stowage

Two systems are generally used for lashing of coils in a stowage of two or more units high. The securing which is performed by means of chocking all empty spaces in the toplayer by means of square



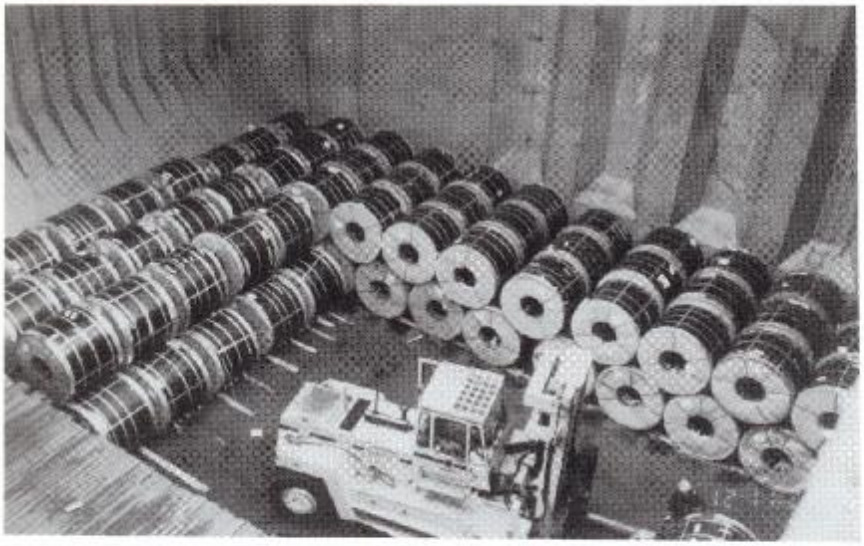
View on method of the lashing and securing of steel coils by means of flat metal strapping bands.

Steel coils in stow.



General view on the method of stowing steel coils in a square shaped cargo hold.

General view on the stowage of steel coils.



timber is less and less used and is in many instances replaced by the "metal strapping band system". Even when wires are used to secure, timber chocking etc., will not be necessary if core lashings are applied.

In the first case large quantities of square timber are used to fill up all empty spaces in the toplayer of coils and additional wire lashing is performed to those units which are vulnerable to shifting, especially the coils stowed in the ship's side in case a pyramid stowage is performed. With the "metal strapping band system" one and every coil in the toplayer is lashed by means of pneumatically driven tools. Hand tools for tightening must never be used. With the latter system strapping bands are abundantly used and therefore the usual chocking with timber can be dispensed with. Every coil in the top tier is lashed through the eye to the understowed units preferably with a short lashing. Every coil is thus lashed by means of two strapping bands each of which are secured by means of two steel clips. The short lashing system demands that a lashing gang has to standby during the loading operations and therefore, for economical reasons, the system has been somewhat altered within the years. It is now most common practice that lashing starts only on completion of loading operations in a hold. In this case the strapping band is lead through a coil stowed in the second tier from the top, is crossed over the coil to be lashed and is passed through the eye of another coil in the second tier on the other side of the coil to be lashed. The loop is further extended and runs via the eye of the coil which is to be lashed, the latter in such way being kept in position. Additional double lashing is usually performed for those coils which are sitting in a dangerous position such as the external coils in a pyramid stowage.

Where appreciable spaces exist either forward or aft of the face of a coil stowage, the top coils in a multi tier stowage in the area of the brow (face) of the stow, and the coils in the same area in a single tier stow, must be block lashed to prevent the end coils moving out of stow when the vessel is labouring in a seaway. Usually the lashings extend three coils deep into the stow and in the olympic block lashing system there are nine coils per block with adjacent lashings overlapping. For such an arrangement to be effective spaces between coils within the block lashing must be wedged before the lashings are tightened.

(B) Coils Wire Rods

Appearance

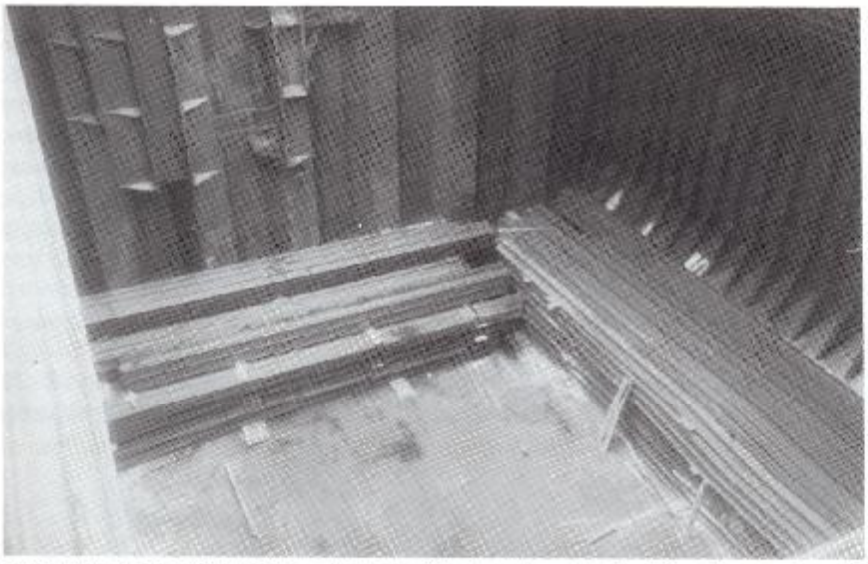
Steel wire rod which is a semi-finished hot drawn product is usually wound into coils with a weight ranging from 0.5 to 2.5 tons average. The coils, or sometimes bundles which are consisting of two or more smaller units, are usually secured by means of a minimum of four steel wires or strapping bands. In case of moderately compressed bundles being secured by strapping bands a loping wire is sometimes fitted over the circumference in order to secure the straps against shifting together during handling. Great care should be taken in checking the securing of the bundles as a single missing or broken securing band may not only cause the bundle to fall apart during further handling but might cause the stowage to become unstable.

In connection with physical damage it is so that in further processing the wire is lead through a number of dies which eventually results in its gauge being reduced to a required diameter. It is not as is sometimes argued, that imperfections such as gouges and score marks to the winding surface will eventually reduce or disappear during the manufacturing process. Any defect will follow the wire through the process, will increase in importance compared to the reduced wire diameter, and will eventually cause the wire to break. Care should be taken not to drag coils over the quay during loading, to use suitable lifting gear, and to avoid steel to steel contact in the stow.

If wire is wrapped one should interpret this wire to be of a special quality which should not become wet and for which physical damage might have a detrimental effect.

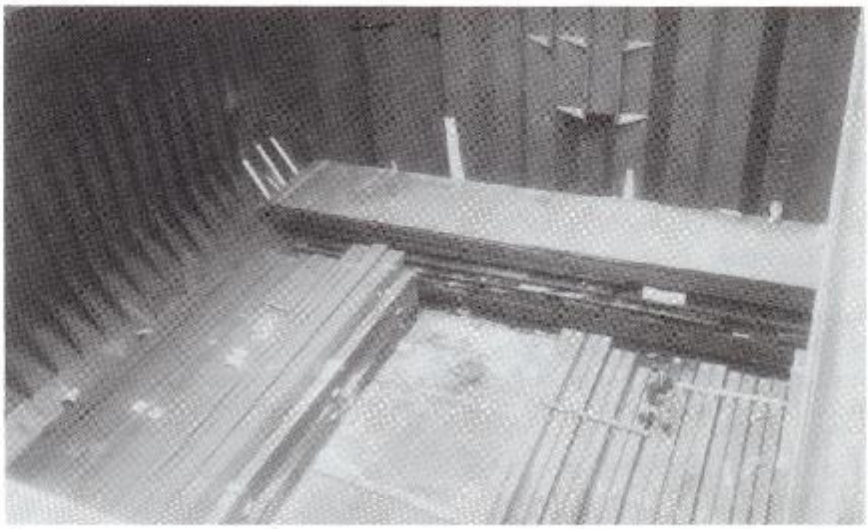
Handling and Stowage

This material is either lifted by means of "cobra wires", which is a steel wire with rope protection woven within the steel strands, or by means of "C" hooks. In case cobra wires are used every sling should only lift one bundle at the time but more slings can be used to lift more bundles.



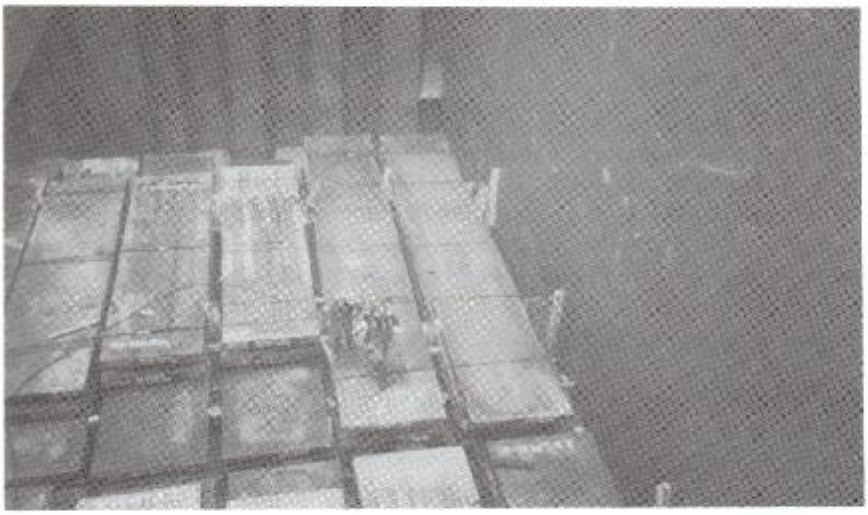
Structural steel in the wings loaded in a fore and aft direction to protect the ship's sides against possible movement of athwartships stowed cargo.

Slabs and long bars in stow.



View of stow of long steel plates athwartships and fore and aft stow of structural steel.

View of Californian method of stowage of steel slabs in a box shaped hold.



Adequate sized coils of steel wire and unitised bundles are generally stowed with their cores in a fore and aft direction in the ship, but there is no objection to perform an alternative stowage. When the full tanktop space is used, it is possible to build up the stow in a fore and aft direction under the hatchsquare and to fill the ship's sides with bundles stowed in an athwartships direction. This system avoids coils from being dropped into the ship's sides but implements a perfectly tight and stable stow so that steel driving plates can be laid on the bundles and forklifts can be landed on top for stowing the bundles in the wings.

In general dunnage wood is used on the tanktop plating not in order to spread the weight but in order to avoid steel to steel contact and for the protection of the wire against contact with any moisture collecting on the tanktop.

In those areas where the wire could come in contact with structural parts of the vessel dunnage wood or plywood is equally used in order to avoid scoring of the windings.

When stowing the bundles of wire rods, which stow should extend from side to side of the compartment, care has to be taken to arrange it in such a way that the coils are tightly and compactly stowed.

Lashing and Securing

In case the stow does not occupy the whole of the cargo space and terminates leaving an empty space, it is essential that it is secured by pulling the outer bundles to the bulkhead. This is generally performed by fitting a wire in front of the rows in an athwartships direction and by pulling this wire to the bulkhead, through the eyes of the coils, in several positions.

Further securing, unless for those coils which are in an unstable position, is not required as wire rod stowages settle considerably during the voyage.

(C) Tin Plate

Appearance

Thin steel sheeting covered with a fine layer of tin, used in the canning industry for food conservation, presents itself for shipment in form of coils and packages.

The coils are usually placed eye to the sky on a strong wooden or steel skid, externally protected by a metal envelope, being secured by means of a number of steel strapping bands. The sheet form tinplate, shipped in rather small square bundles, is contained in steel boxes which are fitted with bearers beneath to facilitate handling.

Handling and Stowage

Tinplate is very sensitive cargo and should always be kept dry whilst physical damage should at all times be avoided. The slightest damage or distortion of boxes of tin plate may result in expensive delays to the fully automated machinery used in further processing. One should also consider, and this applies to the boxes as well as to the coils, that any excessive pressure applied in the stow to the external packing results in deformations and imprints on the plate surface which eventually causes a considerable amount of material in the package to be rejected. Instances where the lashing gang had left bulldog clips lying around on the packages whilst stowing have caused not only deformation to the sheets but have punctured the metal envelopes giving sweat water free access to the contents.

Coils as well as boxes are always to be lifted by means of braided wire slings unless the pallet is made in such a manner that chains or wire slings can be used without coming into contact with the packing material. For this reason, in case more than one box of tinplates is lifted, a spreading device is required in order to avoid squeezing of the top package.

Coils

The coils are usually stowed two or three units high from side to side of the hold when care should be taken that, for the two high stowage, sufficient dunnage is placed in an athwartships direction in order to lock the coils together. The empty space left in the ship's side of non-box type vessels should be chocked off whilst the coils are to be blocklashed by means of steel wires or preferably by means of metal strapping bands. The metal strapping band is easier to apply and due to its nature avoids imprints of the lashing material which might be the case if steel wires are used.

It is common practice for stevedores, providing they have the equipment to do so, to fill the remaining space in the ship's side by means of other suitable cargo.

In case the wooden skid extends beyond the diameter of the coil it is obvious that a non-tight stowage is performed in which case the empty spaces existing between the coils themselves should be chocked by means of wooden wedges and/or timber. The timber stanchions or the wooden wedges, in case the remaining space is smaller, should be linked by nailing a wooden board over the top in order to prevent them from dropping down in case slackness in the stow develops.

Boxes

Boxes of tinplates are stowed in layers from side to side in the hold when care is taken, in spite of the wooden skids provided, to place layers of dunnage athwarthships at least in between every second layer or preferably in between every layer. Failure to do so creates a very unstable stowage as the packages are stowed one on top of the other to form unsecured columns of boxes in the stowage in which case they will chafe and move during heavy weather and cause the packing and/or contents to become damaged as a result of friction. Providing the packages are not too high it is usually possible to extend the dunnage out to the lower wing tanks so that the package in the next layer can rest partly on the adjacently stowed package and partly on the lower wing tank slope plating. This prevents empty spaces in the ship's side which for this type of cargo, in view of the dimensions of the packages and the height to which this cargo is sometimes stowed, should be avoided.

Any empty space in one of the layers should either be bridged by means of dunnage or if the space is too big it should be filled by means of square timber. The toplayer should preferably be complete and the remaining empty space, providing it is reasonably small, should be tommed off whilst all smaller empty spaces between the packages are to be wedged. The wedges are to be linked by a nailed wooden board placed over the top in order to prevent them from dropping down in case slackness develops.

In case a large empty space would unavoidably remain in one or more layers of the top stow it is preferable to start off with a new layer or to fill the space with other cargo rather than to build large timber stools.

(D) Steel Slabs

Appearance

Steel ingots are held at a high temperature until they are transferred to the rolling mill where they are rolled into a semi-finished block of metal referred to as a steel slab. These slabs will eventually be rolled into a steel plate and ultimately form hot rolled steel coils.

The finished slab has dimensions of about 250 mm thick and 2,500 mm wide and is produced in various lengths. Slabs are unwrapped and unprotected against rust. The nature of this material is such that it is impervious to damage.

Stowage, Lashing and Securing

A relatively new system which is now in use for loading steel slabs is the so-called "California block stow" system.

This system consists of loading slabs straight upwards, one slab on top of the other, the different tiers being interlinked with square timber. Olympic lashings by means of metal bands are applied to the top tiers only.

This manner of stowage should only be employed in vessels with box shaped holds. Such vessels have wing tanks which extend for the entire depth of the hold in which case the hold side plating is vertical and terminates at a right angle with the tank top plating — there are no slopes to port and starboard.

Such stowages, in the normal type of bulk carrier, which are not winged out to the ship's sides are unacceptable because they are a potential danger to the ship and her crew. Such heavy weights, as form a slab cargo, are less liable to shift than relatively lighter items of cargo. However, once they commence to move they usually do not stop moving until they have caused considerable and serious damage.

The stowage of slabs in the normal type of bulk carrier should be winged out, over the lower wing tanks, to the ship's sides. Being overlapping and fully dunnaged in every tier.

(E) Plates

Appearance

Mild hot rolled steel plates, either coated or non-coated, are shipped as loose pieces or in bundles being secured by a number of steel strapping bands. It is usually the smaller sized plates which are made up into bundles, some of which are occasionally tarpaper wrapped. The larger sizes, which might present themselves in lengths of up to 12 metres, are generally used in shipbuilding and tank construction whilst the smaller plates will be used as general purpose plates in the fabrication industry.

Handling and Stowage

Large sized plates are usually lifted by means of two sets of steel hooks attached to a spreader bar. For small gauge plates in lengths of over 6 metres the quantity of hook sets is increased and possibly assisted by an end hook at each short side of the plate in order to avoid the lifting gear to shift during manipulation. Care should be taken not to lift plates with different width in the same load as otherwise, apart from the dangerous nature of this operation, the protruding plates will unavoidably become bent at the edge. Closely check whether the weight of the bundle does not cause the plate edges to become bent and should reduce the quantity of plates lifted if this is the case.

In case plates can not directly be lifted with shore cranes, they are brought alongside the vessel by means of forklift. In general a single forklift is sufficient for safe handling of most plates unless we are dealing with small gauge plates or plates in lengths above 6 metres in which case two forklifts should be used. This especially applies to long plates where handling with a single forklift has in many cases led to the plates becoming permanently deformed. Another damage which is not readily visible is score marks to the surface resulting from handling with forklifts which, in case of tankbuilding plates, results in very high re-conditioning costs.

Stowage of steel plates on board a vessel is somewhat contradictory to the ideal stowage of steel plates. Loose steel plates are in many cases stored on the quay without the use of any dunnage resulting in a perfectly level stow. It is obvious that this stowage can not be performed on board vessels in view of the danger of shifting resulting from steel to steel contact and because lifting of the plates prior to slinging would drastically increase the time necessary for discharging. Dunnage is therefore used and dunnaging should be performed with the utmost care. Dunnage wood should be of a uniform thickness., It should be kept in line vertically throughout the stow in order to avoid permanent deformations to the plates and the stow should be kept level. In case longer plates overstow smaller plates, any gaps in the stow must be properly filled by means of either dunnage or square timber so that the next layer lies flat after landing.

Contact with structural parts of the vessel must be avoided as this might result in damage to both vessel and plate. Special care should be taken for plates not to rest on the vessel's side tanks as settling of the stow during the voyage might result in the plate edge being bent upwards.

As a general rule one might say that the use of dunnage should be restricted to the minimum and should only serve the following two goals.:

— to keep the stow level at all times
— to facilitate lifting at the discharging port

Lashing and Securing

Providing the stow is level and no cargo is protruding above the stow securing can be restricted by choking all empty spaces in the top layers of plates by means of wooden wedges and square timber. Any protruding plates or bundles are to be secured against shifting either by means of choking or wire lashing.

(F) Structural Steel

Appearance

Structural steel is shipped in lengths of up to max. 18 metres (60 ft). Structural steel covers all types of steel sections, including channels, angles, beams, flats, rounds and reinforcing bars, which are used in structural work. They are usually shipped as unwrapped single units or in the form of unwrapped bundles.

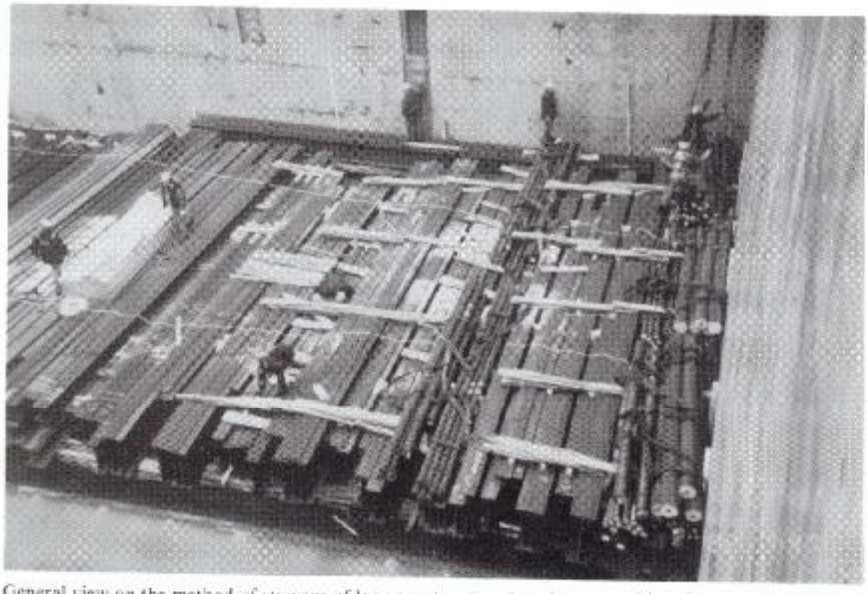
Stowage

Structural steel would normally be expected to occupy the lower stowage position within a ship's hold. The stowage of long structural steel commences by placing dunnage on the vessel's tanktop to hold the goods clear of the ship's metal work. This assists in spreading the weight, protects the ship's structural parts and guards against the goods being contacted by any moisture which might collect beneath the cargo. Flat pieces of timber are used to hold the steel clear of the ship's side frames and tank sides, and under no condition it is admissible to permit the goods to be in contact with any component parts of the vessel's structure. When stowing beams and similar constructional steel, it is important that the webs of beams are kept vertical and that the flanges overlap in an over and under manner, otherwise there is risk of the steel becoming severely distorted. Mixed sizes should be avoided where possible as this can cause gaps in the stow which later may lead to the whole stow collapsing. Furthermore, sufficient dunnage is to be used throughout the stow. The purpose is twofold. The first consideration is to bind the mass of steel into a solid block within the cargo space. The other purpose is to facilitate slinging at the port of discharge. In order to avoid warping or bending of the long lengths of steel the dunnage must be kept vertically in line throughout the stow.

Athwartships stowage of steel beams is best avoided. In particular one should avoid the ends of beams being stowed in the wings of the compartments. If during the voyage the dunnage compresses, the beams may settle, leaving the ends resting against the lower wing tank sides and the middle of the beams unsupported. As a result the beams may become permanently bowed, as well as risking damage to the tanks themselves. Structural steel should be stowed in a fore and aft direction. Notwithstanding this, situations do arise when in order to prevent part of a cargo being shut out from shipment, some structural steel does have to be stowed athwartships. Should this type of stowage be unavoidable, it is recommended some lengths of steel are placed fore and aft in the wings, adjacent to the ship's side frames, before the layer of athwartships steel is loaded.

