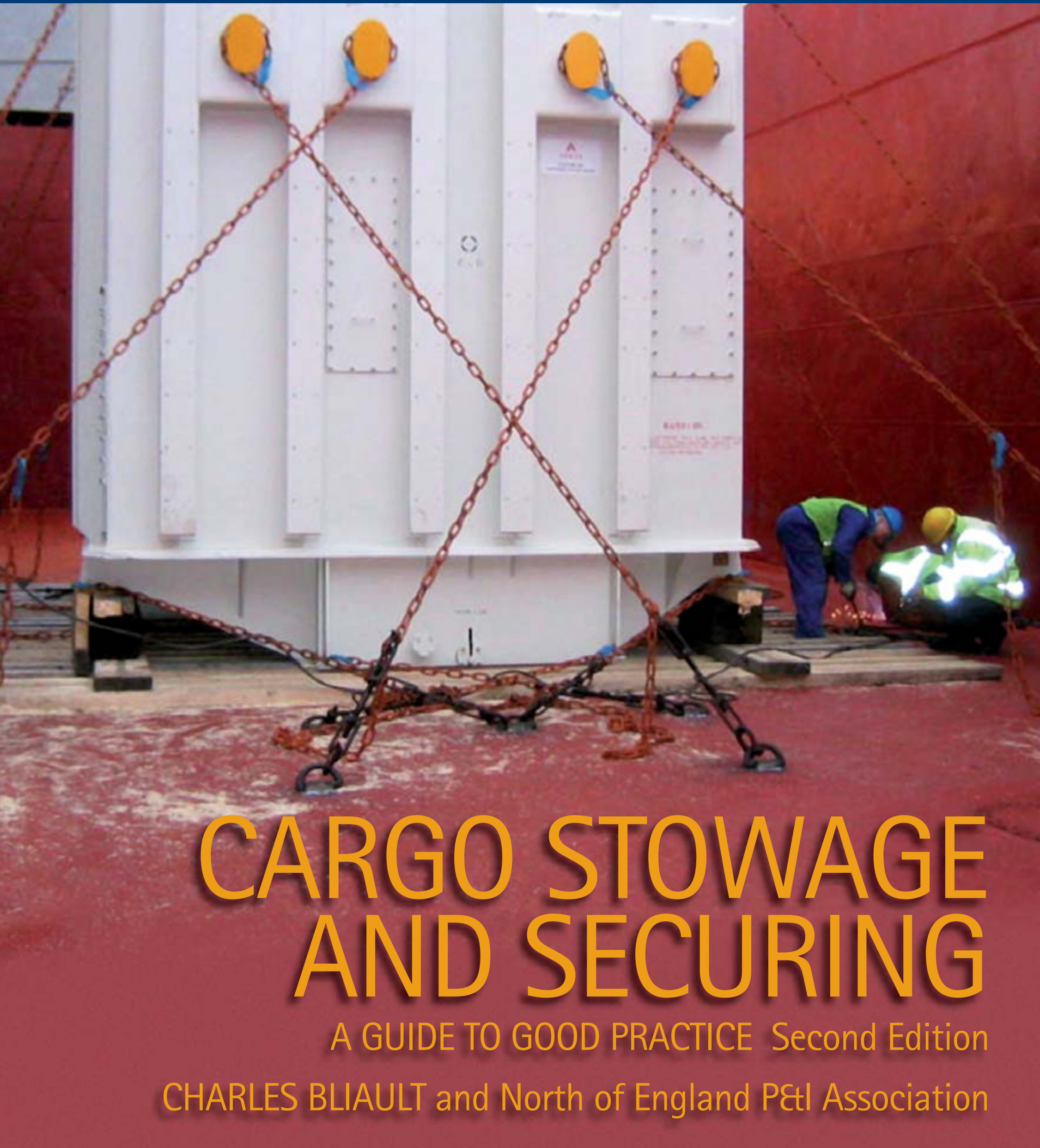
LOSS PREVENTION
GUIDES



CARGO STOWAGE AND SECURING

A GUIDE TO GOOD PRACTICE Second Edition

CHARLES BLIAULT and North of England P&I Association

NORTH OF ENGLAND P&I ASSOCIATION

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The Quayside, Newcastle upon Tyne, NE1 3DU, United Kingdom

Telephone +44 191 232 5221
Fax +44 191 261 0540
Email risk.management@nepia.com
Website www.nepia.com

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Authors: Charles Bliault and North of England P&I Association

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TERMS OF USE

Chapter 1

INTRODUCTION

The proper, adequate and satisfactory stowage and securing of items of cargo are of the utmost importance for the safety of the crew, the carrying ship, and the items of cargo themselves. If items of cargo are not stowed and secured in a proper manner, bearing in mind the intended voyage and the time of year, those items of cargo might shift from their stowage position, and damage might be sustained by the item of cargo or the ship, or ship's staff might suffer injury.