Lashing and Securing

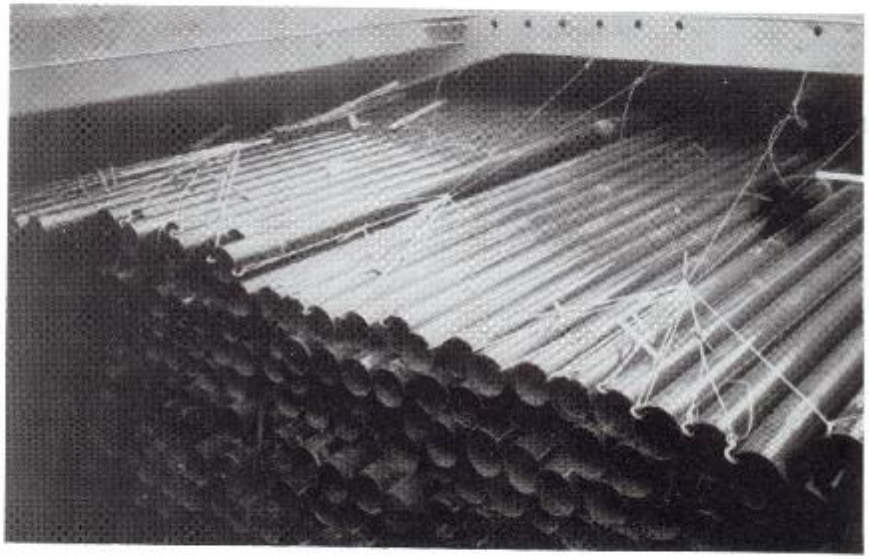
Structural steel, whether bundled or not, can be secured against movement by blocklashing the uppermost tiers of the cargo with strong steel wires. Wedges or square timber can be driven between any gaps. This will ensure that there is no pile up of the steel through rolling of the ship or movement in a fore and aft direction.



General view on the method of stowage of long constructional steel — stowed in a fore and aft direction.

Steel and pipes lashed in stow.

View on stowage of large pipes in the hold of a ship. Method of lashing applied to the top layer of pipes to avoid shifting.



(G) Sheet Piling

Appearance

Sheet piles are hot rolled "Z" shaped profiles in lengths of up to 60 feet. The sheet piles are either shipped loose as single pieces or connected one to another in which they will be described as double sheet piling. The keying arrangement with which one piece is connected to the other is called a finger edge. The sheet piles are driven in the ground and are generally used in instances where a building pit, whether on land or at sea, is to be made and a water and/or earth barrier is to be formed.

Handling and Stowage

Sheet piles, in view of their construction, provide a sufficient lengthwise strength so that they can be lifted at two points. The handling of longer lengths requires the use of a spreader bar not only to avoid unnecessary stress in the piles but also for safety reasons. The finger edge is the most critical part of the sheet pile and damage in this area should be avoided. Braided wire slings have been used to handle this material for a number of years but experience has proved that a doubled chain sling at each end of the pile(s) does not result in damage and provides a safer way of handling.

Single sheet piles are difficult to stow and require large quantities of timber to be used in order to level the stow before a next layer can be stowed. Therefore piles are usually shipped as double sheet piling in which case the stowage, although requiring care, is much facilitated.

The double sheet piles are usually loaded one on top of the other without the use of any dunnage so to form an unsecured hood shaped bundle of 7 to 10 pieces high. Higher stowage would result in the piles sustaining damage through inside bending or cracking. At this stage square hardwood timber is laid all over the stow in an athwarthships direction which is supported by means of stools built up crosswise laid timber in the gap between every load. The quantity of lines of square timber and stools to be used should be guided by the length of the sheet piling.

The next layer of piles is thus stowed on the timber flooring performed.

Lashing and Securing

In view of the considerable work involved in lashing of this type of material, as a result of the large gaps in between the different stack, sheets pilings are usually overstowed by other steel cargoes. In case no other cargo is available one should fill all empty spaces in between the topstow by means of nailed square timber. Preferably block lashing should be performed by means of steel wires which are to be passed under the cargo prior to commencement of the stow.

(H) Pipes and Tubes

(1) Large Diameter Pipes

Appearance

Large diameter pipes are shipped as single units and are used for the transport of gas, fuel or water. Large diameter pipes can be either coated, when the coating may consist of bituminous materials — carbolac — polythene — epoxy paint etc., or non-coated. The ends of the pipes may be plain, provided by bevelled ends for welding purposes, or with collar ends.

Handling

Every type of pipe listed above, will be handled differently and requires in many occasions special loading gear.

Any type of damage either to the outer or inner circumference, whether we are dealing with coated or non-coated pipes, or to the ends is to be avoided. Usually, especially when we are dealing with full shipments, the pipes are stored on the open quay or on wagons and will be directly lifted by means of shore cranes. The use of forklifts should be avoided but in case these should be used utmost care is to be taken and the necessary precautions followed in preparing the forklift as well as the transport so as not to cause any damage. Pipes are lifted either by means of copper or Teflon coated steel hooks attached to each end or by means of adequate belts but never by means of steel wires or chains.

Special care should be taken in case pipes with bevelled ends are shipped, as any appreciable dent — to the bevel will require a piece of pipe to be cut off, in order to perform a new bevel, with high handling and transport costs being involved.

Stowage

Large diameter pipes are always to be stowed in a fore and aft direction in order to avoid shifting during the voyage. The stow of large diameter pipes should always be kept level which involves specialised stevedores and a considerable number of labourers in order to fit the necessary timber stools. Loading starts off from the tanktop on which sufficient layers of flat dunnage or square timber are laid, usually about 3 metres apart. In the case of collar type pipes large sized square timber is to be used in order to keep the collars free from the tanktop. Collar type pipes are kept apart in an athwarthships' direction by fitting wooden stanchions in between the bottomlayer of pipes. In this case the bottomstowed pipes are also properly secured by means of nailed wedges.

The stowage starts at one side of the hold and the remaining empty space at the other side of the hold is filled by means of wooden stools being composed of crosswise laid and nailed pieces of square timber. A piece of plywood cut out in the diameter of the pipe will assist in raising the wooden stool to the level required by the pipe, which will be loaded on top of the stool, will eventually be at the same level of the pipes, which will be loaded in the cantlines. This procedure should be continued throughout the loading operations hence the reason why a number of labourers need to be on standby. Pipes are usually landed on timber being placed on the previous layer and are rolled by manual force into the ship's side.

In case of collar type pipes it is obvious that every layer, in view of the collar, is loaded with the collar alternatively in a fore and aft direction.

In case of longitudinally welded steel pipes it is preferable, if possible, to keep the welding seam free of cantline contact with over- or understowed pipes.

The stacking limitation is regulated in the A.P.I. rules and it is preferable to inquire with and get a written confirmation from the shippers.

Polythene or epoxy coated steel pipes will require padding to be laid in between the pipes, such as straw filled plastic strips, this according to the instructions of the shippers.

In case **deck stowage** is performed, the most common method is to stow the pipes in pyramid fashion over the hatchcovers from side to side of the deck. The key points in this stowage are the bottomstowed pipes on both sides of the deck which should be adequately supported either by a strong bulwark or by pieces of steel beams welded on deck in case of an open railing at the ship's side. In order to keep the stow on deck and over the hatches level, this type of stowage requires large quantities of square timber to be used. In view of the rather complex procedure to be followed for this type of stowage it is required to call in expert advice.

Lashing and Securing

The lashing of under deck stowed pipes is usually performed by chocking all empty spaces in the topstow and by pulling a number of steel wires over the top. These wires are attached to available padeyes in the ship's side deeper in the stow. The lashing wire should be provided with two turnbuckles as the wire, over this length, is bound to stretch much more than the compensating capacity of a single spanscrew.

At the open end of the stow is advisable to secure the topstowed pipes to the bulkhead by fitting a wire athwarthships in front of the layer and pulling it at regular intervals to the bulkhead by a pass

through the inside of the pipe. An alternative system is to hook shackles to the pipes ends and to secure them to the bulkhead by leading a small sized wire through the available eye of the shackle.

Lashing and securing of **deckstowed** pipes consists of chocking all empty spaces in the toplayer and by passing a sufficient number of adequately sized steel wires (usually 18 or 22 mm) over the stow from side to side. The steel wires, attached to an available point in way of hatchcoaming, are passed under the stow of pipes on deck, and are eventually secured together on top of the stow by means of at least two adequate sized spanscrews. The steel wires should be tightened by means of a mechanical or hydraulic jacking system. Chain lashing can be used taking into account that, as for wire lashing, proper protection should be provided in order to avoid damage to the body of coated pipes.

(2) Smaller Diameter Pipes

Appearance

Small diameter pipes, whether loose pieces or in bundles, usually have a protective coating. They may be oiled, greased, varnished, painted or galvanised and are usually 6 metres in length. The ends may be plain, bevelled, or provided by sockets or couplings. In most cases the pipes are shipped in bundles either round or hexagonal shaped and are secured by means of a number of flat metal steel strapping bands. Occasionally pipes will be seen to be stowed in wooden or protected steel racks. In this case we are dealing with drilling pipes or joints for the oil industry and special care is to be taken in handling. Special types of pipes such as stainless steel pipes or pipes with very small diameters are usually shipped in cases.

Handling and Stowage

Smaller sized pipes and bundles are usually brought alongside the vessel by means of forklifts and are very susceptible to physical damage such as bending if inadequately transported or lifted. Lifting is preferably performed by means of protected steel wires or by belts in order to avoid score marks to the periphery of the pipes.

In connection with the pipes destined for the oil industry, commonly known as "joints", stowage and handling requirements should be obtained from the shipper. Some of these pipes, namely those containing a high chrome percentage, should not come in contact with carbon steel in which case non-protected forklifts and crowbars can not be used. Also the lashing wires should be protected as some of these pipes can be bacteriologically contaminated even through contact with dunnage wood.

Small sized pipes, in view of their frail nature, are usually topstowed and should preferably not be overstowed by any other cargo unless it is very light.

A perfect stowage, with the exception of the hexagonal shaped bundles, is usually not possible in view of the round shape of the majority of the bundles offered for shipment the aim should be to perform a stowage which is as level as possible. A sufficient quantity of dunnage should be fitted between in the layers in order to facilitate the discharging operations and also in order to avoid score marks whilst pulling the lifting wire away after landing.

Lashing and Securing

Securing is performed by filling all empty spaces in the topstow by means of wooden wedges or square timber. Any incomplete layer (always to be avoided if possible) should be wire lashed to the ship's side. Securing with "flat metal" strapping bands is very convenient for this type of material.

TIMBER PRODUCTS

Timber measurements are the most complicated and laborious of all the various measurements in use for shipping purposes. The unit of measurement in use in the U.K., North European countries,

etc., is "a standard" of which there are many varieties, bearing no relation one to the other as shown below. In North America the unit of measurement is the 1,000 board feet; in France, Italy, Belgium, etc., the unit is the "Stere", equivalent to the cubic metre of the metric system, while "Petrograd standard" is almost exclusively used in the U.K. — wholesale transactions in battens, boards, deals, planks, etc., being on that basis.

Timber cargo may consist of a "composition" of logs, deals, battens, small batten boards, small boards, scantlings, slatings, and laths — the latter two being usually in bundles. A good composition for cargoes is two-thirds deals and battens and one-third boards, and the vessel with clear holds should stow this at about 225 cubic feet per standard.

If the cargo consists of more boards and contains quantities of small boards, slatings and laths, the stowage factor would be subsequently higher. For example bundles of laths stow at about 320 cubic feet to the standard.

By a custom prevailing in the Baltic wood shipping countries a shipper is supposed to have a margin of one-sixteenth of an inch in cutting his planks. This margin is very often exceeded and may be found to be as much as one-eighth which the ship carries free.

Newly cut timber, being full of sap, is naturally much heavier than timber cut the previous season and the vessel is not able to carry so high a deck load as with old cut timber.

If the vessel is to load a cargo of new cut timber, with the excessive marginal cut, and the "composition" is a poor one the intake would be more than 5 per cent less than her ordinary capacity, and it is impossible for a ship owner to estimate what his ship will load. Experience in a 1,200 standard ship has shown the intake to be as much as 70 standards below capacity under these circumstances.

The average weight of Baltic sawn wood is about 2½ tons to 3 tons to the standard.

The best type of timber carrying vessel is that which has a large beam in proportion to draft with a minimum number of obstructions in the hold, such as stanchions and web frames.

The vessel will carry a "good cargo" or otherwise according to whether the Charter provides for a proper proportion of short lengths, laths, pickets, etc., to be provided for filling broken stowage and that such be delivered alongside when the loading commences. Full stowage below decks adds to the amount of deck load which can be carried.

Receiving

In some timber loading ports, the shippers demand receipts for cargo when brought alongside by raft of lighter and before it is received on board.

As part of all such cargo may be lost through drifting away, sinking, fire, or even by theft, the risk involved in the granting of receipts for cargo before it is actually shipped is substantial and, in so far as the receiver of the cargo at destination is concerned, the customary noting of protest, following loss of cargo from alongside avails nothing — at the same time, the noting of protest where cargo is so lost is necessary in the interests of the owner.

Unless the charter-party specifically provides for the issuing of Bills of Lading so delivered, no documents should be signed until the cargo is actually on board.

Lumber Bills of Lading not infrequently are presented with a clause to the effect that the lumber is "free from splits and shakes" which term is often taken to mean that the goods have not been split or damaged by rough handling before shipment. "Splits and shakes" when present are in the main, due to latent conditions, these defects developing as the wood dries.

From this it is evident that, with such a clause in the Bill of Lading even if the cargo be quite free of such defects when shipped, the ship may be liable for claims for deterioration which has developed along natural lines during the voyage.

Bills of Lading should therefore be endorsed "not responsible for condition or quality".

Slings

While the use of chain slings is permissible for handling deals and battens, rope or webbing slings should be used for boards, box boards, slats, laths and similar classes of timber as well, of course, as with prime woods. Slings with spreaders will be required for packaged timber.

Damage to Account of Charterers

Careful note should be made of any damage sustained by the ship or her fittings during the loading and or discharging. All such should be reported by letter to the charterers or their local agents. When loading heavy logs careless lowering or rough dragging of logs when discharging, frequently results in the buckling of frames, damaged pipes, cement chocks, etc.

Packaged Timber

Sawn timber is almost invariably packaged or unitised. These packages may vary in length and size, depending on the handling equipment, consignee, etc. Specialised handling equipment, such as straddle carriers, may be used, and special terminals provided for the handling and stowage of this type of cargo. Where packages consist of sawn lengths of varying length, it is normal practice to square off one end to give a flush face. Where such packages of varying lengths are made up, and where the holds of the vessel are not suited to cargo made up in this way, there may be a great deal of wasted space.

Packaged timber square at both ends are suitable for deck stowage which must be tight and compact. Uneven ends may be carried within the stow, but the perimeter must consist of square end packages. Athwartships stow of packaged timber is not permitted at the perimeter.

Deck Loads

When deck loads are carried, which is more frequent than not, the upper deck should be assisted to carry its load by hard wood wedges driven between the deck beams and a plank placed athwart on top of the timber cargo below, and adequate compensation should be made in the same means for any stanchions which have to be removed — the practice of removing stanchions should be restricted as much as possible.

When dunnaging under a deck cargo of timber, use rough 25 mm boards placed diagonally 750 mm to 1,000 mm apart, so as to distribute the weight evenly over the beams, etc., and avoiding buckling deck plates.

Stanchions to support deck loads at the side should be of sufficient length as to extend not less than 1,200 mm above the finished level of deck cargo, to permit manropes being fitted to same for the protection of the crew. Stanchions, which usually are supplied by shippers as part of the cargo, should be spaced about 2,500 mm to 3,000 mm apart and be inclined inboard.

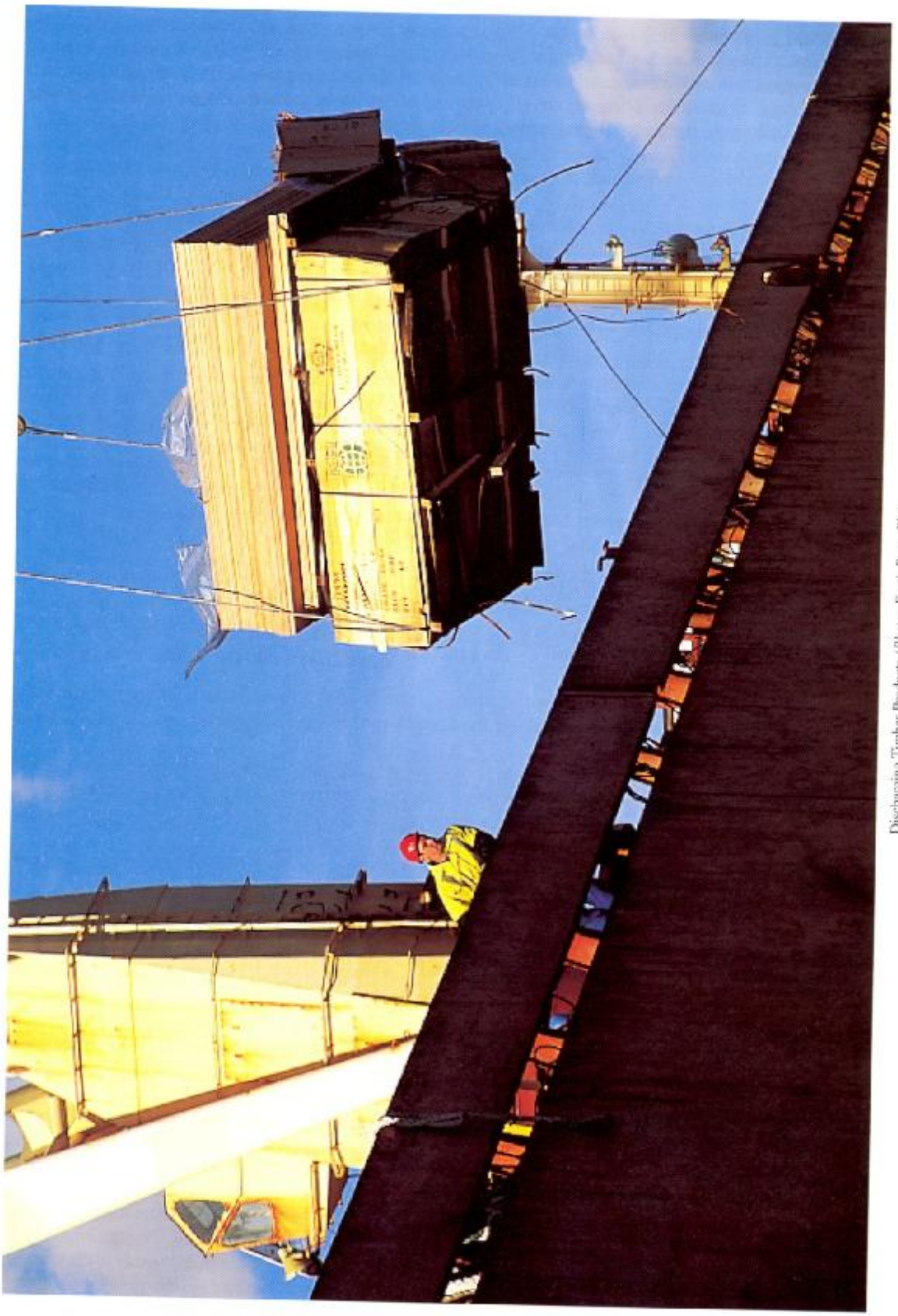
Chain lashings are probably the most effective lashing method for deck cargoes of timber. Certain systems are designed around webbing made of man-made fibre.

Lashings are usually shackled to eye plates or wing bolts riveted to the part of the sheer strake, extending above the deck stringer bar, or to the deck, spaced 2,500 mm to 3,000 mm apart; each length of chain long enough to meet its mate in the middle line, where the two free ends are connected to a heavy turn buckle and slip hook by which the chains are set up.

Arrangements should be made to jettison the cargo, normally by senhouse slips attached to the lashing chains. If forced to jettison, this evolution is highly dangerous and should be precluded by constant vigilance and attention to the lashings during passage.

Regulations and Recommendations

Various countries have regulations, recommendations and codes of practice for the carriage of deck cargo of timber. These should be carefully examined and any appropriate regulations carried out. Typical of these include the British Merchant Shipping (Loadlines) (Deck Cargo) Regulations 1968; IMO Code of Safe Practice for ships carrying timber deck cargoes, 1991. This publication is an update since the first publication in the early 1970s and incorporates new systems and techniques learnt from casualties during the interim period and allows for the larger and more sophisticated ships that have come into service.



Discharging Timber Products *(Photo: Forth Ports Plc).*

Pit Props

Pit props are short, straight lengths of timber, mostly fir, debarked, and are exploited in large quantities from such countries as Scandinavia, Baltic Russia, etc.

The props vary from 75 mm to 250 mm in diameter and are shipped in standard lengths, 3.5 ft, 4.0 ft, 4.5 ft, 5.0 ft, etc., up to 11.0 ft, which is about the maximum. Crooked or split props should be rejected. The unit of measurement in the pit prop trade is the English (cubic or pile) "fathom", i.e. 6 ft × 6 ft × 6 ft = 216 cu. ft, freight being payable on that basis.

A fathom of props varies considerably in weight, from 2.5 tonnes or less to on occasions, as high as 4 tonnes, such depending partly on the class of timber but more particularly on its moisture content. When receiving from wharfs or railway trucks, the timber being relatively dry, approximates for less weight per fathom, when the props are brought alongside in leaky barges, or are rafted alongside, the weight per fathom is consequently high.

Pulp and Paper Products

Paper

Paper is made from vegetable matter reduced to pulp, such as wood, esparto grass, flax refuse, straw, jute, also rags. Spruce, Balsam, Hemlock, Cottonwood and other timber are used.

Paper is usually in shipped rolls, the ends of which are, in some cases, protected by circular discs of wood; in other cases the rolls are simply wrapped with thick paper with extra layers over the ends.

Rolls of paper vary from 500 mm to 2,135 mm in length, i.e. width of paper, while the diameters vary considerably averaging in mixed shipments to about 900 mm.

The main categories of paper consist of newsprint, printing paper and kraft. All are extremely sensitive to mechanical damage particularly at the flat ends of the rolls. Any such damage will reduce the effective width of the paper, and may make it totally unsuitable for use in the printing process. Flattening of the reels and distortion of the core may make them useless for modern high-speed printing presses, and result in heavy claims for damage.

Holds must be properly prepared before loading. They must be clean and any sharp protrusions should be cushioned in the best possible manner to avoid damage to the paper. Ventilator or fan openings must however be left free as air circulation is very necessary to avoid condensation damage to the paper.

Paper reels must be stowed in several ways.

on end;
on the bilge or roll, athwartships;
on the bilge or roll, fore and aft;

or any of these in combination.

The chosen method of stowing may be determined by several factors, namely the nature or type of vessel and its equipment, the sizes of the reels to be loaded, the facilities available at the loading or discharging ports, and possibly any special requirements of the consignees.