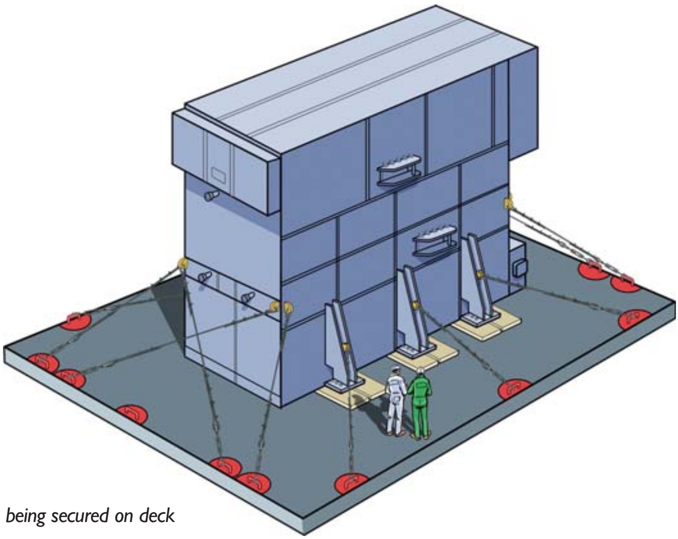
This guide will take the reader through some basic rules to be remembered on every occasion during the loading and securing of cargo, will describe where regulations, recommendations and general guidance can be found, will describe recommended methods to be used for particular items and types of cargo, and will then give some guidance upon the points to be remembered during passage-planning and the voyage itself. It is not intended that this guide will give details of precisely how to secure any particular items of cargo. It will set out the basics and point to publications that give the rules to be followed. This guide does contain information, such as for the calculation of lashings, taken from codes, but only that which is essential for the clear understanding of the text.

Under chapter VI, regulation 5(6) of the International Convention for the Safety of Life at Sea (SOLAS), 1974, ships engaged in the carriage of all cargoes, other than solid and liquid bulk cargoes, are required to carry a Cargo Securing Manual that has been approved by the administration. Thus, the provision of a Cargo Securing Manual is a mandatory requirement. Such a manual gives, for the ship for which it was prepared, guidance for the safe carriage of cargo items for which that ship was designed and cargoes with which, therefore, the crew ought to be familiar. The ship's Cargo Securing Manual will incorporate much if not all of the guidance and information given in the International Maritime Organization (IMO) Code of Safe Practice for Cargo Stowage and Securing and the ship's manual should be used in conjunction with the Code. This guide has been designed for use alongside the ship's own Cargo Securing Manual, and together with IMO and other publications.

Despite there being codes of safe practice and publications giving advice on the safe stowage and securing of cargo, incidents continue to occur during which pieces of cargo shift and damage is sustained. It has always been recognised that, when ships' staff have greater knowledge and are more aware of hazards, those hazards can be avoided and accidents can be prevented. The object of this guide is to increase the seafarer's knowledge of the forces acting upon items of cargo, and of the basic requirement for the safe stowage and securing of cargo, and to help with the understanding of the codes and guidelines to aid loss prevention.