Stowage of reels on end in the vertical position enables the use of special handling equipment which has been developed for the purpose of loading and discharging this cargo, such as:

The Jensen Sling, available in different versions for lifting between two and eight reels. The Jensen Sling is a semi-automatic lifting device developed for the purpose of lifting paper reels in the vertical position. Operation is reasonably simple and labour is required only to guide the device into the hoisting position. On landing the load is automatically released.

The vacuum lifting device which is available for lifting reels in pairs of six, eight, ten or more simultaneously. Vacuum handling, however, makes certain demands on the package, and the person in charge must be familiar with these and satisfied that all requirements are met. Furthermore, for safety reasons, personnel should not be allowed to remain in the hold or on

the sector of the quayside where handling with vacuum attachments is taking place. It may be necessary to fence off the working area.

The Core Probe is another semi-automatic device, which is applied in the reel core and expands to grip the walls of the core when it is lifted. Core Probes may be used with frames or spreaders to handle anything up to 20 reels in one lift, depending on the weight of the reels and the handling capacity of the crane available.

If paper reels are to be discharged conventionally by putting machines into the ship's holds, it is important that a "break in" area be provided in the square of the hatch to facilitate discharge. This may best be done by stowing preslung reels on the bilge or roll in a sufficiently large area to enable a clamp truck to manoeuvre.

Rolls of paper should be stowed solid and well chocked off to avoid movement when the vessel is at sea. If consideration of space renders desirable the stowing of the top tier on its side or bilge over paper stowed on end, it is essential that every precaution be taken to ensure that this top tier is adequately chocked off. If the vessel is stiff or normally has a violent motion in a seaway, providing other suitable cargo is available, this form of top tier stowage should be avoided. It is extremely difficult to chock the top tier on its roll over paper stowed on end, and serious claims have resulted in such stowage breaking loose.

In end holds, the greatest care should be exercised to ensure that the platform on which the ground tier of rolls is stowed is both level and firm. When a full cargo of paper is carried, the most satisfactory way of doing this is by building a series of platforms (or bridges) of suitable width to take the diameter of the larger rolls, the platforms themselves resting on substantial bearers.

All stanchions, ladders, etc., should be well covered with burlap or other protecting material to avoid chafage of rolls; and dunnage should be thorough throughout, to prevent movement of the rolls, particularly so if the cargo does not entirely fill the hold or compartment.

Slings made of webbing (man-made fibre) or soft rope should be used, and utmost care taken to avoid chafe and damage while handling and lifting. Loading or discharging of paper rolls by swinging derricks should not be resorted to owing to the difficulty of keeping rolls from banging against hatch coamings, the ship's side, etc., which tends to destroy their shape and inflict other mechanical damage.

The dragging of rolls from wings or ends of compartments to the square of the hatch should be prohibited. The use of cargo hooks, crow or pinch bars should never be permitted when handling paper.

The amount of broken stowage with a cargo of paper is very considerable. The smaller rolls may, with reasonable care, safely be utilised for "fillings" in the wings etc.

Rolls of paper vary considerably in their moisture content. In a totally enclosed space therefore (e.g. a closed box container) the migration of moisture might take place, i.e. sweat.

When rolls of paper are stowed on their ends, adequate space between tiers may be needed to access the mechanical handling equipment. In this case a well proven method of restraint may be provided by inserting pneumatic dunnage bags.

Pulp

Wood and paper pulp is shipped in compressed bales both as "dry" and "wet" pulp. It is made from various kinds of timbers, and is shipped in large quantities from the timber areas of the world, e.g. Scandinavia, Canada, British Columbia, U.S.A., etc.

Wood pulp is very liable to damage and contamination by dirt (particularly fibres) or the remnants of previous commodities in a ship's hold. During handling it must be kept clear of any contact with ropes, etc., and should be loaded and discharged with wire or chain slings. Remnants of the previous cargo (and particular grain) should be carefully removed and the space cleaned before the commencement of loading pulp.

Bales of pulp may be unitised with wire banding securing the bales. It is very often permissible and acceptable to lift by this banding, and some proprietary equipment is designed so to do.

It is advisable, however, that certificates of strength be provided for the banding.

Timber: Terms and Definitions, etc.

Battens

A sawn piece of timber from 150 mm to 180 mm wide and not less than 100 mm thick. Stow at 220/225 cu. ft per Standard.

Battens, Small

A sawn piece of timber under 150 mm wide and less than 50 mm thick. Stow at 230/240 cu. ft per Standard.

Battens, Ends

A sawn piece of timber under 2,500 mm in length.

Baulks

A large heavy beam of timber — hewn or sawn.

Boards

A sawn timber 50 mm thick and under, any width. Above 150 mm stow at 230/240 cu. ft per Standard and 250/260 cu. ft below 150 mm thick.

Deals

Sawn timber no less than 50 mm thick and 230 mm or 250 mm wide. A Petrograd "Standard Deal" is 1 piece, 75 mm × 280 mm × 1,830 mm. A "Slit-deal" is 30 mm thick. A "Whole deal" is 15 mm thick. A "Hundred deals" = 120 pieces, 150 mm × 75 mm × 280 mm × 165 cu. ft.

Flooring

White or yellow boards, chiefly 19 mm to 38 mm thick, planed, either square edged or tongued and grooved.

Laths

Thin narrow strips of wood for the building trade (plasterers' laths). The usual dimensions for sawn laths are 25 mm to 32 mm to 8 mm. American laths vary from 6 mm to 12 mm thick, different sizes being known as "Lath", "Lath and half", and "Double lath". Laths stow about 320 cu. ft to the Standard.

Lumber

The term usually applied in the U.S.A. to timber.

Log

A heavy piece of timber either round, hewn or sawn. Logs cut lengthwise are known as cants.

Pickets

Sharpened stakes — shipped in bundles.

Pit-props

Are short, straight lengths of timber mostly fir, denuded of the bark (see "Commodities").

Plank

Any piece of sawn wood of substantial thickness and length.

Prime-wood

This expression applies to the more valuable classes of timber, such as oak, mahogany, beech, whitewood, etc., used in the furniture and allied trades.

Railway Ties

See Sleepers, below.

Rickers

Light poles varying from 6,000 mm to 16,750 mm in length used for scaffolding, making builders' ladders, etc.

Scaffolding

Light poles of varying length (see above).

Shingles

Thin slats of wood used for roofing — one end being thinner than the other. Shipped in bundles.

Shooks

A complete set of staves (body and head) for making casks or cases ready for assembling. Shipped in bundles usually but occasionally loose.

Slats

Strips of wood used in the manufacture of light cases, usually of deal — shipped in bundles.

Sleepers

English sleepers usually are of Baltic fir, in other countries they are composed of the cheaper hard-woods such as oak and jarrah, the latter being very suitable for the tropics.

Staves

See Shooks, above.

Waney Timber

Pieces of timber which have round edges — either hewn or sawn square leaving part of the round on edges.

Wood-goods, Heavy

"Any square, round, waney or other timber, or any pitch pine, mahogany, oak, teak or other heavy wood goods, whatever . . ."

Wood-goods, Light

"Means any deals, battens or other light wood goods of any description"; and for deck cargo purposes the following is added: "Each unit of goods must be of a cubic capacity not greater than 0.42 cubic metres".

Cars

At time of shipment cars should have their petrol tanks drained. Cars carried with fuel in their tanks may be subject to IMDG regulations.

When cars are being manoeuvred on to vehicle decks, full mechanical ventilation must be utilised to remove fumes.

Only properly authorised and trained drivers should be employed. They should be issued with clean overalls to avoid soiling the upholstery.

Loading ramps should not be so steep as to either cause risk of damage to vehicles with small ground clearance or to cause engines to labour unduly when cars are ascending the ramps. Speed of loading/discharging will be adversely affected if the angle of the ship-to-shore ramp is too severe. A better than one-in-ten slope should be achieved if possible. Change of slope (from ramp to deck, for example) should not exceed 7 degrees. Decks should be properly treated with a good non-slip compound on vessels where the cars are not firmly lashed down.

Cars arriving for shipment under their own power should be checked for moisture, snow, mud or other debris that may be adhering to the vehicle, and affect it in subsequent transport. Any such dirt might cause the car to be subject to quarantine regulations of the country of destination.

REFRIGERATED CARGOES

Preamble

Today refrigerated cargoes move in very substantial quantities. Many reefer vessels are specialist carriers almost wholly dedicated to the carriage of refrigerated cargoes under a variety of temperatures.

In recent years the tendency has been for the carriage of cargoes under hard frozen conditions to be at significantly lower temperatures than hitherto, and this is particularly so in the carriage of fish, the movement of this commodity now being a significant feature of refrigerated cargoes.

The introduction of ISO containers has proved to be of outstanding value in ensuring good out-turn of cargo under refrigerated conditions. Their use helps protect the cold chain from producer to consumer. It significantly reduces the physical handling requirements, with the attendant possibility of dirt and contamination. Conventional break bulk shipments may be handled 15 times between leaving the freezing works and arriving in the market place. The container also reduces opportunities for pilferage.

However, notwithstanding the above, for the foreseeable future refrigerated cargo will continue to be carried extensively in specially designed, pallet efficient, reefer ships. The size of port, development of trade, the seasonal nature of many refrigerated commodities (e.g. fruit), all contribute to the choice of transport mode to be employed.

Introduction

This section deals with general principles of refrigeration as they affect cargoes. For recommendations about the carriage of individual items please see the relevant sections in Part 3.

As a general rule, refrigeration implies a reduction of the temperature below the ambient air temperature. With notable exceptions, e.g. bananas and seed potatoes, the temperatures concerned are usually between about 40°C and zero.

Refrigerated cargo is not the same as frozen cargo; in the latter, temperatures are usually about −18°C or lower.

An increasing amount of cargo is being carried under temperature control and knowledge of the principles behind this form of carriage is essential. In many instances, the shippers will give specific carriage instructions, but there are some general principles that apply to all temperature-controlled cargoes.

Many reefer vessels are dedicated to the carriage of temperature-controlled cargoes, and these may often have a reefer engineer aboard with specific responsibility for the cargo. Increasing amounts

of cargo are also being carried in temperature-controlled containers with self-contained refrigeration units. Although most of these are carried on dedicated "mother ships", some may be carried as deck cargo on general duty vessels. Finally, increasing numbers of containers are being carried as boxes to be cooled by provision of cooled air from the carrying ship, e.g. "port hole" containers.

The Reasons for Temperature Control

Prevention of Damage by Microorganisms

Almost all organic matter is constantly under attack by microorganisms such as yeasts, moulds or bacteria. Microorganisms, like all living things, require adequate moisture and an appropriate temperature to enable them to grow. So far as temperature is concerned, in general the higher the temperature the faster the rate of growth, for example, the rate of growth of almost all microorganisms doubles for every 10°C increase in temperature. Equally, the rate of growth halves for each 10°C reduction in temperature.

There are upper and lower limits to this effect. For most microorganisms, the rate of growth at temperatures below zero is very small while most will not grow at temperatures above about 45°C.

Thus, carrying an organic cargo at lower temperatures will tend to slow down the rate at which it can be damaged by microorganisms because they grow much slower at the lower temperatures.

Prevention of Changes in the Cargo

Many cargoes are alive. The best known examples are fresh fruit and vegetables, but there are many other examples, e.g. most cereal grains and some timber. As a part of their life processes living organisms respire, i.e. they take in oxygen and give out carbon dioxide in exactly the same way as animals. This process creates energy to drive the life processes within the organism and produces surplus heat as a side effect.

This is a second reason why some cargoes must be refrigerated, since if the surplus heat is not removed during the voyage it may produce adverse effects on the cargo. If the heat of respiration is not removed from a cargo of fresh fruit, the increased temperature within the cargo may induce chemical changes in the composition of the fruit which, in turn, will permit physical changes that may cause the cargo to deteriorate. For example, pears carried at ambient temperature will warm up, thereby increasing their rate of ripening. As they ripen, they become softer and are more prone to bruising, irrespective of how well they have been packed and stowed.

Gas Evolution and Ventilation

Living cargoes give off gases as a consequence of their life processes. Many cargoes absorb oxygen from the air in the hold and give out carbon dioxide. All fruits and vegetables do this and so do most cereals. Undressed timber, i.e. logs from which the bark has not been stripped also produce carbon dioxide.

In unventilated holds, the amount of carbon dioxide can build up to lethal levels, and there have been cases of seamen being suffocated by entering such holds without breathing apparatus.

Fruits and some vegetables also produce a gas called ethylene during ripening. This gas is a natural plant hormone, and as such can induce ripening in other fruits and vegetables that may be stowed in the same hold. If adjacent holds or compartments are interconnected by a common system of air ducts, then the production of ethylene in one compartment can induce ripening in the others.

Ventilation

Therefore, it is essential for refrigerated cargo holds to be properly ventilated. The purpose of the ventilation is to replace the cargo space air with fresh air. This sweeps out most of the ethylene and

delays or prevents the early ripening of the cargo. Ventilation also reduces the level of carbon dioxide within the hold often with beneficial effects on the cargo. It is difficult to measure ethylene directly in the air within a cargo hold, so it is usual to measure the level of carbon dioxide and to use this as a guide to the ethylene level. The carriage instructions for fruit and vegetables should include a value for the maximum acceptable level of carbon dioxide in the hold air.

Some cargoes, especially certain fruits, can benefit from an increased level of carbon dioxide within a hold. Carbon dioxide levels above a certain value actually slow down the respiration of the fruit and delay the onset of ripening. It is the composition of the air that influences the cargo and not just the level of carbon dioxide. The effects of both oxygen and carbon dioxide levels must be considered when deciding how to carry a particular cargo.

In general, a reduction in the amount of oxygen present tends to retard the rate of respiration and hence prolong cargo life. There is usually 21% oxygen in air, and this level needs to be reduced to about 10% before any real effect on the rate of respiration is seen. Since rate of respiration is dependent on temperature, it follows that the lower the temperature in the cargo the lower the oxygen concentration can fall without causing other problems. Fruit and vegetables may also be sensitive to low oxygen concentrations and to low temperatures, which of themselves can cause physical disorders, leading to quality deficiencies.

An increase in the carbon dioxide level is beneficial to some fruits since it tends to delay the onset of ripening. The air contains only some 0.034% of carbon dioxide, and relatively small amounts above this can be beneficial. The addition of only a few percent of carbon dioxide to the air in the hold can have a marked effect oil respiration, leading to prolonged life for the fruit. However, if carbon dioxide levels rise too high then damage to the cargo may follow.

Recently, methods have been worked out for some fruits to be carried in gas-tight holds, in which an atmosphere has been generated with specific levels of carbon dioxide and oxygen. These so-called controlled atmospheres confer appreciable benefits on the cargo in terms of maintaining its quality in the same condition as it was loaded. The actual levels of carbon dioxide and oxygen required for a particular fruit may differ widely from one variety to another. For this reason precise carriage instructions should be given by the shippers for any fruit or vegetables to be carried under controlled atmosphere.

Refrigeration and Moisture

As air is cooled, so its capacity to hold moisture becomes lower. This is usually seen in refrigeration circuits by the ice which forms on the cooler coils. In a closed circuit where cooling air is recirculated through holds without any access to the outside, there tends to be a drying effect on the cargo. If fresh fruit is exposed to constant cooling air, e.g. an apple placed in a domestic refrigerator, moisture will be extracted from the fruit by the cooling air. This leads eventually to deterioration of the fruit which becomes dry and wrinkled as it loses moisture. Most cargoes are protected to some extent by their packaging, but even so the drying effect is very real and can be the cause of damage to refrigerated cargoes.

Ideally, such cargoes should be carried at a controlled humidity as well as a controlled temperature. Unfortunately, this is technically quite difficult to achieve on board a ship, and it is not usual to attempt humidity control. Ventilation with fresh air alleviates the potential problem to some extent, and this is usually all that can be done.

Ventilation and Stowage

Proper stowage of cargo destined to be refrigerated and hence ventilated is most important. Most cargoes are packed in boxes or cartons often with inner wrapping. While this may protect against drying and physical damage, the packaging tends to restrict the free flow of cooling air around the cargo. Thus, stowage becomes extremely important in facilitating the flow of air.

Some cargo is loaded already on pallets, and this is ideal for proper air flow. Where boxes are loaded as individual pieces, it is important to ensure they are placed on dunnage or battens, leaving adequate ventilation channels between adjacent blocks. If cartons have ventilation holes pierced in

them, then these must be placed "in register" to allow free entry of air. Stowage should be "box on box" and not in "brick form".

Care should be taken to see that the cargo is stowed in accordance with the air flow within compartments, and this will depend on the way in which the cooled air enters each compartment. There are many different types of refrigeration system in use, depending on the design of the ship and the stowage of reefer cargoes must be individually decided by the Master, depending on circumstance. In general, boxes and cartons should be stowed with their long axes all pointing in the same direction. Most reefer have vertical air flow within compartments, and in these cases it is advisable to place kraft paper or other material across the air vents that are not covered by the cargo, to avoid short circuits of the air flow.

Frozen Cargo

This is cargo that has been deep frozen prior to loading. Such cargo should be at −18°C or lower. The task of the ship is to keep the cargo at the same temperature as it was loaded, i.e. maintain deep frozen conditions. In some instances there are legal requirements to carry cargo at temperatures below a certain value. These will be dealt with under the appropriate alphabetic heading in Part 3.

Deep frozen cargoes are not living, and do not respire or produce heat, so the task of the refrigeration system is much simpler.

Fresh Produce (Fruit and Vegetables)

In general, fresh produce is usually carried under temperature control and the provisions of that section apply to these cargoes. This section further amplifies some of the essential characteristics of fresh produce.

Fruit and vegetables are living and so respire, taking in oxygen from the air and producing carbon dioxide. As noted in the section on refrigeration, this process also involves the production of heat, hence the need for temperature control.

It is customary for shippers to produce written carriage instructions, and this section merely lays down general guidelines for background.

For very short voyages of no more than a few days (3 or 4), fruit picked at the right time, i.e. that is not already ripe, can be carried without refrigeration.

All fruit and vegetables must be properly ventilated even if carried at ambient temperatures.

Fruit should not normally be carried in ships not fitted with mechanical ventilation systems. It is possible to build air shafts into a stow using dunnage, but this is not really satisfactory and is not recommended.

Fruit should not be co-stowed with any other cargo that might pick up taints, e.g. flour, tea, coffee etc.

Carriage temperatures for fresh produce fall into two clearly defined categories. Produce that is tolerant of low temperatures is carried in the temperature range between −5°C and +0.05°C. Note that most vegetables consist largely of water, and because of this they have a freezing point closer to zero than most fruits. Thus, carriage temperatures for vegetables must not fall below zero.

Carriage is effected at temperatures near to the freezing point of the produce, taking into account the sensitivity of the temperature control equipment to avoid freezing part of the cargo. Typical examples are apples, pears, cherries and kiwifruit, and most vegetables.

Some produce is more sensitive to low temperature carriage, so must be carried at higher temperatures, which represent a compromise between the harmful effects of low temperature (chill damage), and the beneficial effect of low temperatures in retarding ripening and alleviating micro-biological damage. Typical examples are bananas, avocado, pineapple, melons, aubergines, ginger, marrow and squashes.

Cargoes of individual produce that may be very sensitive to lower temperatures will always have written carriage instructions from the shippers. Such goods should not be accepted without such instructions. Examples are bananas, plantains and pineapples.

Some fresh produce can be carried without refrigeration, but with special ventilation requirements. Examples are onions and potatoes. The method adopted will depend on the length of the intended voyage, ambient conditions and the required shelf life.

Receiving Cargo

Ideally cargo presented for carriage under refrigeration should be pre-cooled to the carrying temperature since normally the vessel or container is only provided with sufficient power to deal with heat leakage and the modest amount of heat generated by living cargoes. Even with full use of reserve power the actual freezing of say a large tonnage of meat at killing temperature would involve a completely unacceptable delay when loading. Thus perhaps the prime consideration when receiving cargo for refrigerated carriage is to see that it is at the correct temperature. There is always liable to be a slight rise in the temperature of the surface occurring during trans-shipment which the ship can well take care of provided the internal bulk of the packages is at the correct temperature. Spear thermometers are available to determine this. It may even be necessary to drill holes into frozen meat to ascertain the actual bone temperature. Where the thin flanks of carcass meat are soft they must be re-frozen before storage or badly distorted carcasses will result on discharge. Care should be exercised in such cases to see that the soft carcass has not just received a cold blast to freeze the outside flank which will now appear in a good hard condition whilst the inside is still warm hence drilling for the bone temperature. Blood-stained shirts will indicate that a carcass has at least partially thawed since initial freezing and should be considered with suspicion. Again if soft or wet carcasses are stowed in this condition they may well distort, nesting one into another and blocking the necessary air flow. If wet from rain these may freeze together, resulting in considerable damage when prised apart on discharge. Similar conditions can arise with frozen cartons, which must be clean, dry and free from frost at time of loading. Chilled cargoes are of less concern in this respect, but owing to their more sensitive nature great care and inspection is called for during receiving and stowage. Most packaged fruits, and vegetable cargo will be presented pre-cooled but must be carefully examined for the odd warm or over-ripe lot which should be rejected. The general condition noted and the space sealed and the carrying environment reached as soon as possible. If as sometimes occurs a fruit cargo is presented for loading at orchard temperatures, the ship may have to undertake the cooling down to the correct carrying temperature. This facility must be requested by the shipper in writing, or the Bill of Lading claused accordingly. Once agreed, the cooling down must be carried out as quickly as possible. However, very rapid cooling cannot be achieved since the incoming cool air must not be at or below the freezing temperature of fruit. Maximum air circulation must be possible throughout the stow, with adequate intermediate dunnage and battens to assist the cooling process. If the stow does not cover the whole deck encompassing all the air delivery outlets then those not covered must be temporarily blocked off to prevent short cycling of the air. Similar considerations concern deep frozen cargoes. When close stowing regular shaped cartons it is important that none are significantly above the carrying temperature, since in a close stow the cool circulating air will not be able to penetrate and reduce the temperature of any one package or group of packages.

Preparation of Spaces to Receive Cargo

The generally sensitive nature of refrigerated cargo requires very careful preparation of the space to receive it. Cleanliness is obviously of great importance particularly with foodstuffs. The space must be free of odours and microorganisms and may well require fumigation. The introduction of ozone will deal with remaining airborne smells but lingering ones which have been absorbed by the insulation or dunnage may well require the removal and renewal of the affected portions. Fans should be run in both directions to clear smells and dust, etc., from the air trunking. Bilges and scuppers must be clean, tested and U-bend vapour traps sealed with brine to prevent cross taint between compartments. Adequate and clean dunnage must be provided or, if already in place, inspected to ensure an adequate air circulation under, around and through the cargo as required. Old dunnage may well get moved during discharge with the possibility of blocking air circulations of some sections. This must be then repositioned. Extra dunnage may be required for adjacent compartments which are of widely varying

temperatures, e.g. over double bottom oil tanks liable to steam heating; chilled cargo compartments over deep-frozen holds. Thermometers, gas sampling points, fire detection and extinguishing equipment should be carefully checked and inspected. Inspection should also be made of any pipes passing through the space, particularly their joints, for any sign of leakage and tested if in any doubt. Closing arrangements, locker doors and hatch plugs should also receive careful examination. The space can then be cooled down to slightly below the carrying temperature and held there for at least 24 hours to ensure that all the residual heat is removed from insulation dunnage and other fittings within the space. The air temperature will quickly rise when the compartment is opened for loading and every opportunity should be taken to run the fans during breaks in the loading operation.