Chapter 2

GENERAL INFORMATION



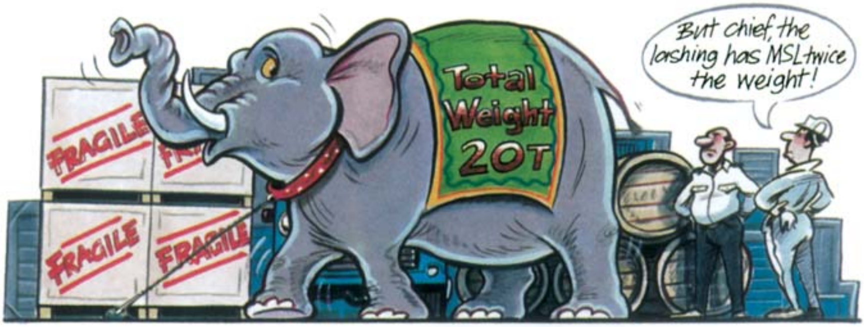
Project cargo being secured on deck

BASIC RULES TO BE FOLLOWED

Here are some rules that are, essentially, common-sense and good seamanship practice. Whereas all pieces must be treated individually, it is not the case that some rules only apply to certain pieces of cargo and some to others – all of these rules should be borne in mind during every voyage and for every piece of cargo.

Basic rules for cargo stowage and securing
• Be thoroughly familiar with the IMO Code of Safe Practice for Cargo Stowage and Securing and any subsequent amendments.
• Be thoroughly familiar with the contents of the ship's own Cargo Securing Manual.
• Establish the weight of the item of cargo and, where possible, the position of its centre of gravity.
• Decide what types of lashing materials are to be used to secure the item, and then determine the maximum securing load (MSL) of the lashings.
• Examine the item of cargo and ensure that it is in a condition suitable for transportation on board on the current voyage and can be adequately and properly secured on board.

- The IMO rule-of-thumb method may be used to calculate the number of lashings required; that is, the total of the MSL values of lashings on each side of a unit of cargo (port as well as starboard) should equal, or exceed, the weight of the item. The IMO advanced method may be used for heavy-lift items or where appropriate.
- The item must be stowed in a position where there is sufficient space for lashings to be led athwartships, forward, aft and downwards. There must be eye-pads or other strong anchorage points for the lashings to be attached to on all sides of the cargo item. Lashings should be independent from one another.
- Lashings should be attached to secure anchorages on the item of cargo, or should be taken around the item or around strong parts of the item of cargo. Lashings fitted to the cargo item should not be led in such a way that they damage either the anchorage point, themselves or the part of the cargo around which the lashing is led.
- Lashings should be balanced on each side and each end of the item of cargo, and therefore also in the athwartships and in the fore-and-aft line of the ship.
- Ensure that all the cargo securing equipment is in good condition and is the most appropriate equipment for the job.
- Establish the maximum permissible loading for the hatch cover, deck or tank top onto which the cargo is to be stowed and ensure that the loading rate is not exceeded in way of the cargo. Where necessary and appropriate use suitable timber or other materials to spread the load over a greater area to avoid overloading.
- The item of cargo should be placed on firm and secure ground. An item of cargo should never be placed on, and / or secured to, something that itself is not secured to the ship.
- Use dunnage materials, in the form of timber, plywood sheets, rubber mats and so on, to increase the coefficient of friction between the cargo and the surface upon which it is stowed. Avoid steel-to-steel contact. Ensure the surface is clean, dry and free from oil and grease.
- Ensure that the stowage and securing of one item of cargo does not interfere with any other items of cargo and does not cause another item of cargo to be damaged.
- Examine, so far as is possible, cargo stowed within the item to be carried (for example, on a flat rack container or in a road vehicle) to ensure that the cargo is properly stowed and secured on that unit or vehicle. If it is not, shippers or other onshore personnel should be advised to rectify the problem before the container or vehicle can be loaded.
- Ensure that the arrangement of the items of cargo and their lashings is such that routine inspections of the cargo and adjustment of the lashings can be carried out in all parts of the deck or compartment and that the stowage or lashings of particular items do not hinder or restrict those inspections that must be carried out throughout the voyage.



WHERE THE REGULATIONS, RECOMMENDATIONS AND GUIDANCE CAN BE FOUND

The IMO publishes SOLAS, codes of safe practice and guidelines that set out requirements that must be followed and complied with. Additionally, there are a number of books that give recommendations and guidance for the stowage and securing of particular items of cargo.

International regulations

SOLAS

SOLAS – the International Convention for the Safety of Life at Sea – is one of the principal conventions of the IMO, which periodically discusses and adopts requirements and amendments to it. The current publication, at the time of writing, SOLAS Consolidated Edition 2004, is the consolidated text of the 1974 SOLAS Convention, the 1998 SOLAS Protocol and a number of subsequent amendments.

SOLAS incorporates requirements with regard to all aspects of the operation of a ship including in chapter VI on the carriage of cargoes. The chapter is in three parts, and part A applies to the carriage of cargoes that, owing to their particular hazards to ships and persons on board, may require special precautions. Regulation 5, in part A, deals with stowage and securing and, to avoid any ambiguity, that regulation is quoted in Appendix I of this book. Parts B and C deal with bulk cargoes and grain.

It must be remembered that SOLAS is being reviewed constantly and amendments are published regularly.

Code of Safe Practice for Cargo Stowage and Securing

The IMO Code of Safe Practice for Cargo Stowage and Securing, or CSS Code as it is known, was first published in 1992, following IMO resolution A.714(17) of November 1991. That edition of the CSS Code incorporated general principles for the safe stowage and securing of cargoes, definitions of terms in general use, some basic recommendations to be followed, some guidance with regard to actions in heavy weather and when cargo has shifted. Annexes 1 to 12 contained guidance upon the stowage and securing of particular types of cargoes and appendices 1 to 5 quoted other resolutions and circulars to be considered. In 1994/1995 three amendments to the original text of the CSS Code and a new annex 13 were published. Annex 13 gives methods to assess the efficiency of securing arrangements for non-standardised cargo.

In 2003 a new edition of the CSS Code was published that incorporated all the amendments, annexes 1 to 13 and changes in the contents of annex 13. Thus the new edition incorporates all the general principles, definitions and recommendations from the earlier CSS Code, the cargo-specific guidance in annexes 1 to 12, annex 13 and the appendices.

The CSS Code is the document upon which Cargo Securing Manuals are based. It must be remembered that the CSS Code is updated from time to time and further amendments will be published.

Guidelines for the Preparation of the Cargo Securing Manual

The guidelines describe what a Cargo Securing Manual should contain and how that information should be laid out. The guidelines give definitions of terms and some useful information about certain cargo types.

Code of Safe Practice for Ships Carrying Timber Deck Cargoes

Timber deck cargoes are different from all other types of cargo carried on deck and are secured in a manner different to that which applies to all other cargoes. Consequently, a separate code was devised a long time ago, the 1991 Code being the current version at the time of writing.

Code on Intact Stability

This Code contains the requirements for intact stability criteria for different types of ship. The Code also gives details of information required on board, general precautions against capsizing and operational procedures relating to weather conditions.

Safe Stowage and Securing of Cargo Units and Other Entities in Ships other than Cellular Container Ships

This resolution, attached as appendix 1 to the CSS Code, gives some general guidance.

Elements to be Taken into Account when Considering the Safe Stowage and Securing of Cargo Units and Vehicles in Ships

This resolution, attached as appendix 3 to the CSS Code, gives elements to be taken into account by the various parties involved with the stowage and securing of cargo units and vehicles.

Guidelines for Securing Arrangements for the Transport of Road Vehicles on Ro-Ro Ships

This resolution is attached as appendix 4 to the CSS Code and gives detailed guidelines for securing arrangements for the transport of road vehicles on ro-ro ships, including requirements for securing points on the ships' decks and on road vehicles to be carried.

International standards

Standards are published by the International Organization for Standardization (ISO), which is a worldwide federation of national standard-setting bodies.

Standards are issued on a wide range of subjects including the construction of ISO containers, the packing, handling and securing of freight containers, the construction and use of pallets and the construction and use of other types of packaging.

National regulations

Many maritime nations issue their own regulations that are in addition to those that bring into force the international regulations. In the UK, Merchant Shipping Notices (MSNs), Marine Guidance Notices (MGNs) and Marine Information Notices (MINs) are issued. MSNs are mandatory and relate directly to the regulations and the codes and should be read together with those regulations and codes. MGNs and MINs contain additional guidance and information on particular subjects. In addition, there are the old 'M' notices, which preceded the latest notices, many of which are still in force.

Agencies in the UK and in other countries produce instructions and guidance booklets that give recommendations with regard to the stowage and carriage of cargoes loaded at their ports.

Publications

Thomas' Stowage

Thomas' Stowage (first published as *Stowage–The Properties and Stowage of Cargoes* in 1928, the most recent edition having been produced in 2002) is, rightly, used throughout the shipping industry for guidance and information about the properties and stowage of cargoes. The book gives a great deal of information about the stowage and care required for particular types of cargo.