Taint

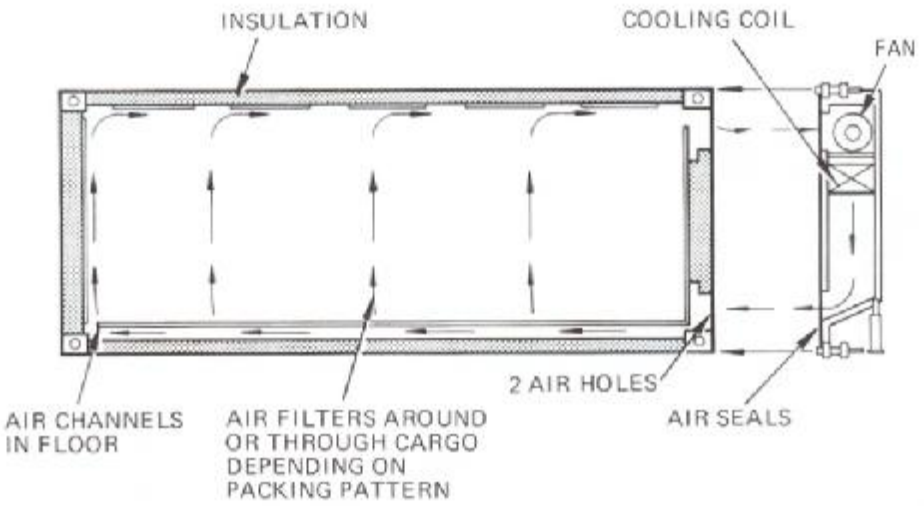
Odour, either pleasant or obnoxious, is closely associated with taste, and it is undesirable that even a pleasant smell should intrude into the one expected from a favourite food or perhaps completely override its own delicate flavour. It is in this connection with foodstuffs that taint is principally a problem. Some products produce strong odours in themselves — others may be particularly susceptible and readily absorb foreign smells. These properties of the various products are noted in the alphabetical section and they should not be stowed together, even though they may require the same considerations of temperature and humidity. The separation of odious and sensitive cargoes into separate airtight compartments would in most instances solve this problem (see Part 2, "Obnoxious Cargoes"). Badly fitting locker doors, container doors, hatch plugs, or fan spaces, might allow for a certain degree of cross tainting as indeed would common scupper systems not sealed with U-bends or traps filled with brine. Pipes passing through a cargo space present a particular hazard as a leaking oil pipe or oil tank sounding pipe may result in obnoxious fumes entering the space. Special care is required with living cargo when air changes are necessary to ensure that fresh air introduced is completely free of taint, similarly that the vented air expelled from a space is not drawn into a space where it might cause contamination. An odious cargo may well leave a well tainted atmosphere behind it after discharge, and a sensitive cargo should not be worked through this space either loading or discharging until it has been well ventilated and the odours removed.

Ozone

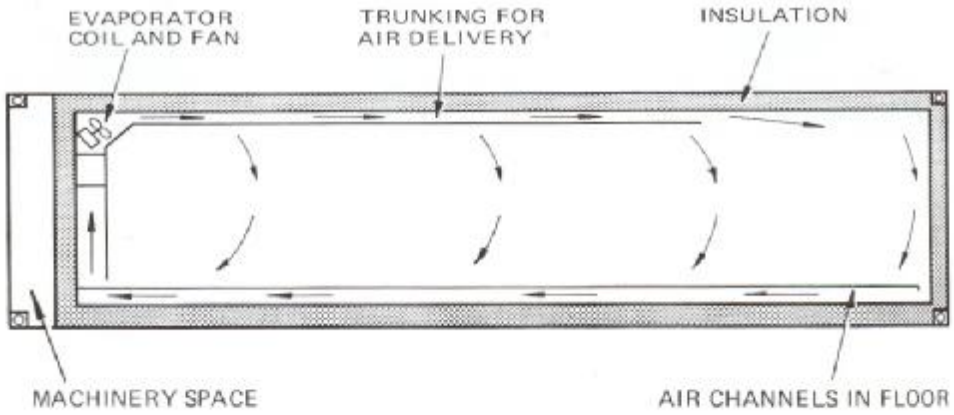
An oxygen enriched gas may be introduced to eliminate the odours by oxidising the offending molecules. This gas may be produced by electrically operated apparatus placed in the fan spaces and the gas circulated throughout the affected area. It should be noted that the ozone will only deal with airborne odours. Those which emanate from spills will continue until the spill has been cleared up and any damage to insulation or dunnage which has absorbed the spill quickly removed or renewed. Furthermore all traces of ozone should be removed by fresh air ventilation before the space is entered, or sensitive cargo worked through and loaded into the space. Particular care should be exercised before entering into the fan space to attend to or remove an ozone machine where there is liable to be a concentration of gas.

Containers

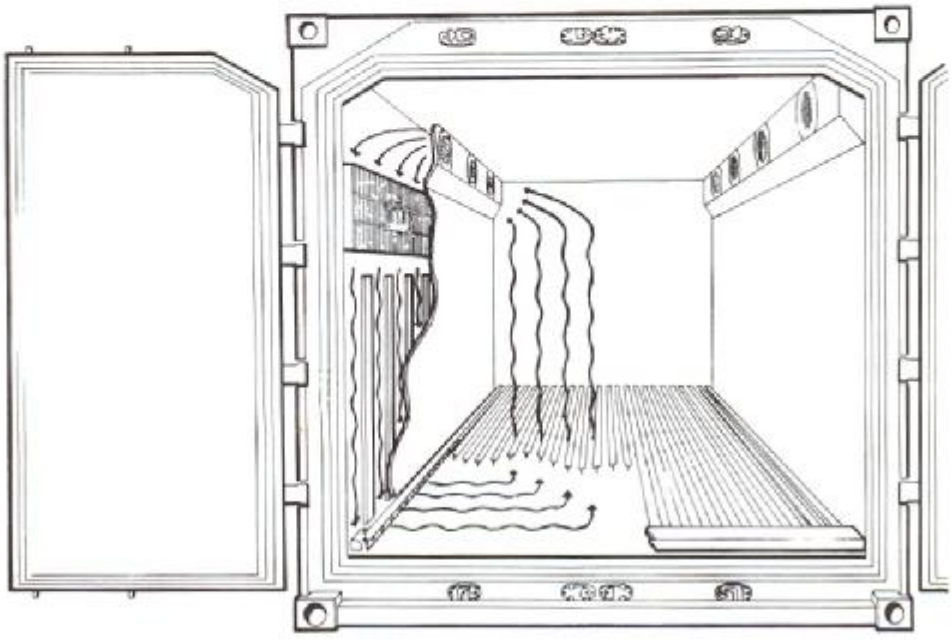
Unlike permanent cold stores or refrigerated ships, where robust equipment is under constant care by qualified personnel, the ISO refrigerated container may travel by many different modes and be in the care of many and varied people. Prior to being despatched to load refrigerated cargo (usually at shippers' premises), the container and its machinery should be subjected to a rigorous examination. External damage received during previous handling must be noted and if necessary repaired — and in cases where the external sheathing is pierced, insulation must be examined with particular reference to the ingress of water. Internally the successful carriage of refrigerated cargo depends on air circulation. All airways and battens should be inspected for damage particularly floor extrusions where fitted and fans tested. Cleanliness is of paramount importance and should be dealt with as previously



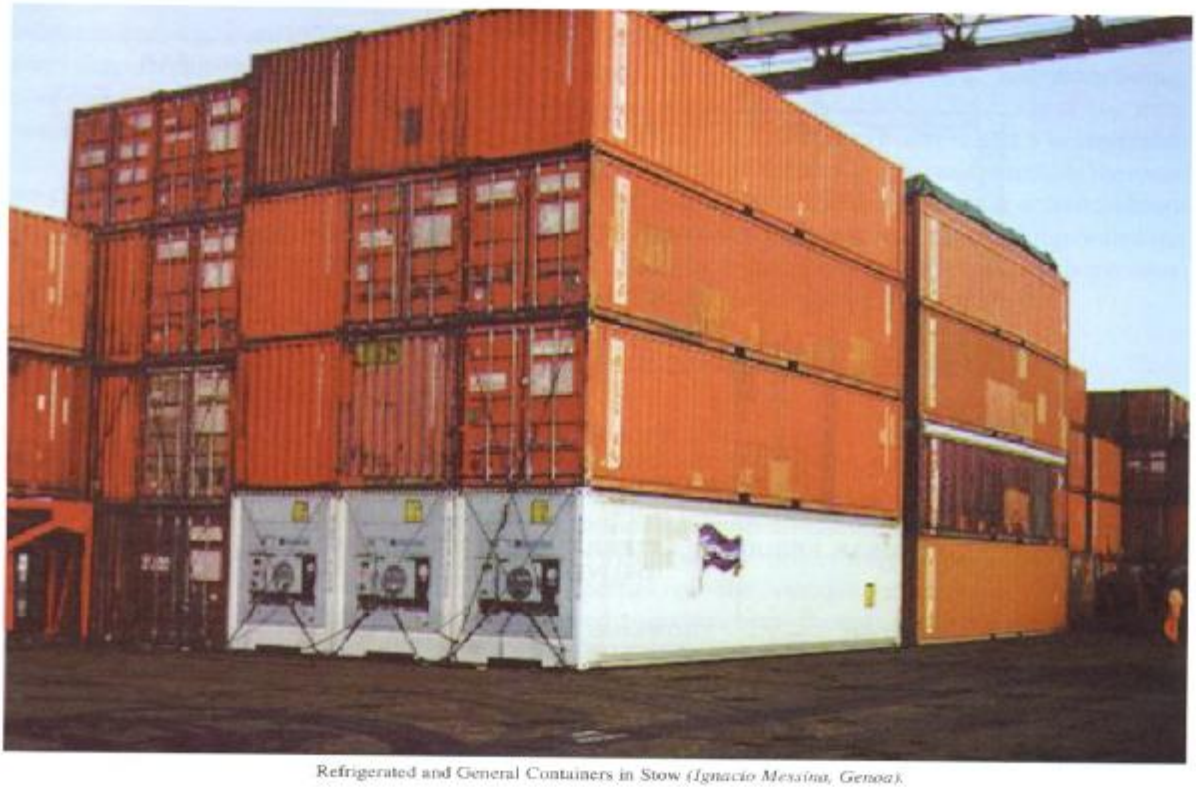
INSULATED CONTAINER REQUIRING EXTERNAL REFRIGERATION SOURCE. BOTTOM AIR DELIVERY.



INTEGRAL REFRIGERATED CONTAINER. TOP AIR DELIVERY.



INTEGRAL REFRIGERATED CONTAINER. SIDE AIR DELIVERY.



Refrigerated and General Containers in Stow (*Ignacio Messina, Genoa*).

outlined. Doors and their fastenings including hinges should receive special attention and an airtight seal ensured when closed.

Stowage position on board the vessel will be governed by: the commodity carried, its temperature and other requirements; the type of container — port-hole or integral, air or water cooled, possibly with Clip-on unit.

The insulated container, cooled using the ship's refrigeration by way of port-hole apertures in the front, is usually stowed in cell guides, care being taken to ensure that the port-holes are facing the correct way, and that 8 ft and 8 ft 6 in containers are neither mixed nor placed in slots designed for a different size.

Air-cooled integral containers, and containers fitted with Clip-on units are usually stowed on deck, though vehicle decks of Ro-Ro vessels, with appropriate ventilation facilities, may be suitable and acceptable.

Water-cooled integral containers must be stowed so that the hose connections are facing the correct way, and the comments (above) regarding 8 ft and 8 ft 6 in container problems also apply.

The vent closures of port-hole containers must be open prior to loading, though any empty insulated containers in the system should have their vents closed to prevent short-cycling of cold air.

Inspecting and testing should be carried out by qualified personnel and a certificate issued. Containers may require to be pre-cooled before loading (depending on the type of cargo and local regulations). When a Clip-on unit is fitted, or in the case of integral unit containers, the correct temperature for the cargo to be carried must be set, and the recording chart fitted after first winding up the clockwork driving mechanism. Information recorded on the chart should include:

Date and place of stuffing.
Carriage temperature required, plus any additional information, e.g. the requirement to change delivery air temperatures at any stage of the voyage, etc.
Commodity, type and packaging.
Container number.

When appropriate (e.g. for live fruit cargoes) the air intake/outlet vents should be set open to allow CO_2 and other gases to exhaust from the container. When loaded, sealed and delivered to the ship in the case of port-hole varieties there is little that can be done other than external examination including

seals and port-hole fittings and inspection of the accompanying documents. If a Clip-on unit is fitted thermometers and thermostat settings should be inspected and the air temperatures recorded along with its general condition and if a temperature recording chart, this should be studied and removed for future reference. Similarly an integral unit, if running on its own diesel generator, fuel and lubricating oil should be checked and the unit should be stowed so that access is available to machinery. If the ship is to supply the electric power it must be ascertained that the required cable is available with suitable connections. Although largely standardised, differences are sometimes found, and converting links should be available. The voltages and transformer settings should be carefully checked before connecting up. Thermostat settings should be checked correct for the contents and the plant operating smoothly. Though major machinery breakdowns are a specialist's concern and unlikely, regular checks for the temperature must be made and variations investigated. The causes may be simple and easily rectified. A blown fuse, slipping or broken fan belts, thermostat settings altered by vibration. Simple tools with a few spares should be carried. Attention to minor defects can well save a valuable cargo.

Get-you-home Procedures

In the event of container machinery failure beyond the capability of local resources to rectify, it may well be possible to yet save some of the cargo by adopting certain emergency procedures. If the cargo is hard or deep-frozen in a well insulated container with good door seals it may survive for several days depending on the ambient temperature. Shielding from direct sunlight will help. Even then the probability is that only the outer portions of the cargo will suffer, but undoubtedly the best way of dealing with such a situation is to introduce coldness to the cargo. This can be done by dumping liquid nitrogen or carbon dioxide into the container and allowing it to vapourise within the space, when any heat that has leaked in will be consumed. Points to bear in mind: ensure that the gas used will not harm the cargo (not normally a problem with hard frozen products); also that it will not adversely be affected by the very low temperatures produced, particularly locally. It is not possible to regulate the temperature when resorting to this method of refrigeration, and it is quite unsuitable for chilled cargoes. Solid CO_2 (dry ice) may be a suitable alternative. Normally supplied wrapped for protection during handling, it is necessary to open the wrapping to permit evaporation. The more exposed are the blocks from their wrappings, the more rapid the evaporation the greater cooling effect — and the shorter the life of the blocks. Although there is little point in economising on CO_2 to the possible detriment of the cargo. Care should be taken when handling blocks of dry ice; the extreme temperature may cause severe burns on contact with the bare skin.

Neither of these gases, nitrogen or CO_2, will support life so apart from the damage they would do to living fruit cargoes, personnel when opening a container which has received this treatment should ensure that adequate time has been allowed for ventilation before entering. Being heavier than air these gases should flow out readily like water, but beware of pockets trapped in a tight stow. Dumping of CO_2 or nitrogen, or the use of dry ice, are not suitable for chilled living cargoes. The rapid introduction of nitrogen or carbon dioxide would kill the product both on account of the very low local temperature and the effect of the gas itself on fruit's respiration (although it is possible for these gases to be introduced in small quantities using sophisticated control equipment).

Where chilled live cargoes are involved, shading from the sun, even hosing down of the container will help, but inevitably the temperature will rise and the ripening process increase. Ventilation at this time is essential to remove harmful vapours produced by the cargo and replace the oxygen necessary for the health of the fruit, though this may give rise to an accelerated rise in temperature. It is only by speedy transfer of the cargo to a more acceptable environment that it will continue to prolong its storage life.

Temperature Measurement

There are many instruments capable of doing this; perhaps the commonest is the mercury or alcohol glass thermometer.

When using these instruments (apart from their fragile nature as with all types of thermometers) it is important that the sensing head (in this case the bulb) is kept in the environment where the

temperature is required to be known long enough for all the liquid in the bulb to settle to that temperature and ensure the correct degree of expansion or contraction. It must also be shielded from any extraneous source of heat or cold. In liquid cargoes it is simple enough to immerse the bulb for a few minutes. In the case of solids, if not too dense, it may be possible to carefully insert the thermometer. Special metal sheathed cases are available with pointed ends to enable proper penetration to be obtained, but due to the presence of the metal case, will require a greater time for the whole to achieve the true temperature of the commodity being measured. In other instances it may be necessary to drill a hole (particularly in hard-frozen commodities) to ensure penetration to the heart of the article to obtain its true temperature. In the case of sealed packages such penetration may well destroy or seriously reduce their value, and a close approximation of the temperature can be obtained by sandwiching the thermometer between two packages and wrapping them together for a while to exclude draughts and other outside influences. It may well be considered advisable, on receiving a cargo of sealed packages, the temperatures of which have to be ascertained, to penetrate a selected sample and these should be conspicuously marked so that the same package can be used for measuring the internal temperature if required on discharge, thus reducing the number so damaged.

A bi-metal instrument consists of two strips of dissimilar metals with different coefficients of expansion joined together at one end, such that the varying temperature causes them to expand or contract at a different rate, this variation being accurately measured as a temperature reading, and connected to a calibrated dial. More robust than the glass thermometers, they are easier to read, but require appreciably more time to settle and for the temperature to be measured.

Electrical resistance thermometers depend on the fact that the resistance of a wire or filament will vary in ratio to its temperature. Here it is necessary to have a suitable instrument to measure the resistance, calibrated in degrees of temperature, but the sensing probe may be at a remote distance from the instrument. These distant reading thermometers are of particular value during the actual carriage of the cargo, as the sensing probes can be distributed amongst the stow and then the temperature read off externally during passage. Such instruments can also be fitted with a recording chart to give a continuous record of the temperature of the cargo during passage.

In certain cases the importing country will require proof that the requisite temperatures have been maintained for the required time. This may be to ensure cold sterilisation of the commodity with regard to parasites in living cargoes, or for other temperature monitoring requirements. A temperature recording chart fitted to integral refrigerated containers may serve a similar function.

CONTROLLED ATMOSPHERE (C.A.) CARGOES

Controlled atmosphere storage or transportation provides a means to augmenting (but not in any way replacing) high quality refrigeration in order to enhance the shelf life of fresh fruits and vegetables. It is being adopted for use in the hold spaces of refrigerated ships.

The respiration rate of produce is closely related to its rate of maturation and subsequent deterioration. Respiration rate is reduced by holding at an optimum temperature as low as possible without freezing or chilling the produce. It may be reduced further by reducing the oxygen content of the surrounding air. Atmospheres containing below 2 per cent oxygen are found to be most beneficial, though the exact composition of an optimum atmosphere is species and variety dependent. The degree of benefit obtained from c.a. varies widely between different types of produce. It may be advantageous for some produce to use additional controls on carbon dioxide, humidity and ethylene level.

Low oxygen and high carbon dioxide atmospheres have also been used to slow microbiological deterioration of fresh meat, though this is more often done nowadays using vacuum packaging or similar techniques.

A common means of providing c.a. in a ship's hold involves the use of an air compressor and a membrane separator. The membrane acts rather like a sieve and effectively separates nitrogen and oxygen from the air. A nitrogen enriched stream (perhaps 98%–99% nitrogen) is then injected into the hold space under appropriate controls in order to maintain the desired atmospheric composition. For the system to be effective, good sealing and good control are needed.

It should be noted that the shelf life of produce, previously subjected to c.a. and then stored in air, has not been fully investigated for many varieties. It should also be noted that whilst some produce (e.g. apples, bananas) may be transported without c.a. and could therefore possibly be carried without

major loss in the event of c.a. failure, much subtropical produce may not survive the length of a sea voyage without c.a.

Of necessity, c.a. involves flooding hold spaces with an atmosphere which will not support human life. Safety is therefore a paramount issue. Systems of controls on access, warnings, and alarms are needed. Specific recommendations are provided by classification societies such as Lloyd's Register of Shipping.

BULK CARGOES

Introduction

Cargoes shipped in bulk are many and varied as may be seen from the Appendix, and stowage factors can vary between as little as 0.31 M3/tonne (11 cu. ft to the ton) to something in excess of 2.81 M3/tonne (100 cu. ft to the ton).

However the same considerations must be borne in mind as with any other cargo, namely weight distribution, stability of the vessel, the nature of the cargo and whether it may have any tendency to shift, as well as the safe carriage of the cargo to ensure delivery in a satisfactory condition. Where appropriate, the Master must be furnished in writing with the moisture content of the cargo and certifying that it is within the transportable maximum permissible moisture limit.

In addition, possible chemical reactions should be taken into account, namely whether the cargo is likely to emit toxic or explosive gases, liable to spontaneous combustion, or possible corrosive effects.

In this case the IMO Code of Safe Practice for Solid Bulk Cargoes stipulates that it is essential for shippers to provide adequate information to all personnel involved regarding the physical and chemical properties of the material presented for shipment so that adequate precautions may be taken

Panamax bulk carrier.

to ensure safe shipment. The IMO Code should be referred to for full information, but Appendix 5 of this book contains the following information from the Code:

1. List of cargoes which may liquefy.
2. List of bulk materials possessing chemical hazards.

It is, however, stressed that these lists are not exhaustive, and in each case when the loading of bulk cargo is contemplated currently valid information should be obtained from the shipper regarding its physical and chemical properties prior to loading.

The methods of loading bulk cargo are almost as varied as the cargoes concerned and may range from antiquated and obsolescent systems giving load rates of as little as 50 tonnes per hour or less to modern loading facilities able to pour the commodity into the ship at rates of up to 7,000 or 8,000 tonnes per hour.

Whatever the method, close liaison with the shore at all times during loading is essential. It must be remembered the equipment in motion cannot always be stopped immediately, and there may be a considerable quantity of cargo which of necessity has to be run off the belts even after the decision to cease loading has been made. Many loading terminals are in isolated areas where there may be no facilities at all for discharge and in the event of any overloading taking place it may well take several days at high cost to discharge the excess cargo which took only minutes to load.

Proper distribution and disposition of bulk cargo is essential. Ships have broken their backs both in loading and discharge through insufficient attention to this factor, although it might be considered obvious that undue stresses and strains on the hull must be avoided (see also Part 1, "Safety").

Concentrates

Concentrates are partially washed or concentrated ores. Copper, lead and zinc are shipped as bulk in concentrate form. Concentrates are powdery or lumpy in character and may carry a considerable moisture content, however this is normally regulated by the exporting country. Prior to loading the shipper should advise of any known characteristic or hazard in particular whether it is liable to moisture migration or becomes flammable or toxic under certain conditions. It is particularly important that the question of special precautions should be considered whenever the cargo to be carried has a moisture content which is likely to exceed 7 per cent in any part of the shipment. It should be borne in mind that the normal moisture content may have been seriously increased should there have been heavy rain during storage or loading, or leakage into the holds during the voyage. In these circumstances the vibration of the ship may cause the moisture to saturate and the concentrate to turn into slurry with consequent danger of the vessel taking a serious list.

GRAIN AND SEED CARGOES

The term grain includes wheat, maize, oats, rye, barley, rice, pulses and seeds.

Proper carriage and a sound and correct delivery of grain calls for constant and expert attention from all concerned, but the most onerous of the duties fall upon the Master and Officers of the vessel.

The loading and carriage of grain cargoes is governed by the International Convention on Safety of Life at Sea (SOLAS) regulations with which every ship's Master and Officers should be familiar. In May 1991 the IMO adopted a new International Code for the carriage of grain in bulk (International Grain Code 1991 edition). This replaced the original chapter VI of the SOLAS Convention 1974.

Bills of Lading

If any doubt exists as to the condition of the cargo the Bills of Lading should be suitably claused. Failure to issue Bills of Lading reflecting the true condition and description of the cargo may be construed as fraud.

Quantity Clause

As it seldom, if indeed it ever happens, that Masters or Officers are in a position to check or vouch the quantity of grain, the seeds or other cargo of like character shipped, mates' receipts and bills of lading should always be claused "shipper's weight, quantity and quality unknown" . . . or in the case of bagged cargo taken on board "So many bags said to contain . . . weight, quantity and quality unknown".

Settling

All grains settle in stowage, even to the extent of 5 to 6 per cent (which can be well below the deck beams, in the lower holds of a good-sized ship), so that good trimming is absolutely necessary in the interest of the safety of the vessel. The duty of seeing that grain is properly trimmed should always be attended to by the ship's officers and never delegated to others.

Ventilation

Ventilation systems on bulk carriers are not normally designed to penetrate cargoes carried in bulk. It therefore follows that efficacy of ventilation applies only to the surface of the cargo and the air space above. Unless transportation is from one extreme of climate to another it may well be to let well alone.

Principal Grain and Seeds of Commerce

Their properties and peculiarities are described elsewhere in this book under their respective titles. Many kinds are shipped in exceedingly large quantities, either in bulk or in bags, for use either as foodstuffs or for oil extraction; others in moderate quantities in bags only, while some, valued for their medicinal and other properties, are handled in small quantities only and usually are put in bags of superior manufacture or in well made cases. Grain in bags occupies 8 to 10 per cent more space than in bulk:

	M3/tonne			*M3/tonne*			*M3/tonne*	
Grain or Seed	*Bags*	*Bulk*	*Grain or Seed*	*Bags*	*Bulk*	*Grain or Seed*	*Bags*	*Bulk*
Ajwan	2.23		Cummin	3.62		Oats	2.31	2.12
Alsike	1.28		Dari	1.48		Onion	1.81	
Alpia	1.67		Durra	1.48		Paddy	1.81	
Alpiste	1.67		Fennel	2.65		Peas	1.39	
Aniseed	3.34		Flax	1.59	1.39	Poppy	1.98	
Barley	1.76	1.55	Gingelly	1.67		Rape	1.67	
Bayari	1.56		Gram	1.39		Rice	1.45	
Beans	see Beans		Grasses	1.95/2.51		Rye	1.53	1.39
Buckwheat	1.84		Guinea Maize	2.23		Sesame	1.67	
Canary	1.67		Hemp	1.90		Shursee	1.67	
Caraway	1.73		Jowaree	1.59		Soya Bean	1.39	1.23
Cardamom	2.09		Kernels	1.34		Spinach	1.95	
Carthamus	2.51		Linseed	1.62	1.42	Sugarbeet	3.76	
Castor	2.01		Locust Bean		2.45	Sunflower	2.93	
Cebadello	2.37		Maize	1.50	1.37	Surson	1.67	
Celery	2.12		Millet	1.39		Tares/Vetch	1.79 ch	
Cloves	1.34		Mirabolams	1.95		Teel	1.67	
Common seeds	2.79/3.07		Mowrah	1.70		Timothy	1.95	Vary
Coriander	3.62		Mustard	1.67		Trefoil	1.67	greatly
Corn	see Maize		Negro Corn	1.48		Tokmari	1.64	
Cotton	2.09		Niger	1.78		Turkish Millet	1.48	
Croton	2.23		Oats Clipped	2.06	1.84	Wheat	1.45	1.31

Grain Stowage Factors — The figures given above are a close approximation only, as no figure can be relied upon correctly to express the actual space to be occupied by any grain or seed at all seasons and from all ports. The factors vary over a considerable range for, amongst others, the following reasons: the quality or the density of a grain, pea, bean or seed varies according to grade, crop, season and country of origin; whether it is shipped early or late in the season, etc.

Stowage factors of bagged grain vary also according as to whether the compartment is large or small, deep or shallow, square or pointed, the presence of obstructions, and depends, also on whether the bags are well or slack filled (see "Stowage Factor").

To attempt a fixed factor of stowage would, therefore, be but to mislead. The above factors represent fair averages and will suffice to enable the carrying capacity of a vessel or compartment to be estimated within a reasonable margin.

A fairly accurate stowage factor, for any given grade of seed, at any port or season, can be calculated by the following formula, if the weight of a bushel of the seed is accurately determined.

$$\text{For Imperial bushel of 1.2837 c.f.} \quad \frac{\text{constant } 2875.5}{\text{weight in lb}} = \text{stowage factors for bulks.}$$

$$\text{For U.S.A. bushel of 1.2445 c.f.} \quad \frac{\text{constant } 2787.6}{\text{weight in lb}} = \text{stowage factors for bulks.}$$

For bagged grain, etc., add 8 to 10 per cent.
See Appendix 8, "Grain Weights and Measures".

Preparing Holds for the Reception of Grain Cargoes

In order to pass surveys in accordance with Charter party and/or Statutory requirements at the load port it is absolutely essential when proceeding to load grain to make every effort to ensure that the holds are properly prepared for the reception of the grain cargo.

Failure to do so will, more often than not, result in the necessity to call in shore labour, if surveys are failed, as union agreements at many world grain ports prohibit the use of ships crew for cleaning work in port.

In order to pass inspection by the appropriate authority, be it grain board or state, the hold must be "clean and dry, free of previous cargoes and rust scale, and in every way fit to load the intended cargo." The hold must be well ventilated and free from odours. In America the certificate of cleanliness is issued by the United States Department of Agriculture. The National Cargo Bureau is empowered by the Government to approve and monitor the grain loading calculation. The NCB also has the option of inspecting the holds, but will not authorise the calculation until the cleanliness certificate has been issued.

From the foregoing it will follow that particular attention must be paid to removing any loose rust or scale. Previous cargoes' residues must be removed from between frames and stringers. Underside the frame deck beams must be hosed or swept clean, as claims have arisen where the motion and vibration of the ship has caused previous cargo to become dislodged and fall onto the existing cargo, producing contamination.

If there are signs of insect infestation these must be attended to either by spraying with appropriate insecticides or by sealing the holds and fumigating with some approved type of smoke bomb.

Any timber or dunnage remaining in the holds must be removed.

All bilge suctions must be thoroughly clean and free from old grain.

Approved Grain Loading Methods

The Maritime Safety Committee, at its Fifty Ninth session (May 1991), adopted a new International Code for the safe carriage of grain in bulk (International Grain Code). This replaced the original Chapter VI of the 1974 SOLAS convention, which contained, detailed regulations on the carriage of grain in bulk, with more general requirements and placed detailed provisions on grain in a separate mandatory code.

There are a number of approved loading methods including the following:

1. (a) A document of authorisation issued by the administration of the Country of Registration, or a Contracting Government on behalf of that Administration must be produced.
   (b) Appropriate stability data approved by the Administration of the Country of Registration, or a Contracting Government on behalf of that Administration must accompany the document of authorisation so that, if required, the Master may demonstrate the ability of the ship to comply with the stability criteria required by the regulations.
   (c) Where an equivalent arrangement is accepted by the Administration, in accordance with Chapter 1 Regulation 5 of the Safety of Life at Sea Convention 1960 or 1974, as appropriate, it must be included in the document of authorisation.
2. Specially suitable ships, e.g. self trimming or partly self trimming vessels may load bulk grain provided they comply with the following conditions:
   (a) They are constructed with two or more vertical or sloping graintight longitudinal divisions suitably disposed to limit the effect of any transverse shift of grain.
   (b) As many holds and compartments as possible shall be full and trimmed full.
   (c) For any specified arrangements of stowage the ship will not list to an angle greater than 5 degrees at any stage of the voyage where:
      (i) in holds or compartments which have been trimmed full the grain settles 2 per cent by volume from the original surface and shifts to an angle of 12 degrees with that surface under all boundaries of those holds and compartments which have an inclination of less than 30 degrees to the horizontal.
      (ii) in partly filled compartments or holds free grain surfaces settle and shift to an angle of 12 degrees with that surface, or to such larger angle as may be deemed necessary by the Administration or by a Contracting Government on behalf of the Administration and grain surfaces if either overstowed by a suitable cargo, or strapped and lashed, shift to an angle of 8 degrees with the original level surfaces. If shifting boards are fitted due allowance is to be made for the divisions of the hold or compartment limiting the transverse shift.
   (d) The Master is provided with a grain loading plan and a Stability Booklet approved by the Administration or by a Contracting Government.
   (e) The Administration shall prescribe such precautions as the trimming of the ends of holds or compartments to meet the required stability criteria where "shedder plates" have not been fitted at the ends of such holds or compartments.
3. Ships without documents of authorisation by their own Country or Registry or a Contracting Government may in certain circumstances be permitted to load by the Administration at the loading port but that Administration will decided the conditions to be fulfilled.
   (See I.M.O. Code for Safe Carriage of Grain in Bulk (International Grain Code) 1991 Edition et seq.

Trimming of Bulk Grain Cargoes

Self trimming bulk carriers routinely have stability calculations for wings trimmed and untrimmed. Many countries now insist on calculations for void spaces at forward and after ends of hatches. If these are not available owners and charterers may face additional stevedoring charges for the costs of end trimming.

The IMO Resolutions governing the carriage of grain require that the void depths at the ends of compartments are taken into account in meeting the stability criteria.

The formula for calculating the mean void depth for a compartment as given in the Resolutions is as follows:

For the purpose of calculating the stability of ships carrying grain in bulk it shall be assumed that:

(i) in filled compartments of ships with hatch side girder depths between 500 and 600 mm, the average depth of the underdeck void (VD) is 460 mm.

(ii) when the depth of the hatch side girder is not between 500 and 600 mm the average void depth shall be calculated according to the formula:

$$Vd = Vd1 + 0.75\,(d - 600)\,mm$$

where Vd = Average void depth in mm

Vd1 = Standard void depth from the Table

d = Actual girder depth in mm.

In no case shall Vd be assumed to be less than 100 mm.

If for example the end of a compartment had a hatch end girder of 3 ft (i.e. 915 mm) and the end bulkhead was 16.4 ft (i.e. 5 m) from the hatch coaming, then using the above formula:

$$Vd = Vd1 + 0.75\,(d - 600)\,mm$$
$$= 430 + 0.75\,(915 - 600)$$

Average Void Depth = 666 mm or 2.18 ft.

TABLE I

Distance from Hatch End or Hatch Side to Boundary Compartment metres	*Standard Void Depth Vd1 mm*
0.5	570
1.0	530
1.5	500
2.0	480
2.5	450
3.0	440
3.5	430
4.0	430
4.5	430
5.0	430
5.5	450
6.0	470
6.5	490
7.0	520
7.5	550
8.0	590

If the required stability cannot then be achieved the loading Administration will order trimming of the cargo to throw the grain into ends of the compartments. In some cases it may be possible to utilise spout extensions or scoops to achieve the filling of the ends without machine trimming but this will depend on the particular design and capability of the grain elevator.

For this reason it is advisable that the stability data carried by the ship should include "trimmed moments" as well as "untrimmed moments" so that the ship's Master may be able to exercise the option whether to use "trimmed moments" and trim the ends of compartments or use "untrimmed moments" and not trim should it prove possible to meet the stability criteria in this condition.

In order to meet Charter party conditions regarding cargo quantity and trim provisions it may very well be necessary to leave one or more holds slack. As slack holds create the largest upsetting moments in order to comply with stability criteria and stay within the maximum angle of heel of 12 degrees, it may be necessary to secure the free surface of the grain.

This may be done by strapping or overloading with bagged cargo. Although both methods are generally expensive, strapping is the less time consuming.

It is achieved by setting up wires in position prior to loading at a requisite distance below the anticipated free surface of the grain, and holding them in the wings by lashings. After the required quantity of grain has been loaded and, if necessary levelled, it is covered by fore and aft and athwartship dunnage. Thereafter the wires are joined by bottle screws and tightened so that a taut strapping is formed over the grain surface.

In filled compartments where the saucering method is used to reduce heeling moments it may be done in one of two ways, either by filling a saucer shaped depression left in the grain in the square of the hatch with bagged cargo, or using the "bundling of bulk" method. The latter is generally the least expensive of the two methods. It is achieved by lining the saucer shaped depression with an acceptable material laid on top of athwartship wires or strapping and dunnage. The saucer is then filled with bulk grain and the lining closed over the top. Further dunnage is laid on top and the lashings brought together, tightened and secured.

ORES

When full or large part cargo of ore is carried, its longitudinal distribution should be carefully decided upon so as to avoid too much weight in the middle, causing sagging tendencies; and, on the other hand, in order to ensure sea-kindliness and avoid risk of hogging, not to have an excess of weight at the extreme ends. According to the nature and density of the cargo, it is frequently the practice of large carriers to distribute cargo in alternate hatches. Careful consideration must be given to get the longitudinal stresses within accepted limits. To this end Masters of large carriers should be provided with loading diagrams setting out distribution of cargoes for varying conditions. The results of current investigations suggest that the alternative hold loading method should be avoided. Similarly a fast loading rate contributes to excessive stresses. Both problems exist for economic reasons at the loadport. However in order to avoid risk of loss of life both the foregoing problems should be addressed. Further investigation should be made into torsional stresses when the ship is working in a bow or quartering seaway.

If as sometimes happens the cargo is delivered from one tip, the vessel should be moved frequently so as to bring all hatches, in fairly quick alternate rotation under the tip, it being an exceedingly dangerous practice to receive all the cargo intended for one hold while other holds are empty. Many vessels have received permanent damage from this cause.

During recent years there have been a disturbing amount of losses of bulk carriers of about 120,000 tonnes deadweight carrying ores. These catastrophes have been accompanied by a disastrous loss of lives. It may be that ships scantlings have not increased commensurate with the deadweight carrying capacity. It cannot be over emphasised that strict attention must be paid to the loading rotation which at all times must be within the ships longitudinal stress tolerances. A prudent owner should carry out a careful inspection of the frames in the holds after such cargoes have been carried, particularly if they are carried on a regular basis or if the ship has been put to a contract of affreightment.

Finely Crushed Ores

When receiving finely crushed ores, it is important to bear in mind the possibility that the normal moisture content (of 8/10 per cent) may have been seriously increased by heavy rains during storage in semi-open trucks, sheds, etc. In that condition the vibration of the ship may cause the moisture saturated ore to become slurry with the consequent danger of the vessel taking a serious list. In such cases bagging has been found to be necessary to prevent the cargo from shifting.

In all ships which carry these cargoes an adequate range of stability should be preserved throughout the voyage so that, if a shift occurs, the list will be minimised (see extract from IMO Code of Safe Practice for Solid Bulk Cargoes in Appendix 5).

In two- and three-decked vessels, a proportion of a full cargo of ore, varying with the class of ship, should be received into the 'tween decks in order to reduce the strains and make the vessel easier in a seaway. The ore should be trimmed into the wings and to the bulkheads, and not left in the square of the hatch, otherwise the risk of setting down the decks will exist.

The National Cargo Bureau Inc. of New York in a circular headed "Weights in and on Deck", regarding the loading of selected commodities, advised that, in order to reduce the risk of distortion or failure of 'tween deck structures (including hatches) due to concentrated stowage of heavy cargo on any part of a 'tween deck or hatch, the cargo should be so distributed that the weight, per square foot, on any part of a 'tween deck or hatch should not exceed that for which they were normally designed.

To ascertain the approximate weight per square foot to be stowed in 'tween decks and hatches the following formula is recommended:

Height of 'tween deck × 45 = the approximate weight in Pounds per Square Foot.

With part ore cargo, the ore should be levelled off and, if overstowing with grain, seeds or other dry cargo liable to damage from moisture, it should be laid over with planks, or stout bamboo, double crossed close enough together to keep the packages from resting on the ore; these to be double matted or covered with burlap. Matting or burlap only is not sufficient. Not infrequently, especially in Indian ports during the S.W. Monsoon season, wet ore such as manganese is loaded and subsequently perishable cargo, such as oil cake, ground nuts, etc., offered for shipment on top of the water soaked ore.

No system of dunnaging and matting such as referred to in the foregoing can be relied upon to prevent damage when perishable goods are stowed on wet ores.

When Chrome Ore and Manganese Ore are carried they should be stowed in such a manner as definitely to preclude any possibility of the smallest quantity of Chrome Ore getting mixed with Manganese Ore. The admixture of even a small proportion of Chrome with Manganese renders the latter useless for important purposes in connection with the steel trade.

Particular care should be taken to prevent any loose grain mixing with the ore; numerous are the claims which, in the past, had to be met on that account.

Oils or acids should never be stowed on or over ore. When loading ore in a rainy weather, if intending to complete with dry or general cargo, hatches should be covered at night.

Some ore cargoes, when shipped in the dry seasons, are very dusty, in which case other cargo should adequately be covered up.

Hematite or Iron Ore is shipped either as "Run of mine", "Crushed and graded" or "calcined" ore (a very dusty cargo).

If Bagged Ore is shipped, the condition of the bags should be carefully noted — it happens that many are partly rotted through lying on damp ground.

Bills of Lading should be claused "weight unknown, not responsible for loss of weight". Ore shipped in the open roadsteads of India, etc., often loses 4 to 6 per cent weight between leaving mines and actual shipment — mostly lost overboard from lighters. When the swell is high the loss is sometimes even greater.

The various ores stow, approximately, as follows:

	M3/tonne	
Ore	*Bag*	*Bulk*
Aluminium Bauxite	1.11	0.84/0.98
Antimony Stibnite	0.56	0.42
Asbestos	1.67/1.81	—
Chrome	—	0.33/0.39
Cinnabar	0.56/0.61	—
Cobalt	—	0.50/0.56
Concentrates	0.42/0.56	—
Copper	—	0.39/0.56
Corundum	1.11/1.25	—
Galena or Lead	0.45/0.47	0.33/0.39
Garnet	0.50/0.56	—
Hematic or Iron	—	0.33/0.47
Kainite	1.06/1.11	0.98/1.03

	M3/tonne	
Ore	*Bag*	*Bulk*
Lead Concentrates	—	0.33/0.39
Magnetite	—	0.42/0.47
Manganese	0.61/0.70	0.47/0.50
Manganese Perox	—	0.42/0.47
Nickel	0.56	—
Silver	0.61	0.70
Tin	0.61	—
Wolfram or Tungsten	0.45/0.50	—
Umber	—	1.11/1.17
Uranium	0.47/0.50	—
Zinc Blende	—	0.56/0.67
Zinc Concentrates	—	0.50/0.56

IMO Code of Practice for Bulk Cargoes is referred to in the Appendix.

Mineral Sands

Ilmentite, rutile and zircon sands are refined products and any form of contamination can be harmful to them. In consequence the following procedures should be followed prior to shipment:

1. Any residues of previous cargo must be removed. Particular attention should be given to the cleanliness of the underside of steel hatch covers, horizontal flanges of under deck beams, stringers or horizontal stiffeners, and the flanges of portable hatch beams. Particular care should be taken in removing phosphates, sulphur or ferrous residues as these are especially undesirable.
2. Any loose rust scale should be removed from the compartment prior to loading and particular attention should be given to the underside of steel hatch covers and the "hidden" flanges of frames.
3. The compartment should be washed down with a final washing with fresh water.
4. The compartment should be dry.
5. All bilges should be grain tight. All spaces on the crown of the bilge should be cemented and the limber boards covered with two thicknesses of hessian or burlap, secured by thin battens at their top and bottom edges, and an overlay of burlap be allowed to lie over the crown of the bilge. Should plastic or polyethylene material be used, it is desirable that a section of limber boards adjacent to the bilge suction be covered with burlap.
6. Where suction boxes are flush with the hold ceiling, as in most modern bulk carriers, suction plates should be covered with two thicknesses of burlap and cemented in place.
7. Should the vessel be fitted with spar ceiling it is advisable to remove the lower 6 or 7ft as bulldozers or grabs are likely to be employed during discharge.

Ilmenite is a very heavy sand stowing about 0.36 M3/tonne (13 cu. ft to the ton), and it is almost black in colour and is found on the coast of India, Malaysia, Australia, etc.

From ilmenite titanium is also extracted from which the whitest pigment is obtained. Titanium is widely used in the manufacture of paint.

Properly trimmed ilmenite sand, which has a clinging tendency and a large angle of repose, is not likely to shift. With part shipments in large compartments, the ilmenite when in bulk should be overstowed, or if this is not possible, adequate steps taken to avoid any shifting of the stow. The cargo on account of its weight, should be well spread over the ship in order to avoid undue strains. It is dustless.

Rutile is a mineral obtained from certain sands in Australia and Brazil. It is used for hardening steel, etc. This is a very fine cargo and as such is not really suitable for grab discharge.

Zircon is another sand which is used in the process of hardening steel, etc.

PETROLEUM CARGOES

This section is designed to give an overview of the carriage and measurement of crude oil and products in Oil Tankers, and in Deep Tanks or Drums in General Cargo Vessels, and is not meant to be used as an operational training guide. However, emphasis has been put on certain operations where improved practices may assist in reducing/preventing potential claims. The section is limited to an introduction to the transportation of hydrocarbons, the types of products involved, bulk oil measurement practices and the issuing of documentation where cargo shortages and claims may become an issue. There is also reference to preparation of tanks, cargo heating and stability/stress concerns.