Lashing and Securing of Deck Cargoes

First published as a book in 1994, this gives in great detail how deck cargoes should be lashed and secured; many of the techniques described can also be used on under-deck stowed items.

Steel–Carriage by Sea

This book describes all aspects of steel products from manufacture, through storage and on to carriage in ocean ships. The book describes how steel items should be stowed and secured on board.

Further details of these publications can be found in the Bibliography in Appendix VI at the back of this guide.

THE CODE OF SAFE PRACTICE FOR CARGO STOWAGE AND SECURING

The CSS Code was first published in 1992 and the current edition at the time of writing is that of 2003.

The purpose of the CSS Code is to provide guidance on proper stowage and securing of cargoes. When a ship is on passage in a seaway, the motions of the ship will lead to acceleration being introduced into items of cargo and the forces created by those accelerations must be counteracted by securing arrangements to prevent movement of cargo items. Thus, proper stowage and securing of cargoes is essential, but it must be remembered that reducing the amplitude and frequency of the ship's motions will reduce the forces acting on the cargo.

The CSS Code draws the attention of shipowners and ship operators to the need to ensure that the ship is suitable for the intended cargo and is properly equipped, and provides advice on proper stowage and securing, actions to be taken in heavy sea conditions and actions that may be taken to remedy the effects of cargo shifting. The CSS Code is divided into seven chapters giving general advice followed by annexes giving cargo-specific advice, including annex 13 which gives methods of assessing the efficiency of securing arrangements. Finally, five appendices provide additional information.

In more detail, annex 13 gives some guidance and methods for the assessment of lashing arrangements. It gives a definition for the maximum securing load (MSL) and the method for calculating the MSL for lashing materials. It describes the rule-of-thumb method, which is the basic method for calculating the required strength of lashings, in section 6. Section 7 gives the advanced calculation method, which may be used to calculate the external forces acting upon a single item of cargo and then whether or not the chosen lashing materials and number of lashings to be fitted are sufficient.

CSS Code contents

Chapter 1 – General

The CSS Code applies to cargoes carried on board ships (other than solid and liquid bulk cargoes and timber stowed on deck) and, in particular, to those cargoes whose stowage and securing have proved in practice to create difficulties. This chapter gives definitions of terms used and general descriptions of the forces that are involved, and which must be absorbed by the stowage and securing arrangements, and some guidance on minimising the forces. Guidance on the behaviour of cargoes, their tendency to deform or compact for example, and how to estimate the risk of cargo shifting is then given. The requirement for a Cargo Securing Manual is mentioned as is the need for appropriate and well maintained equipment and information about the cargo to be carried being provided before loading. It should be remembered that relevant expertise might be needed, to assist the master, in the planning of the stowage and securing arrangements for any special transport units.

Chapter 2 – Principles of safe stowage and securing of cargoes

This chapter draws attention to the various aspects of the safe carriage of items of cargo. The cargo should be suitable for carriage, and should be stowed and secured appropriately bearing in mind the characteristics of the cargo and of the ship, and the friction between the deck and the base of the cargo unit. All procedures should be properly supervised and all enclosed spaces must be safe for entry. The master should ensure that all the necessary procedures are followed. Finally, the chapter highlights the need for cargo stowage and securing declarations.

Chapter 3 – Standardised stowage and securing systems
This chapter gives recommendations for systems on ships designed specifically for items such as containers, railway wagons and shipborne barges. All arrangements should be designed for the specific cargo and approved, and adequate information should be on board.

Chapter 4 – Semi-standardised stowage and securing
This chapter deals with ro-ro cargoes such as road vehicles, roll trailers and automobiles. These cargo items should be provided with securing arrangements as set out in section 5 of the annex to resolution A.581(14), which is given as appendix 4 to the CSS Code. The provisions of other sections of that annex should also be followed. Any item that does not comply with the requirements should be dealt with as if it were a non-standardised item of cargo and stowed and secured accordingly.

Chapter 5 – Non-standardised stowage and securing
Non-standardised items of cargo pose a variety of problems and therefore each cargo item or shipment must be dealt with separately. Cargoes that have proved to be a potential source of danger can be divided into 12 categories and each is dealt with in a separate annex.

Chapter 6 – Actions which may be taken in heavy weather
This chapter gives advice on how stresses induced by excessive accelerations caused by bad weather conditions could be avoided.