The section should be studied in conjunction with the International Convention for Safety at Life at Sea (SOLAS Convention), The IMDG Code, The International Safety Guide for Oil Tankers and Terminals (ISGOTT), the International Convention for Prevention of Pollution from Ships, the MARPOL convention and its protocol together with the latest edition of the Clean Seas Guide for Oil Tankers.

The subjects of personal and operational safety on Tankers, and the safe carriage and handling of hydrocarbons in bulk, are not covered in this section as there are other comprehensive sources which can be used. However, aspects of Safety on General Cargo Vessels which are not covered in other sources are mentioned, but are for complimentary use only and should be studied alongside the Blue Book and ISGOTT.

Crude Oil

A mineral oil which comprises mainly of a mixture of hydrocarbon compounds found in many parts of the world. The principal producing areas are the Middle East, Latin America, West and North Africa, Eastern Europe, Far East/Australasia, North America and Western Europe and the crude petroleum may be conveyed to the refining centres by pipeline, oil tankers, rail tank car or road tank car.

Crude oil is an inflammable liquid the flash points of which are very low and are therefore very rarely quoted. It has a density which may vary from 0.750 to 1.000 (see density of petroleum).

Petroleum Products

The principal products of petroleum by distillation are as follows:

Liquefied petroleum gases (L.P.G. — mainly propane and butane).
Motor gasoline.
Kerosene.
Gas oil.
Fuel oil.

In addition to the foregoing so called straight-run products, other products which result from more complex refining processes include:

Aviation gasoline.
Premium grade motor gasoline.
Premium grade kerosene.
Lubricating oil and greases.
Wax.
Bitumen (asphalt).

Yields of each product vary over a wide range depending on many factors including the grade of crude oil refined and the particular processes employed.

Petroleum Products and Other Substances Giving Off Inflammable Vapours

(See also the section: Dangerous Goods).

The following list of "Inflammable Substances" is by no means complete. Those substances not included will fall into their appropriate category according to their individual flash points and according to whether or not they are miscible with water.

"Benzine" or "Spirit" Class — Flash point below 73 degrees F (22.9 degrees C).

Immiscible with water:

Petroleum spirit	Lythene	Butyl acetane (iso)
Benzine	Motor Spirit	Carbon disulphide
Benzol	Naptha	Ether (sulphuric)
Benzolene	Toluol	Ethyl (acetate)
Gasoline	Xylol	Nickel carbonyl

Miscible with water:

Acetone	Diacetone alcohol	Methyl alcohol
Ethyl alcohol (Spirits of wine)	Methylated spirit	Propyl alcohol
	Pyridene	

Ordinary Class — Flash point 73 degrees F (22.9 degrees C) and upwards.

Amyl acetate	Amyl alcohol	Butyl acetate — normal
Butyl alcohol	Coal tar	Ethyl lactate
Kerosene	Mineral oil	Paraffin
Shale oil	Turpentine	White spirit (Turpentine substitute).

Variable Class — Variable flash point.

The following substances are of variable composition and should be grouped, therefore, according to their composition, flash points and other properties as certified by the makers:

Celluloid solution — (Collodion cotton in solution in or wet with inflammable liquids).
Paints — Bituminous paints, photogravure printing inks.
Polishes, Boot creams, etc. — Enamels.
Polishes, linoleum — India rubber and gutta percha solution.
Polishes, liquid metal — Roisin oil.
Ship's compositions — Tar oil compounds.
Varnishes, oil — Varnish, spirit.

Fuel and Lubricating Class — Those having a flash point of 150 degrees F (66 degrees C) and upwards.

BULK OIL MEASUREMENT

Some useful definitions relating to the measurement of bulk petroleum:

Density: Mass per unit volume.

In-transit loss: Difference between the Total Calculated Volume measured on board a vessel after loading and the Total Calculated Volume measurement on board prior to discharge (including OBQ "On Board Quantities" measured before loading).

On board quantity (OBQ): Sum of the measured liquid volume and non-liquid volume in cargo tanks just before loading, excluding clingage, hydrocarbon vapours and the content of associated lines and pumps. OBQ includes material in slop tanks where "Load on top" procedures are followed (see Petroleum — Bulk Carriage).

Outturn: Quantity of a cargo discharged from a vessel, measured by a shore terminal.

Outturn loss: Difference in Net Standard Volume of oil between the quantity shown on the Bill of Lading and the quantity shown on the Outturn Certificate.

Remaining on board (ROB): Sum of the measured liquid and non-liquid volume after measurement in cargo tanks on completion of discharge, excluding clingage, hydrocarbon vapours and the contents of associated lines and pumps.

S & W: Total sediment and total water suspended in the oil. In some parts of the world the old term "B S & W" (Base or Bottom Sediments and Water) is still used. This is generally found by analysis on a representative sample of the oil being loaded, and the result will be in percentage volume. The Nett volume delivered to the vessel (or received from the vessel upon discharge) is derived from this figure, and in the crude trade particularly, the result of this analysis is of extreme commercial importance.

Vessel experience factor — (VEF): Adjusted mean value of the vessel load ratios obtained after several voyages. The ratios consist of the quantity (TCV) of oil measured on board a vessel, immediately after loading (less the On Board quantity "OBQ"), i.e. quantity received by the vessel, to the quantity (TCV), measured by the loading terminal, i.e. the quantity delivered to the vessel (see Bulk Oil Measurement section).

The ratio is as follows:

$$\text{Vessel Load Ratio} = \frac{\text{Vessel's TCV after loading} - \text{OBQ}}{\text{Shore TCV loaded}}$$

Volume correction factor (VCF): Factor for correcting oil volumes to a standard reference temperature condition. For crude oil and products such factors should be obtained from the Petroleum Measurement Tables.

Volumes for measurement calculations:

total observed volume (TOV): volume of oil, including volume of free water measured at the observed oil temperature and pressure;

gross observed volume (GOV): volume of oil, excluding volume of free water measured at the observed oil temperature and pressure;

gross standard volume (GSV): volume of oil, excluding free water volume, calculated at standard conditions, i.e. 15°C and 1.01325 bar, and including OBQ, "On board quantities", unless stipulated;

net standard volume (NSV): volume of oil, excluding free water and S & W (i.e. suspended and disolved water and suspended sediment), calculated at standard conditions, i.e. 15°C and 1.01325 bar. This is normally calculated for Bill of Lading and/or Outturn purposes by the Terminals concerned;

total calculated volume (TCV): gross standard volume plus the free water measured at the temperature and pressure prevailing and including OBQ, "On board quantities", unless otherwise stipulated.

Water cut or dip: Measured depth of free water lying on the bottom of the tank, found generally by utilising a "water-finding" paste smeared on a sounding rod or measurement probe.

Wedge formula: This formula is used for calculation of OBQ or ROB, and generally relates to the volume of liquid material in a ship's tank, which is considered to lie in a "wedge formation" in the after end of a tank when the ship is trimmed by the stern (see Bulk Oil Measurement section). This formula relates to the dip, ship's trim, dipping point location and the tank's dimensions when the ship's calibration tables cannot be applied. Derivation of this formula can be found in the Appendix by courtesy of the Institute of Petroleum.

Weight conversion factor: Factor, dependent on the density, for converting volume to weight-in-air. Such factors should be obtained from the API-ASTM-IP Petroleum Measurement Tables.

Weight:

gross weight-in-air: weight of oil loaded including S & W, but excluding free water;

net weight-in-air: weight of oil loaded, excluding free water and S & W;

Note: Since, by definition, all commercial weights are "in air", the term is only included for sake of clarity and general usage.

Weight in vacuum: mainly used in the products trade, but some Oil Terminals declare this quantity on the Bill of Lading. It is the result of multiplying the volume in cubic metres at 15°C by the standard density (kg/litre) at 15°C, which by definition, is measured in vacuum.

Density of Petroleum

The Density of crude oil and products is defined as mass per unit volume, expressed as kg/litre or kg/cubic metre at 15°C.

Sometimes used are the associated properties, Relative Density (formerly Specific Gravity) at 60/60°F and API Gravity which relate density of the oil to the density of water. The relationship between API Gravity and Relative Density is given by:

$$\text{API gravity at 60 F} = \frac{141.5}{\text{rel. density 60/60 F}} - 131.5$$

Conversion of API Gravity to Density and Relative Density or vice versa is made using Tables 3, 21 or 51 of the API/ASTM/IP Petroleum Measurement Tables.

For establishing the density at 15°C (kg/Litre) of an oil having been given a relative density 60/60°F between the ranges of:

0.654–0.683	deduct	0.0001	to give density (kg/Lt) at 15°C		
0.684–0.757	"	0.0002	"	"	"
0.758–0.786	"	0.0003	"	"	"
0.787–0.852	"	0.0004	"	"	"
0.853–0.941	"	0.0005	"	"	"
0.942–1.033	"	0.0006	"	"	"
1.034–1.075	"	0.0007	"	"	"

The Standard Temperatures within the Oil Industry are usually either 60 F or 15 C. It is emphasized that density (Kg/Litre) is at 15 C (59 F) and not at 60 F. In some Countries when Crude or Products are shipped, a standard temperature of 20 C is used when quoting the density. In a few ports other standard methods may be used.

Volume of Petroleum

Crude oil and Products are generally measured in Barrels (bbls) or Cubic Metres (M3) and when converting from one volume to the other at an **observed temperature** the following is used:

Barrels (bbls) at Observed Temp. = Cu. Metres × 6.28981

If conversion at Standard Temperature is required i.e., from Cubic Metres at 15 C to barrels at 60 F then apply the following:

(This is Table 52 of the API/ASTM/IP Petroleum Measurement Tables. Note that in the Tables Density is usually expressed in kilogrammes/Cubic Metre as opposed to kilogrammes/litre).

Density 15 C	Bbls per Cubic Metre
654.0 – 697.0	6.295
698.0 – 778.0	6.294
779.0 – 901.0	6.293
902.0 – 1074.0	6.292

Eg: Given 63000 Cubic Metres at 15 C, density at 15 C (kg/litre) = 0.830
63000 × 6.293 = 396459 Bbls at 60 F.

When converting from barrels at 60 F, to Cubic Metres at 15 C then apply the following:

Density 15 C	Cubic Metre per Bbl.
654.0 – 683.0	0.15886
684.0 – 722.0	0.15887
723.0 – 768.0	0.15888
769.0 – 779.0	0.15889
780.0 – 798.0	0.15890
799.0 – 859.0	0.15891
860.0 – 964.0	0.15892
965.0 – 1074.0	0.15893

Eg: Given 450000 Barrels at 60 F, density at 15 C (kg/litre) = 0.840
450000 × 0. 15891 = 71509.500 M3 at 15 C.

Ullage Survey

Bulk Liquids shipped in Tankers are measured by undergoing a manual "Ullage Survey" or Gauging operation at each of the vessels tanks, or by remote gauge readings in the vessels Cargo Control Room. Ullage is the depth of free space above the liquid in each tank measured from the oil surface to a calibration point. This may need to be corrected for trim or list to find the corrected ullage. Ullages, temperatures and water cuts (with water-finding paste) are normally made in the presence of an Independent Inspector. Owing to the increasing demand for "Closed Measuring Systems" in many countries both on safety and environmental grounds, and for maintaining the integrity of the inert gas system in operation on most crude oil tankers and some product tankers, electronic and intrinsically safe measuring systems are often used for measuring these Ullages, temperatures and water cuts.

Ideally, the method employed for the Ullage Survey at the loading port (e.g. electronic measuring device, ullage tape) should be the same employed at the discharge port. The ullage measuring device or tape should be checked for accuracy prior to use. Ideally the temperature measuring device should be checked for accuracy against a calibrated mercurial thermometer before being brought into use, but a mercurial thermometer or an electronic temperature device, which are traceable to a calibrated

thermometer, is a sufficient alternative. However, the independent inspector in attendance should have the necessary means to check the ship's temperature device and should be asked to produce the proving records for his equipment. He should be requested to undergo this check in the presence of a Deck Officer. Large volumetric discrepancies have been known to occur between the ship and shore figures when these important checks have been overlooked.

Cargo Calculations

There is a Calibration Table for each tank and these will be entered to find the observed volume of liquid, the Total Observed Volume or TOV, corresponding to the corrected ullage. The volume of free water also found from the tank calibration table should then be deducted from the TOV to obtain the Gross Observed Volume of oil or GOV. This observed volume then has to be brought to a volume at the industry standard temperature of 60 F or 15 C. This is achieved by entering the ASTM-IP Tables to find the appropriate Volume Correction Factors by using arguments of observed temperature against Density, API or Relative Density (S.G.). In some Countries when Crude or Products are shipped, a standard temperature of 20 C is used when quoting the density.

It is important that the correct density information is received from the terminal before the Ship's Staff complete their cargo calculations so that cargo shortages, if any, can be identified and an appropriate Protest Letter issued against the Bill of Lading figures.

Documentation — Ullage Reports

Upon completion of the Ullage Survey at the Loading port, an Ullage Report should be prepared and the received quantity calculated and compared with the Bill of Lading figure. The Chief Officer should take into account the Vessel Experience Factor, when it is conceivable to do so, in order to ascertain whether a possible shortage exists. Should there be an apparent shortage, despite the rechecking of measurements, then a Letter of Protest should be addressed to the Terminal Operators or Shippers.

Similarly, on arrival at the discharge port, following the Ullage Survey, an Ullage Report should be prepared, and the arrival figure compared to the departure Load port figure. Should an appreciable discrepancy exist, then measurements should be rechecked. Recheck also whether trim and/or list corrections are necessary.

If the Loading/Discharging Terminal is at an open berth such as an SBM or FSU, where ship's movement has possibly occurred, then the Ullage Reports should be endorsed appropriately, i.e. "Vessel moving during ullaging".

Measurement of OBQ and ROB

For Definitions of OBQ and ROB, and wedge formulae, see Definitions on page 108.

The measurement of residues, particularly after discharge (ROB), is of vital importance and can give rise to substantial claims. Within the Crude Oil trade, many of these claims may have been justified when insufficient attention has been given to Crude Oil Washing, and stripping together with appropriate trimming and listing of the vessel for efficient drainage. When a heated cargo has been carried, shutting off steam coils too early can cause rapid cooling of the remaining cargo, and prevent efficient stripping from taking place. Many owners engage surveyors to represent their interests at ROB surveys, but the main issue is ensuring in the first place that minimum residues remain. Double hull vessels have an added advantage over single hull, as there is generally an after bilge well within the double bottom, aiding the process of the stripping operation and reducing the amount of residues. It is important that the Chief officer (or Cargo Officer) is well rested prior to this operation, so that he can apply himself to this operation effectively.

When measuring OBQ/ROB in the crude oil or dirty products trade, the cargo tanks are normally dipped using a sounding rod or an ullage tape with a heavy bob. The use of a portable electronic device for this procedure is not recommended. According to the ISO Standard for the measurement of ROB

and OBQ (ISO 8697: 1999) at least four positions in each tank should be used for quantification purposes and that one of these positions must be the reference gauging position as defined in the vessel's tank capacity table. The Institute of Petroleum and the American Petroleum Institute are not so specific on this issue. (see IP Petroleum Measurement Manual Part XVI Section 1 Crude Oil and API Manual of Petroleum Measurement Standards, Chapter 17.2) Ideally, ROB should be measured from as many positions in a tank as possible but if it is only possible to gauge from one position then the aft dipping point of the cargo tank would be the most appropriate as the vessel will have been trimmed by the stern for her stripping operation, and most of the liquid residues, if any, will tend to lie at the after end of the tank close to the tank suctions. Any liquid cargo remaining in the after part of the tank, unless appreciable, is generally considered to lie in a wedge formation, and for calculation purposes, the "wedge formula" (or ship's Wedge Tables from the Shipyard) will be used. (see definition of "Wedge Formula") If the "wedge formula" cannot be used because the amount remaining is too large (i.e. it is in contact with all of the tank side bulkheads) then the tank calibration tables will have to be utilised using trim correction where appropriate. Measures should be taken to try and confirm that any liquids detected in the after end of a tank are not only confined to a "puddle" below the gauging position. A measurement from an additional after dipping point would confirm whether this was the case or not.

Non-liquids or sludge are generally considered to lie across the bottom of the tanks (evenly or unevenly), and for quantification purposes the tank calibration tables would be used. For this reason it is highly recommended that measurements are taken from as many positions across the tank as possible, and the results averaged. However, there maybe occasions when the "wedge formula" could be used. An example would be when a vessel has been carrying a heavy and/or heated crude or a heated dirty product; the remaining small quantities may form a wedge at the after end of the cargo tanks upon completion of stripping, particularly once the heating coils are shut off. In order to confirm whether this is the case or not, where it is possible to do so, more than one gauging point should be used in order to obtain a profile of the non liquid layer. Any such gauging points should preferably be along the fore and aft line of the cargo tank.

Where disputes arise as to the exact nature of ROB and whether the residue is pumpable or unpumpable, it may be considered prudent for the parties concerned to attempt to take samples of the residue for analytical determination. Despite the result of any test, disputes of this nature are not easily resolved as there are too many variables involved.

Documentation (OBQ and ROB)

In the Crude Oil and Dirty products trade, prior to loading, an OBQ Report (and a Slop Certificate, if slops are on board) is prepared, outlining the nature and quantity of all the residues and free water in the cargo tanks. Similarly, on completion of discharge an ROB Report is prepared, detailing the nature and quantity of the residues remaining in the cargo tanks. If the Chief Officer is satisfied with the effectiveness and performance of the stripping operation and equipment, and the amounts remaining are within normal limits from previous experience on the vessel then he should endorse the ROB Report appropriately. This may assist should a claim situation arise.

Prior to loading in the Clean Products trade, it is quite usual for the inspector to Issue a Tank Cleanliness Certificate. In addition Ship Owners sometimes wish to ensure that their own Tank Dry Certificates are signed prior to loading. All Certificates should be checked for any prejudicial endorsements, and any disputes settled prior to commencement of the loading operation, otherwise the vessel could be held responsible in the event of a contamination claim arising.

Vessels Experience Factor

A profile is built up over a number of voyages, of ratios between the ship's received figures and shore delivered figures at loading ports. Assuming accurate data is collated, the discrepancy shown, apart from a few exceptions, amounts to an error in ship's tank calibration. It is important that the data collected is accurate, and that as much information regarding loading Terminals' calculation methods are obtained from the independent inspectors. One of the most important points is whether the Terminal uses the new or old ASTM Tables for Bill of Lading volume correction. The VEF should be compiled on

"like" data whenever possible. When the Bill of Lading has been based on ship's figures, then the data from this loading would be excluded from the VEF Record. On occasions, when the Bill of Lading is to be based on ship's figures, an accurate VEF Record comes into its own. At a number of Terminals world-wide, which issue Bills of Lading on ship's figures, do also adjust the figure based on the VEF record. It stands to reason that in these cases, from a commercial point of view, the accuracy of the VEF data is crucial (see Definitions).

ASTM — IP Tables for Volume Correction Factors (ASTM D 1250) (IP 200)

Generalised Crude Oils

Table 6A Volume Correction to 60 F against API gravity 60 F.
Table 24A Volume Correction to 60 F against RD 60/60 F.
Table 54A Volume Correction to 15 C against Density at 15 C.

Generalised Products

Table 6B Volume Correction to 60 F against API gravity 60 F.
Table 24B Volume Correction to 60 F against RD 60/60 F.
Table 54B Volume Correction to 15 C against Density at 15 C.

Generalized Lubricating Oils

Table 6D Volume Correction to 60 F against API gravity 60 F.
Table 54D Volume Correction to 15 C against Density at 15 C.

Useful ASTM — IP Conversion Tables

Table 1 — Interrelation of Units of Measurements.
Table 11 — Barrels at 60 F to Long Tons against API at 60 F.
Table 13 — Barrels at 60 F to Metric Tonnes against API at 60 F.
Table 29 — Long Tons per Barrel against SG/RD at 60/60 F.
Table 56 — Cubic Metres at 15 C to Metric Tonnes against Density at 15 C.
Table 57 — Cubic Metres at 15 C to Long Tons against Density at 15 C.

Sampling/Analysis

Sampling can be made by an auto in-line sampler fitted within the loading/unloading line in the Terminal installation, or by a portable sampler fitted to the Tanker manifold flange and/or by manual means. Manual sampling is performed by various means and equipment depending on the product, the individual requirement and also the type of tank openings available.

Samples of the product involved in the custody transfer are tested for density and many other criteria. If crude is being analysed a very important test is that for BSW or Base sediments and water. This is measured as a percentage and will result in a deduction to the Gross Bill of Lading or Gross Outturn making a Nett Bill of Lading or Nett Outturn. Usually the commodity is only paid for on a Nett basis and therefore this particular test can be critical.

The density of the petroleum cargo loaded should be determined in a shore laboratory by the Terminal staff in the presence of an independent inspector. Should ship's staff wish to confirm the density for themselves they should either arrange to have their own surveyor present at the above test or arrange to have their own test done on board the vessel in a well ventilated room, within a safe zone, and with the correct equipment. The analysis should be made on a representative sample of the cargo.

At loading Terminals, when loading clean products, ship's staff should ensure that samples of the initial line displacement are drawn at the ship's manifold, and that "first foot" samples are drawn from each tank. In all oil trades a duplicate set of samples drawn by the Inspector and/or Terminal staff should be requested for retention on board. Separate, so called "official" samples are placed on the

vessel after loading by the Shippers for delivery to the Receivers. All samples retained on board should be appropriately sealed, labelled and stored in a well ventilated space away from heat sources. The samples retained for the ship should only be disposed of once the ship's Owners have confirmed that there is no possible claim arising on the cargo/product concerned. The samples concerned should be disposed of properly i.e. either emptied into the vessel's Slop Tank or in special reception facilities at an Oil Terminal.

N.B. Claims can still arise up to 18 months after the shipment concerned and thus if there is any doubt, the samples should be retained on board for as long as possible. If there is inadequate space onboard the vessel then it is recommended that an appropriate shore storage facility is arranged with the ship Owners.

PETROLEUM — Bulk Carriage

Some useful definitions relating to bulk petroleum carriage practice:

Clingage: Oil residues which "cling" to the surface of tank walls and structures during carriage and on completion of discharge. This is particularly the case when carriage requirements such as cargo heating are not complied with. Unlike ROB these quantities cannot be measured, but can result in large outturn losses in crude oil cargoes, particularly if Crude Oil washing techniques are not undertaken effectively.

Load on top (LOT): Defined as both a practice and procedure in the crude oil trade:

- The "practice" is the act of commingling on board quantities (OBQ) with cargo being loaded.
- The "procedure" refers to the operation whereby water and oil mixtures are collected in a vessel's slop tank during a ballast voyage as a result of water washing of cargo tanks. Settled water is decanted to the sea and the remaining oil slops are "loaded on top" with the next crude cargo.

Slop quantity: The total volume of material collected after such operations as stripping, tank washing or dirty ballast separation. It may include oil, water, sediment and emulsions and is usually contained in a specific tank or tanks for this purpose.

Prior to Shipment of Crude

Crude oil vessels of the future will be either single or double-hulled but all ballast will be segregated (Segregated Ballast Tanker SBT). The older Clean Ballast tankers are gradually being phased out. This will, in most circumstances, remove the requirement either for Terminals to have dirty ballast reception facilities, or for vessels, on a regular basis, to water wash and change ballast on the ballast passage to the loading port. Not only is it more environmentally friendly, but will also reduce the work load. However, there will be times when even a double-hull SBT, or single hull SBT vessel, will have to undergo water washing on her ballast passage. This may be for tank maintenance reasons, prior to dry-docking, to take heavy weather ballast or prior to loading a crude cargo for specialised refining, e.g. a wax-free crude such as Laguna or Tia Juana Pesada from Venezuela.

In these circumstances the oil/water washings are collected as "slops" and the oily/water quantity is reduced to the sea from one of the Slop Tanks via the Oily/Water Discharge Monitor, the oil/water concentration being within special set criteria in accordance with the latest international regulations found in MARPOL and with reference also to the recommendations found in the Clean Seas Guide. The remaining oil and water mixture will be either segregated on board, pumped to a Slop barge or to the Terminal prior to loading, or be "loaded on top" according to Charterer's instructions.

Prior to Shipment of Clean/Dirty Products

It is not the purpose in this section to give specific guidance on tank preparation for specific products. Oil Companies and Charterers differ in their attitudes on this subject dependant on the trade and the end use of the product.

Normally the Petroleum product grades are shipped in smaller tonnage than that allocated to Crude oil. Generally the vessels have a segregated ballast system.

It is important that the Charterers Instructions are sought regarding Tank Cleaning when a change of grade is likely. Some products are incompatible despite tank cleaning. Other products may require little or no tank cleaning except where sludge control is necessary. For example, prior to loading Vacuum Gas Oil, the tanks generally must be free of salt and metals and therefore when tanks are washed they must either be first salt water washed followed by a fresh water rinse, or only fresh water washed. It is possible that samples of any OBQ (On board quantities), sludge and the like, will be taken and sampled in a shore laboratory and the vessel delayed if any contaminants are found and the vessel then has to recommence washing.

Tank coatings should be inspected regularly and maintained. Some products can leach out residues from previous cargoes trapped behind broken down coatings, causing cross contamination.

Cargo Heating

The Institute of Petroleum has published a booklet entitled "Guidelines for the crude oil washing of ship's tanks and the heating of crude oil being transported by sea" (Petroleum Measurement Paper 8). In this booklet there are recommended guidelines for the carriage temperature of certain crude oils. However, specific instructions prior to the loading of any crude oil or clean/dirty products should be requested from the Charterer when uncertain of the carriage requirements. Should Charterer's instructions conflict with the Guidelines (Ref: IP Petroleum Measurement Paper 8), then this should be brought to the Charterer's attention. However, Charterer's final instructions should always be followed.

Steam heating coils should be pressure tested to manufacturers instructions prior to each loading of a cargo which will require heating. Note that most VLCC's (very large crude carriers) generally do not have steam heating coils, except within one or both of the slop tanks.

Multigrade Loading

Efficient segregation is imperative when carrying multigrade crudes and products. There should be at least two valve separation within the ships pipeline system, which should not include tank suction valves.

Stress Criteria

It is imperative that hull stresses are predetermined for the loading and ballasting conditions and also regularly checked at intermediate stages of any operation.

Stability Criteria

A Tanker with cargo wing tanks and centres of conventional design and which has most of her cargo tanks 98% full, would not normally have any stability difficulties. The metacentric height would be large in comparison to General Cargo vessels, but when many tanks are only to be partly filled, then the GM should be precalculated as a precaution. However, OBO's (Oil, Bulk, Ore carriers) and some of the more modern double-hull designed tankers with wide cargo centre tanks, and without oil-tight longitudinal bulkheads along the centre line, have large unobstructed free surface areas, and require extreme care during loading and discharging of oil cargoes, or during ballasting and deballasting. The free surface effect in slack holds (i.e. filled to below the hatch coaming) or wide tanks, can allow unrestricted movement of the liquid, resulting in both loss in stability and "sloshing". It is important that Loading and Discharging Instructions, together with the Stability Data supplied to all these types of vessels, are rigorously followed and before arrival in port a plan of operation is prepared bearing in mind these critical issues. (See ISGOTT).

Crude Oil Washing (COW)

In the crude oil trade, this operation is undertaken during discharge, in order to keep to a minimum the amount of oil residue remaining in the cargo tanks, not only for ROB and Outturn purposes, but to reduce the possibility of pollution when ballasting of cargo tanks is necessary. (See "Prior to Shipment of Crude" ref. Ballast in cargo tanks.) Effective COW also reduces the amount of "clingage" (see Definitions, above).

As previously mentioned under the sub heading **Cargo Heating**, the Institute of Petroleum has published a booklet entitled "Guidelines for the crude oil washing of ship's tanks and the heating of crude oil being transported by sea" (Petroleum Measurement Paper 8). In this booklet there are recommended guidelines for Crude Oil Washing taking into account the differing properties of crude oils. Crude Oil Washing is not always effective, and may give rise to large Outturn losses due to inherent high vapour pressures. Should Charterers instructions conflict with these Guidelines (Ref: IP Petroleum Measurement Paper 8) then this should be brought to the Charterers attention. However, Charterer's final instructions should always be followed.

Carriage of Petroleum Products in General Cargo Vessels — Packaged Petroleum Products

If this class of cargo is carried in an ordinary general cargo ship; the quantity, type, marking, and permissible stowage of cases, drums and containers is governed by the IMDG Code (2000). Reference to this publication must be made and the Master and his Agents must be satisfied that the product is properly packaged and labelled and the proposed stowage is appropriate. In addition, reference should be made to "The IMO Recommendations on the Safe Transport, Handling and Storage of Dangerous Substances in Port Areas". Shippers and Charterers should be requested for detailed information relating to the hazardous nature of the cargo concerned, including details of its toxicity. The information supplied should be displayed for all the ship's staff and stevedores to read. All information supplied by Charterers should be supplemented by the details contained in the IMDG Code for the product concerned.

The Master must be advised on the properties of the cargo and its reaction to exposure to air, water, or fire. Emergency procedures and suitable safety equipment must be in place when dealing with spillage, leakage, or inhilation and contact with skin, eyes etc. (See IMDG Code (2000) Supplement).

Ideally, drums containing hydrocarbons should be stowed on deck, well away from accommodation, all ventilation units, machinery spaces, electrical and working spaces.

There is always a significant risk of fire and explosion when handling and transporting these goods, especially with the Benzine/Spirit Class. Great care must be taken at all times. Smoking and the use of naked lights, non-intrinsically safe lighting or electrical appliances, should be strictly prohibited. Warning signs as to the nature of the hazard, and in particular "No smoking" signs should be prominently displayed around the area of upper deck where the drums are stowed, and the area cordoned off with high-vis. tape. If a large consignment of hydrocarbons in drums is to be shipped, and hold carriage is required, "No smoking" and "Restricted Entry" signs should be prominently displayed around the area of upper deck above the subject cargo hold/s. Additional fire fighting equipment should be stationed and maintained in close proximity to the area from the time when loading commences and until the last drum package is discharged. Prior to discharge the atmosphere in the space must be tested and a "Gas Free Certificate" issued. It is also prudent for a surveyor to carry out daily checks during loading and discharge prior to stevedores entering the hold. This should be complemented by checks made by the Deck Officers during the period of work. A tally of the stevedores entering the hold should be maintained, and the procedure for "entry into enclosed spaces" followed. Ventilation fans should be run at all times during the loading, carriage and discharge of this cargo.

A Deck Officer should check the hold atmosphere during the sea passage, and prior to any entry of the hold, from a remote position on the upper deck area, e.g. from the hold access, using an oxygen analyser and a combustible gas analyser with an appropriate length of rubber piping as a sampling tube. This is to ensure that the atmosphere is not within an explosive range and ensure sufficient oxygen for entry. This equipment may have to be supplemented by a Toxic Gas detector relating to the product being carried. In any event, it is recommended that the first entry of the day should be

made by a responsible person operating a breathing apparatus, and the "all clear" given once the whole compartment has been checked for vapours.

All leaking/damaged or unsealed drums and containers must be rejected. The space or deck must be adequately dunnaged and the stow made even to avoid chafing. The cargo must be securely lashed where movement is likely. Ideally the goods should be shipped on strapped pallets.

When compartments are filled with the Spirit Class of these goods, it is recommended that they be kept, as nearly as possible, hermetically sealed, but when it forms a proportion only of the cargo in any compartment, efficient ventilation is of first importance. To guard against sparks, the mouths of ventilators should be covered with fine gauze wire, especially when situated near the ends of deck houses, accommodation, etc.

It should be borne in mind that the risk of fire, explosion and toxicity, persists after the cargo has been discharged and until all traces of vapour have been expelled from the holds and bilges.

After discharge is completed, special attention should be given to the ventilation of all compartments, for which purpose hatches should be kept uncovered, all ventilation fans kept running, limber boards lifted, all oil and/or oily water in bilges removed, bilges cleaned — the use of naked lights, or defective electric fittings or cable being avoided.

Delicate or edible goods liable to damage by tainting should not be stowed with or near petroleum products, neither should the latter be stowed with or near to commodities which are liable to spontaneous combustion from whatever cause, such as coal, cotton, etc. Stow away from sources of heat.

Carriage in Deep Tanks

Apart from the large volume of these oils carried in bulk by tankers, consignments of certain classes of Mineral Oils are carried in the deep tanks of general cargo ships, some of which are:

Lubricating Oil, Water White Kerosene and Batching Oil — All three are readily contaminated by dirt and foreign matter so that, not only must the tanks be scrupulously clean and dry, the pipe lines must also be thoroughly steamed out, cleaned and all traces of oil, water, or other residue removed.

This requirement is best met by steaming and cleaning tanks, etc., immediately after the discharge of palm or other oil content, the plentiful use of caustic and thorough washing down with hot water.

According to shipper's requirements, the temperature should be raised slowly prior to pumping, usually 38 to 49 degrees C, however check shipper's carrying instructions.

Batching Oil is of straw colour and, as it is sold on its colour, it merits special pipelines. These are usually provided by consignees for discharging the same, as the slightest trace of fuel, lubricating or other oil will contaminate and, in consequence, lower its value.

Another safeguard against contamination resorted to when discharging these petroleum products is to provide a small tank on the deck of the receiving lighter into which the first pumping is received, the oil thus received being later clarified at the consignee's shore plant.

LIQUEFIED PETROLEUM GAS

The term Liquefied Petroleum Gas (LPG) is generally applied to commercial grades of Propane (predominantly C_3H_8) and Butane (predominantly C_4H_{10}). Chemically pure liquefied petroleum gases are carried by sea but are usually identified by their individual names (i.e. Ethylene, Propylene, Butadiene, etc).

Commercial grades of LPG (i.e. Propane and Butane) are not required to be chemically pure; their end use being mainly for heating purposes or as a motor vehicle fuel, an expanding market.

Commercial Propane is maintained in the liquid phase either by pressurisation (at ambient temperature and a pressure of approximately 7.5 Bar Gauge), by refrigeration (at atmospheric pressure and a temperature of −42°C) or by partial pressure/refrigeration (at pressures and temperatures between these two extremes).

Commercial Butane is maintained in the liquid phase by either pressurisation (at ambient temperature and a pressure of approximately 1.5 Bar Gauge), by refrigeration (at atmospheric pressure and a temperature of −0°C) or by partial pressure/refrigeration (at pressures and temperatures between these two extremes).

Vessel Types

Vessels which carry LPG's are of three types:

(a) Pressurised vessels, which carry liquefied gases under pressures up to 17 Bar; these vessels are normally capable of carrying liquids with temperatures up to +45°C.

(b) Semi-refrigerated vessels, which carry liquefied gases up to pressures of about 5 Bar and, dependent on the type of metal and construction of the containers, at temperatures of down to −50°C.

(c) Fully refrigerated vessels, which carry liquefied gases at, or just below, their atmospheric boiling point temperatures. The cargo is kept liquid in the tanks by a combination of an efficient cargo tank insulation system and a refrigeration plant. The tanks are constructed to contain pressures up to about 0.30 Bar Gauge, and always with a slight "over pressure" to prevent any ingress of air (oxygen).

Such vessels are normally intended for the carriage of LPG and liquefied chemical gases and the cargo tanks are constructed of special steel capable of containing liquids at temperatures down to −50°C.

Note: Both the fully refrigerated and the semi-refrigerated vessels are equipped with reliquefaction plants which reliquefy any "boil-off" gases and returns them to the cargo tank as a cold liquid.

LPG's are normally carried in either pressurised or semi-refrigerated vessels, the type used on any particular trade being dependent on the type of facilities at the load and discharge ports which must match the ship type.

The vessels vary between the very small coastal types of 5–600 cubic metres to those of 70–80,000 cubic metre capacity. The smaller vessels usually carry LPG under pressure, whilst the larger vessels are virtually all fully refrigerated.

Cargo Measurement

For the latest in LPG measurement refer to "The Institute of Petroleum — Petroleum Measurement Manual Part XVI — Section 3 — Liquefied Petroleum Gases — Procedure for Oil Cargo Measurement by Cargo Inspectors.

Measurement of LPG's can either be carried out by static means (tank gauge systems) or by dynamic methods (shore line based meters) when loading.

Measurement in ship's tank is normally by automatic gauges of which there are many different types in use (from the float gauge through to ultra sonic and laser systems). Temperature and pressure in each tank are equally as important as the liquid level and are measured by "in tank" instruments. All automatic "in tank" systems should be recalibrated at every opportunity, to ensure accuracy.

Cargo Handling

LPG's are handled under a completely closed gas-tight system and are neither seen nor physically handled. All measurements are made using automatic gauges (liquid level, pressure and temperature). Any samples taken are analysed under controlled laboratory conditions.

Care must be exercised when sampling to ensure that the samples are as representative as possible. The connections on the sampling equipment and the sampling points on the vessel must be compatible.

Cargo Quality

LPG's are used as fuels and as such are vaporised before ignition. If the composition of the LPG meets the specification laid down then no serious problems should be encountered in use, other than the attempted use of the wrong product (e.g. the use of butane, when ambient temperatures are at or below 0°C, would not generate any vapour, with all of the butane remaining in its liquid phase).

Contaminants in LPG are:

(a) Sulphur compounds, other than Diethyl Sulphide or Ethyl Mercaptan (which are used to stench the product with an objectionable odour to make any leaking gas readily noticeable) will cause corrosion to the metals used in pipe work carrying the gas from storage to burner. The standard test for corrosion is the Copper Corrosion test, in which a clean, bright strip of copper is suspended in a sample of the liquid gas for one hour at 40°C. The copper strip is inspected on completion of the test and its visual appearance compared with standard discoloration strips. Discoloration indicates a constituent in the gas which is corrosive to copper and would eventually make any installation using copper piping unsafe due to leakages.

There are a number of empirical tests (tests which are qualitative but not quantitative) for sulphur compounds (e.g. Hydrogen Sulphide may be detected by the use of moist lead acetate paper).

(b) Oily matter and gums will cause sooting when burnt and are undesirable. They also reduce the calorific value of the LPG.

The empirical test for the presence of oily matter and gums known as the weathering test. The test involves the "weathering" or opening a sample of the LPG to atmosphere under controlled temperature conditions and allowing it to evaporate for a set period of time. On completion of the time, the quantity remaining is measured giving some indication of the oils and gums present in the LPG.

(c) Water is another undesirable contaminant. Its presence may lead to the formation of either ice or hydrates which may block the pumping system.

Water, in small quantities, may be dealt with by the addition of small quantities of methanol which is hygroscopic. Care must be taken in the quantities added to ensure that the characteristics of the cargo are not changed to the extent that it becomes unacceptable.

An empirical test for water relies on the effects of water vapour on Cobalt Bromide.

(d) Ammonia; LPG's may be carried in vessels which have previously carried ammonia. Ammonia contamination may result in a product which is highly corrosive to copper or copper alloy fittings.

Extreme care must be exercised when cleaning tanks and associated pipelines, pumps and compressors from ammonia to LPG. At one stage of the operation it is preferable that the tanks are placed under breathable air and then opened up for internal inspection. In some instances it may be preferable to wash the tanks out with fresh water to ensure that all traces of the ammonia and any ammonia salts, which appear as white crystals on the inner tank walls, are removed.

Specifications and Standards

There are various specifications for LPG's and the following standards are typically found within the LPG industry:

(a) A typical LPG standard is that issued by the British Standards Institution.
(b) Another commonly used specification is that issued by the NGPA (National Gas Producers Association of the U.S.A.).
(c) The International Standards Organisation (ISO) also issued standards applicable to the handling, measurement, carriage and analysis of LPG's.

LIQUEFIED NATURAL GAS

Liquefied Natural Gas (LNG) is a clear, water white liquid carried at or just below its atmospheric boiling point of approximately −163°C. Its major constituent is Methane (CH_4).

Natural gas is found either in association with crude oil deposits or, for the commercially exploited deposits, in reservoirs which only contain gas and possibly gas liquids.

Marine carriage of LNG requires specially constructed vessels with containment systems capable of withstanding the extremely low temperature at which the cargo is transported. The liquid is maintained in the liquid phase by a very efficient insulation system minimising heat leakage into the cargo. Any boil-off gases are odourised and pumped into special double-walled piping in the engine room, to be used as fuel for the vessel's boilers.

Whilst maintenance of LNG in liquid form by pressure is technically possible it is considered non viable, commercially, due to the high financial commitment required to build both ships and shore plant capable of containing the high pressures involved.

Containment Systems

An LNG carrier has to meet IMO Class I standards of construction; all such ships are double hulled and the containment system is either inserted or built into the inner hull. There are four main types of containment system:

(a) *Conch Self Standing System* — Tanks are built of a low temperature aluminium alloy and either built in the hull during construction or built ashore and lowered into the holds of the ship.

Insulation is fitted externally between the tank and the inner hull.

(b) *Gaz Transport System* — A system built up on the inner hull consisting of two layers of insulant, perlite in special plywood cases, each layer of insulation having a covering of a high nickel steel metal sheeting, some 1.5 mm thick (called INVAR). The coefficient of expansion of INVAR is approximately 13×10^{-7} m/m/°C (for all practical purposes, zero).

(c) *Technigas System* — A system made up of waffled stainless steel plates laid on an insulating system which has a secondary barrier consisting of a thin metal layer some 15 cms below the primary barrier. The waffling is very carefully designed to allow for the shrinkage of the inner barrier metal under LNG temperatures so that the barrier waffles provide sufficient metal to allow the contraction stress to be taken up during the shrinkage process.

(d) *The Kvaerner-Moss System* — A system of large spherical tanks which sit in "egg cups" in the ship's holds. The tanks are either built of aluminium or special low temperature steel. Insulation is attached to the external surfaces of the spheres.

Stowage

Stowage is governed by the rules concerning loading levels; these are set down to ensure that, whilst at sea, the cargo cannot generate large surface waves and cause structural damage to the containment system, especially in tanks of types (a), (b) and (c) above. These tanks are built with a chined section in the top and bottom which effectively reduces the surface area of any liquid, thus reducing the risk of "sloshing" damage.

Cargoes must be carried with their surfaces in the chined sections. Each vessel is provided with specific instructions concerning the maximum and minimum levels at which she may carry cargo at sea.

LNG vessels do not usually have the facility to reliquefy the boil-off gases. Any boil-off gases, therefore, are odourised and used as fuel in the boilers and the steam produced to power the steam turbine propulsion system. When the vessel is stationery in port the steam produced by the LNG boil-off is dumped through the steam plant condensers.

Cargo Measurement

Measurement of LNG is possible in shore tanks but the loading or discharge process requires that the product is handled in a "closed circuit" to avoid introduction of air (oxygen) into the system; any over pressurisation of the system is corrected by returning liquid/vapour to the cooling process, or burning it at the shore flare. Because of the difficulties in accurately measuring the quantities returned to shore it is normal practice to rely on the ship's calculated cargo for the Bill of Lading quantity.

LNG carrier's cargo tanks are accurately calibrated as are their cargo measurement systems which, by the nature of the product carried, are all automatic. The methods of calculation are normally contained within the Contract of Sale/Purchase/Carriage but there are measurement and calculation standards published by the International Standards Organisation (ISO), The Institute of Petroleum (IP) and the American Petroleum Institute (API).

As discussed above, most LNG vessels will use any "boil-off" gas as fuel in the main boilers whilst at sea and, in fact, most sea passages are fuelled by the "boil-off'. This use of the cargo for ship's purposes is acknowledged in the carriage contracts, the amount used being the difference between the cargo quantity loaded and the cargo on arrival at the discharge port.

The vessel will retain a small "heel" of cargo for use in cooling down the cargo tanks on the ballast passage. This saves time, effort and LNG prior to commencement of loading. Again, account is made of the quantity retained on board and an adjustment made when calculating the cargo delivered.

Handling

Great care and attention to detail must be given to handling this product. In its liquid form its temperature is so low that any contact with the normal metals from which ships are built will result in instant metal failure, with potentially catastrophic results for the integrity of the hull. Special care must be taken to ensure that any loading or discharge connections between ship and shore are fully drained and contain no liquid whatsoever before they are opened. Drain/vent openings are provided and both ship and shore should make certain that the lines are completely free of any liquid.

Monitoring

All LNG ship's are provided with an automatic monitoring system which samples all spaces surrounding the cargo containment system for the presence of LNG vapours. Some are provided with "cold spot" temperature detection, but it may be necessary to institute a system of visual checks of the outer surfaces of the inner hull for "cold spots". These easily can be detected by ice formations which occur in the vicinity of any containment system breakdown. Great care must be exercised when entering the spaces between inner and outer hulls and the Regulations for Entry into Closed Spaces must be fully observed.

LIQUID CHEMICAL CARGOES

Introduction

The wide range of liquid chemical cargoes transported in bulk by tank-ship can be divided into the broad categories viz: chemicals which are liquid at normal carriage conditions and those which are gases under ambient conditions but are liquefied for bulk shipment purposes by the application of higher pressure or lower temperature (e.g. Chlorine and Ammonia respectively). Liquefied Petroleum Gases (LPG), most notably Propane and Butane are usually classified separately.

As the name "bulk chemical" implies, the subject commodities are generally intended for further downstream processing in the chemical industry, often involving expensive and sensitive catalysts which are susceptible to irreversible damage by contaminants in the feedstock. Consequently, most chemical commodities are manufactured to a high level of purity and custody transfer schedules applied during bulk shipment encompass stringent measures for cargo quality control.

GUIDELINES ON CARE OF CHEMICAL CARGOES DURING SEA-BORNE CARRIAGE

Key Points to Consider Prior to Loading

Prior to loading, careful planning is essential. Onboard consideration must be given to a number of technical and operational factors. A summary checklist of key points is given below.

Tank Capacity: Check that there is sufficient volumetric capacity, making due allowance for possible expansion of cargo due to likely increase in temperature.

IMO Tank Type: Select correct tank type (IMO I, II, or III) based upon cargo requirements.

Tank Coating: Refer to tank coating resistance list issued by manufacturer. Refer individual enquiries to the manufacturer if necessary. Ensure that the integrity of the tank coating is satisfactory for the safe care of the goods.

Adjacent Cargoes: Refer to the U.S. Coast Guard guidelines regarding compatibility of adjacent cargoes. Check whether heated adjacent cargoes are present and, if so, if the situation is acceptable.

Temperature Requirements: If the cargo is to be heated or cooled, stow in a tank capable of performing the task. Test the system before loading the cargo. Establish that the stowage is acceptable with respect to adjacent cargoes.

Tank Cleanliness: Ensure that cargo tank cleanliness is adequate. Refer to in-house guidelines and published tank cleaning references.

Vessel's Trim: At all times, the vessel must operate within acceptable operating limits for trim and stability; factors which must be considered for proposed cargo loading and discharge rotation of cargo parcels.

FURTHER EXPLANATORY NOTES

Tank Cleaning and Inspection

Cargo tank cleaning recommendations for most commonly shipped bulk liquid chemical products are set out by Dr. A. Verwey Chemical Laboratories and Superintendence Company reference manual "Tank Cleaning Guide" (latest edition 1992). The guide has been developed along the rules and recommendations set out in the International Maritime Organisation (IMO) Code for the Construction and Equipment of ships Carrying Dangerous Chemicals in Bulk (BCH-Code) and the IMO International Code for the Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk (IBC) and lists chemical products contained in those Codes and in Annex II. Appendices II and III of MARPOL 73/78.

Tank Coating

The suitability of a vessel's particular tank coating for loading a specific chemical cargo can be ascertained by reference to the coating manufacturer's "resistance list" which may also advise on special tank cleaning procedures.

The vessel's officers are also expected to have an up to date knowledge of the condition and integrity of the cargo tank coatings, since degraded and/or perforated/missing coating may cause the vessel's tanks to be rejected for loading a particular chemical grade when inspected by an independent cargo surveyor.

Cargo Lines and Fittings

Inspection of the vessel's cargo pumping, piping and tank heating facilities is an essential part of the preloading survey for determining a vessel's suitability to load a sensitive chemical product. Although many chemical parcel tankers have dedicated cargo piping and individual submersible cargo pumps and heating coils for each tank, there still exist possibilities that prior cargo residues, tank washing solutions, water and/or heat exchange fluid may be retained in undrained piping, cargo pump cofferdam spaces and leaking heating coils. To this end it is essential that tank cleaning operations also include thorough line cleaning and draining of cargo piping and heating coils, blowing of cargo pump cofferdam spaces and pressure testing of heating coils and submersible cargo pump seals.

Care During Loaded Passage

Special attention to instruction details concerning chemical cargo stowage conditions during the loaded voyage is essential in order to maintain product quality integrity which may be affected by variations in conditions of temperature, inhibitor levels, moisture and/or oxygen content of the containment tank headspace vapours.

Certain chemical products are shipped with specific stipulations with regard to the minimum and/or maximum temperature levels for onboard stowage of the grade in question and those parcels stowed in adjacent cargo tanks.

Chemicals which are sensitive to degradation by oxygen are usually required to be loaded into tanks which have previously been purged with Nitrogen to a specified reduced oxygen level in the cargo space atmosphere. Further, the inert atmosphere has to be restored on completion of loading and, by routine monitoring, must be maintained inert throughout the voyage.

Chemically unstable products, notably those which polymerise during passage of time are normally shipped with an inhibitor added to prevent the reaction. The inhibitor system may require specific tank atmosphere conditions and sometimes there is a need to add extra inhibitor when, during a long voyage, the routine cargo tests performed by vessel's officers indicate decline in inhibitor activity. It is essential to monitor the temperature of such cargoes.

Safety Advice

There is an extensive body of information and data sheets on safety and emergency procedures in the handling of hazardous and noxious chemicals. IMO has published an "Index of Dangerous Chemicals Carried in Bulk". The index, prepared by the United Kingdom Laboratory of the Government Chemist, lists chemicals referred to in the BCH and IBC Codes (Chapters VI, VII and XVII and XVIII respectively) and provides alternative names and abbreviations by which certain chemicals are known. In addition to providing the chemical United Nations serial number (UN No.) (where assigned), where possible the number assigned by IMO "Medical First Aid Guide for Use in Accidents Involving Dangerous Goods" (MFAG No.) is also provided for easy reference. Another source of health and safety data on hazardous chemical cargoes is the International Chamber of Shipping (ICS), "Tanker Safety Guide (Chemicals)" which contains individual data sheets on approximately 300 bulk chemical products. The data sheets also provide details of fire and explosion data, physical and chemical data and handling/storage recommendations on the individual chemical grades.

Pollution Prevention

This is an area of intense public concern and legal regulations worldwide are becoming increasingly stringent. The International Convention for the Prevention of Pollution from Ships (MARPOL 73/78) has published regulations with respect to shipboard handling and discharge at sea of harmful substances. Annex II contains details regarding bulk liquid noxious substances and includes liquid chemical cargoes.

All vessels engaged in the chemical trade are required to provide a Procedures and Arrangements Manual (P & A Manual) which is customised to the individual vessel's cargo handling and stowage systems. Amongst several other sections concerning the vessel's equipment, arrangements, procedures and performance characteristics, the P & A manual also lists those chemicals permitted for onboard stowage, relevant restrictions with respect to the pollution category, cargo arrangements and discharge of residues and tank washing solutions to sea and shore reception facilities.

Major Chemical Commodities Shipped in Bulk

Caustic Soda (Sodium Hydroxide Solution)

There are several grades of Caustic Soda traded internationally, some of which require special shipboard handling/stowage conditions in order to eliminate product contamination to prevent crystallisation of sodium hydroxide from the liquid phase ("freezing") and to improve pumpability. "Rayon" and "Mercury" grades in particular require stowage in perfectly coated tanks (not zinc based) or stainless steel tanks. Some shippers may require protection against iron pick-up. Stowage temperature/heating requirements may vary from no heating in warm climates to heating to 43°C in severely cold conditions. The cargo specific gravity may be as high as 1.5.

Sulphuric Acid

At all concentrations, bulk shipment of Sulphuric Acid requires containment in tanks of stainless steel construction materials. However, the more dilute solutions of Sulphuric Acid (common ones are 65%–75% H_2SO_4) are highly corrosive to certain stainless steel alloy formulations. In all cases, the stainless steel manufacturer should be consulted prior to shipping Sulphuric Acid. Mild steel and coated tanks are not suitable for Sulphuric Acid shipments. Commonly encountered, high purity grades (98–99.5% H_2SO_4) have an SG of about 1.84 and an approximate freezing point of +5°C.

Methanol (Methyl Alcohol)

Methanol is regularly shipped as a high purity commodity requiring strict preloading assessment of cargo tank suitability with respect to coating compatibility (consult coating resistance list/manufacturers) and coating condition/cleanliness (wall-wash tests for Chlorides and Hydrocarbon residues) in order to comply with the "water-white" tank cleanliness requirement. Specific Gravity 0.79.

EDC (Ethylene Dichloride)

EDC shipment normally requires that vessel's cargo tank condition is strictly assessed to comply with the "water-white" cleanliness standard by means of wall-wash testing. Tank coating compatibility should also be investigated by reference to the coating manufacturer's resistance list. EDC is a water-critical cargo requiring thorough drying of vessel's cargo handling and containment systems prior to loading. Specific Gravity 1.25.

Styrene (Styrene Monomer)

Styrene monomer is shipped as an inhibited cargo and requires stowage away from heated cargoes. The product is traded at 99.5%+ purity levels and requires a high level of cargo tank cleanliness ascertainable by visible inspection. Certain types of coatings and bare, mild steel tank surfaces may exclude those tanks from carriage of Styrene (check with shipper and coating resistance list). Monitoring and maintenance of inhibitor levels may be required during long voyages. Post-discharge tank cleaning requires special attention to prevent Styrene residues from polymerising.

Benzene, Toluene, Xylene (BTXC)

Benzene requires a closed loading arrangement, restricted adjacent cargo temperatures (maximum 37°C) and a minimum stowage temperature of 8°C.

Toluene should not be stowed with adjacent cargo temperatures in excess of 38°C.

Xylene has three isomers — ortho, meta and para (o, m, p) for which the maximum adjacent cargo temperatures are respectively 37, 37 and 48°C. P-Xylene has a recommended carriage temperature of 23°C, thus frequently requiring heat.

MTBE (Methyl Tertiary-Butyl Ether)

MTBE, a gasoline blendstock (water critical), cargo tanks generally require visual inspection and checking for water in vessel's cargo handling and containment systems. Certain tank coating materials are not compatible with MTBE and resistance lists should be referred to.

MEG (Mono-Ethylene Glycol)

Polyester Fibre Grades (FG) and sometimes Antifreeze Grade, require wall-wash inspection of vessel's tanks to comply with stringent requirements of cleanliness ("water-white standard"). Carriage under Nitrogen blanket is recommended for FG product during ocean voyage. An adjacent cargo temperature limit of 38°C maximum is to be observed and a high degree of tank coating integrity is essential to prevent deterioration of MEG UV light transmittance characteristics by way of pick up of traces of contaminants.

Phosphoric Acid (Ortho-Phosphoric Acid)

Phosphoric Acid is shipped in several grades (e.g. Food, Fertiliser, Commercial) which range in purity from 40–98%. Certain grades are corrosive to stainless steel alloy formulations. The commodity should always be shipped in compatible stainless steel stowage. Manufacturers of the stainless steel construction materials should, if necessary, be consulted before accepting cargo. The high purity (food) grades will require heating to prevent freezing whereas the fertiliser grades contain suspended particulate matter and are often delivered to the vessel direct from the manufacturers at high temperature but do not require on-board heating. A maximum carriage temperature of 50°C is specified otherwise corrosion of stainless steel becomes excessive and certain grades are recommended to be circulated during stowage in order to prevent sludge settlement.

Ethanol (Ethyl Alcohol)

Ethanol is shipped at different proof levels (200 and 190) and in denatured and unadulterated purity forms. The Potable grades, frequently require especially stringent quality control and schedules, including "water-white" tank cleanliness and wall-wash inspection together with specialised organoleptic (taste and odour) inspections. Ethanol is aggressive to some types of cargo tank coatings — check resistance list.

IPA (iso-Propanol, iso-Propyl Alcohol)

IPA normally requires "water-white" tank cleanliness and wall-wash inspection and cargoes frequently have an odour-critical specification.

Adjacent stowage heat must be limited to 38°C maximum and coating resistance list must be consulted when considering this sometimes aggressive cargo.

OILS AND FATS

1. *The Nature of Oils and Fats*

The oils traded internationally can conveniently be divided into several categories. From the point of view of end-use, it is useful to divide edible (fatty) oils into vegetable and marine oils, with the vegetable oils comprising those obtained by the processing of seeds, e.g. sunflower oil, or of fruit, e.g. palm oil, the oil recovered from the fruit of the oil palm. Marine oils are basically all fish oils, but the oils obtained from different species of fish differ considerably in composition. The category of edible oils also include oils of animal origin, including butter oil, lard and tallow.

A second form of categorisation involves classifying the oils on the basis of the extent of processing which they have undergone prior to shipment. Most oils are shipped in the crude state, but the shipment of refined oils, often described as "Refined, bleached and deodorised" (RBD) has increased considerably as Malaysian palm oil production has grown. Refined oils are in some respects more sensitive to poor storage and handling conditions than crude oils.

The division of oils into those that are liquid at normal temperature and those that are either semi-solid or fully solid in this temperature range is important from the point of view of the shipper in view of the effect on handling the oil from the time of loading to that of discharge. Many of the seed oils are liquid at ambient temperature and are often referred to as "soft" oils, whereas oils such as palm oil and coconut oil are sufficiently solid at ambient temperatures to require some heating before being pumped into or out of ship's storage tanks. Castor oil is an unusual seed oil, which is traded internationally by the two most important producing nations, Brazil and India. The chemical structure of its principal component makes if far more viscous than all other vegetable oils and as a result, despite the fact that it remains liquid throughout normally encountered temperature ranges, it requires some heating prior to pumping.

Palm oil and its products, mainly palm oleine and palm stearine, account for a large proportion of the oil traded internationally, mainly using parcel tankers. These oils are shipped for the most part from various ports in Malaysia and Indonesia, but also from Singapore. Large quantities of these oils are shipped to various Asian destinations. The seed oils which are encountered most frequently in international trading are soya and sunflower oils, which are produced in and shipped from South American countries. In addition groundnut (peanut) oil is regularly exported from West Africa. A by-product of palm oil refining, Palm Fatty Acid Distillate (PFAD), is another important cargo.

Although it is possible to transport refined oils over long distances without significant loss in quality, provided proper precautions are taken, oil users in most cases prefer to purchase crude oils, as they can then refine the oil using their own preferred procedure. In the case of palm oil the Malaysian government has encouraged producers to export processed oils, and for this reason large quantities of RBD oils are exported from Malaysia.

2. *Edible Oils and Fats Contracts*

FOSFA International (the Federation of Oils, Seeds and Fats Associations Limited) concerns itself with all aspects of the international trade in oils and oilseeds and provides guidance on many questions relating to the sea-borne transport of oils.

FOSFA International provides contracts for use in the buying and selling of edible oils and fats *in bulk*. The contracts available cover all vegetable and marine oils traded, in most cases on a CIF basis but in some cases also in FOB form. The major role of palm oil products in the international oil trade has led to the development of a contract form specifically for these oils (Contract No. 81) in collaboration with the Palm Oil Refiners Association of Malaysia (PORAM).

The contracts, which may be modified by agreement between the parties to the contract, call for information to be included regarding oil quality, specifications agreed and quantities to be shipped. In the case of Contract No. 80, which covers crude palm oil, analytical characteristics of the oil both at the time of loading and on arrival at the port of discharge form part of the contract documentation. Other clauses in the FOSFA contracts cover tolerance with regard to quantity of oil delivered and the

use of superintendents for surveying and sampling. Standards for the vessel, the ship's tanks used for the contracted cargo and conditions for transshipment also form part of the contract. Insurance and shipping documents are covered by other clauses. The clauses on Sampling and Analysis should be read in conjunction with that on Superintendents.

3. *Acceptable and Banned Cargoes*

The International trade in vegetable and marine oils generally entails the carriage of oil from the producer country to the main user countries. Since the user countries are in most cases not shippers of edible oils this situation leads to the dual use of shipping space, vegetable or marine oils being carried in one direction and other liquid cargoes, mainly chemical cargoes, being carried in the other direction. As vegetable and marine oils carried are predominately used for edible purposes purchasers are increasingly concerned about any indication of contamination, even at extremely low levels.

This concern has led FOSFA to create categories of non-oil cargoes for the protection of the end users of edible oils. Two categories of cargoes carried by vessels before loading a cargo of vegetable or marine oil are now recognised. The main category comprises chemicals or other liquid cargoes which are considered unacceptable from the point of view of possible contamination. FOSFA has, therefore, in collaboration with the (American) National Institute for Oilseed Products (NIOP), created a list of Banned Prior Cargoes, and has at the same time produced a list of Acceptable Prior Cargoes. The chemicals on the Banned List are known to have adverse toxicological or carcinogenic properties, and in some cases the banning extends to the two cargoes carried immediately before the carriage of an edible oil cargo.

4. *Ship Suitability, Tank Coatings and Tank Cleaning*

Ship's Suitability

- The ships shall have top class rating, e.g. 100A1 from an internationally recognised Classification Society.
- Heating coils should be of stainless steel construction only; copper and its alloys such as brass, bronze or gun metal should not be used for any part of the cargo handling system that has contact with the oils or fats, such as piping, pipe connections (pumps), valves, heating coils etc.
- Tank access/cleaning hatches must be staunch and tight with suitable packing and gaskets compatible with the cargo and its carriage temperature.
- Cargo lines should preferably be of stainless steel constructions with sufficient drain valves to ensure complete clearing and draining of the system. The internal structural members in cargo tanks should be self draining.

Tank Coatings

Tanks, other than those of stainless steel, are normally coated, although mild steel tanks are employed for short sea passages. Only coatings fit for food grade products and suitable for the carriage of the oils or fats to be loaded shall be used.

- No closed blisters or loose splits should be allowed in a coated tank. If after initial cleaning any blisters or loose splits are present they should be opened by the ship's staff to determine whether any cargo residue remains behind. Areas of mild steel exposure in coated tanks shall be minimal and in all cases shall contain no loose scale.
- Zinc silicate coated tanks are not favoured and should not be used for crude oil unless the acid value is 1 or under. Specialist advice should be sought if clarification is required.

Tank Cleaning

If there are tell-tale signs of previous cargo residues, the tank should be re-cleaned. With regard to tank cleaning, comprehensive guidance is published by Verwey "Tank Cleaning Guide" which is well known in the tanker trade. Additionally, manufacturers of proprietary tank cleaning chemicals should be consulted for advice in conjunction with tank coating manufacturers for permission to utilise the various tank cleaning products. If clarification is required specialist advice should be sought. Checks should be carried out for carbon monoxide content before entering a heated vegetable oil tank.

5. *Cargo Maintenance*

The range of physical properties of vegetable and marine oils, particularly with respect to their tendency to solidify at ambient temperature, means that the conditions for handling and storing oils cannot be standardised for all oils but must be considered and specified for each type of oil. The International Association of Seed Crushers (IASC) has adopted a temperature regime for the handling and storage of a large number of oils, and details of the conditions adopted as suitable are given in Table 1. The sensitivity of all oils to high temperature makes it essential that where oils are to be heated prior to pumping, this should be done with the lowest realistic temperature differential between heating medium and oil. In consequence, extended heating times prior to discharge are necessary (where the consistency of the oil is such as to require heating).

IASC Recommended Schedule of Temperatures for Carriage of Fatty Foods

OIL	During Voyage		On Discharge	
	Min Deg C	Max Deg C	Min Deg C	Max Deg C
Sunflower		Ambient	Ambient	20
Soyabean		Ambient	20	25
Safflower		Ambient	Ambient	25
Groundnut		Ambient	20	25
Rape Seed		Ambient	Ambient	20
Maize (Corn)		Ambient	Ambient	20
Palm	32	40	50	55
Palm stearine	40	45	60	65
Palm oleine RBD	25	30	50	55
Coconut	27	32	40	45
Fish	20	25	30	35
Palm Fatty Acid Distillate	42	50	67	72

6. *Type of Damage*

Damage to a fatty oil cargo, leading to it being in an unsatisfactory or even unacceptable condition on discharge, may be due to one of several causes, these being:

(i) poor temperature control during voyage.
(ii) sea-water ingress.
(iii) contamination with chemicals or other substances miscible with oils.
(iv) adulteration.
(v) admixture.

It is possible to encounter a change in the characteristics of an oil cargo which may appear as damage but is no more than a natural change in the oil. After a period of some weeks a tank full of, for example, sunflower oil will have a deposit of foots on the tank bottom, and a cargo of such an oil may appear cloudy on discharge despite having been clear at the time of loading. In this case the oil has not been damaged, but claims concerning oil quality are sometimes experienced where the *appearance* of the oil has changed between loading and discharge.

6.1 *Damage Due to Inadequate Care of the Cargo*

Even the presence of natural antioxidants in a crude fatty oil will not protect the oil from gross abuse and for this reason guidelines have been set out for the temperatures to be maintained during carriage and discharge of a fatty oil cargo. Exposure of the oil to high temperature can lead to oxidative damage, which has several ramifications. However, some deterioration in quality can be expected during a voyage lasting three to four weeks in conditions where considerable temperature cycling can occur, and for this reason loading of a cargo the characteristics of which are close to the specified upper limit will sometimes lead to the oil at the port of discharge being outside the specification. Oil colour and Peroxide Value are particularly prone to this problem. Normally only a modest increase in free fatty acid content is found over the average length of journey.

6.2 *Seawater Ingress*

Ingress of water into the ship's tanks constitutes another form of cargo damage, though in this case the damage caused is for the most part more readily reversible than in the case of overheating. A combination of high temperature and excessive moisture content may lead to the formation of free fatty acids, which can have an adverse effect on cargo quality.

6.3 *Contamination*

Contamination with chemicals has in the past constituted the most serious problem for cargo owners as well as the shipping industry, and this was particularly the case where the contaminant is documented as being toxic or carcinogenic. This form of contamination almost always arises due to incomplete removal of the residues from a previous cargo, but may also be caused by the use of incompletely cleaned road tankers transporting oil to the loading terminal. Yet another source of contamination is caused by inadequate processing at the oilseed extraction stage — if the oil recovered is not properly desolventised hexane residues will be found in the oil. The advances made in analytical chemistry have made it possible to detect minute traces of most residues, including those from the second-last cargo carried by the ship. The techniques available can now detect some contaminants at a level of 1 ppm and below.

This type of contamination can again be divided into two categories — contamination with a single compound, e.g. ethylene dichloride, styrene, and contamination with a material which itself consists of a number of compounds. In this latter category diesel oil or other hydrocarbon mixtures derived from petroleum constitute the best and most frequently encountered examples. Contamination with a hydrocarbon mixture derived from petroleum refining presents a complex set of problems, as the principal components comprise an extensive range of molecular sizes, but the mixture normally also contains polycyclic aromatic hydrocarbons which, though present at a relatively low level present considerable difficulty as far as removal is concerned.

Contamination can also take the form of admixture with a fatty oil of another description, sometimes referred to as comingling. This has occurred in the past where a ship has carried two different oils, for example palm oil and palm kernel oil, and insufficient care has been taken to segregate the two cargoes, particularly during loading and/or discharge. This type of contamination obviously does not give rise to any risks as far as oil edibility is concerned, but it may make it difficult to use the oil for the specific purpose originally intended.

6.4 *Adulteration*

Adulteration — mixing of two lower-valued oils to simulate the composition of a more expensive oil — has been known in the past but has been largely eliminated by the development of more sophisticated techniques for the characterisation of oils. By its nature adulteration does not involve the ship, as any adulteration will have occurred before loading.

6.5 *Admixture*

Ships carrying parcels of different vegetable oils must exercise caution to prevent cross-contamination due to faulty valves or a failure to clean lines between discharges of different parcels. Although oils are compatible with one another cross-contamination can have serious consequences for certain uses of vegetable oils and can therefore lead to substantial claims.