Chapter 7 – Actions which may be taken once cargo has shifted
This chapter lists action that may be considered by the master.

Annexes
The annexes 1 to 12 give advice on specific types of cargo and annex 13 deals with securing arrangements as follows.

- Annex 1 – Safe stowage and securing of containers on deck of ships which are not specifically designed and fitted for the purpose of carrying containers.
- Annex 2 – Safe stowage and securing of portable tanks.
- Annex 3 – Safe stowage and securing of portable receptacles.
- Annex 4 – Safe stowage and securing of wheel-based (rolling) cargoes.
- Annex 5 – Safe stowage and securing of heavy cargo items such as locomotives, transformers and so on
- Annex 6 – Safe stowage and securing of coiled steel sheet.
- Annex 7 – Safe stowage and securing of heavy metal products.
- Annex 8 – Safe stowage and securing of anchor chains.
- Annex 9 – Safe stowage and securing of metal scrap in bulk.
- Annex 10 – Safe stowage and securing of flexible intermediate bulk containers.
- Annex 11 – General guidelines for the under-deck stowage of logs.
- Annex 12 – Safe stowage and securing of unit loads.
- Annex 13 – Methods to assess the efficiency of securing arrangements for non-standardised cargo.

Appendices

- Appendix 1 – Resolution A.489 (XII): Safe Stowage and Securing of Cargo Units and Other Entities in Ships other than Cellular Containerships (*adopted 19 November 1981*).
- Appendix 2 – MSC/Circ.745: Guidelines for the Preparation of the Cargo Securing Manual (*13 June 1996*).
- Appendix 3 – Resolution A533 (13): Elements to be Taken into Account when Considering the Safe Stowage and Securing of Cargo Units and Vehicles in Ships (*adopted 17 November 1983*).
- Appendix 4 – Resolution A581 (14): Guidelines for Securing Arrangements for the Transport of Road Vehicles on Ro-Ro Ships (*adopted 20 November 1985*) as amended by MSC/Circ.812 of 16 June 1997.
- Appendix 5 – Resolution A.864 (20): Recommendations for Entering Enclosed Spaces Aboard Ships (*adopted 27 November 1997*).

CARGO SECURING MANUAL

The booklet *Guidelines for the Preparation of the Cargo Securing Manual* was published by IMO in 1997 to show how a manual should be arranged and what it should contain. It is a mandatory requirement under SOLAS that a Cargo Securing Manual, which has been approved by the administration, is provided on board.

The purpose of a Cargo Securing Manual is to set out the standards for cargo securing devices used on board bearing in mind the type of cargo, the characteristics of the ship and sea conditions that a ship might encounter. The manual should be easy to use and must contain information and guidance applicable to the ship for which the manual was drawn up; the idea being that all of the information in the ship's manual should be of use to those on board and information that relates to cargoes that are not carried should not be included in the manual. For example, details of cell guides and the carriage of containers need not be included within the manual for a logger and details of the carriage of logs need not be included in the manual designed for a cellular container ship.

The information given in the manual should follow the layout described in the Guidelines, using the headings and sub-headings in the order shown, and should contain the necessary information specific to the ship. All Cargo Securing Manuals will therefore be in the same format, so that seafarers will become used to that format and will be able to use the manual on any ship efficiently. After the manual has been prepared by, or on behalf of, the ship operator, it must be approved by the administration of the flag state.

The Guidelines set out the format that must be followed in the preparation of all manuals. The manual will be divided into four chapters and appendices.

Cargo Securing Manual format

Chapter 1 – General

At the beginning of chapter 1 there should be a preamble that should include paragraph numbers 1, 2 and 4 of the preamble given on page 1 of the Guidelines booklet and the statement that the manual has been prepared in accordance with the guidelines. The preamble is given in Appendix II of this book. Chapter 1 will then go on to give definitions and general information relating to the ship.

Chapter 2 – Securing devices and arrangements

Chapter 2 contains, in as much detail as possible, descriptions of the securing devices used on board the ship, including the number carried, their strength in terms of breaking load and their maximum securing load (MSL). Tables listing the devices and sketches of individual pieces might also be included. Next should come some advice, and guidelines with regard to the inspection and maintenance of both fixed and portable securing devices. Periods between inspections should be given and how maintenance work should be carried out, there should also be a record of inspections and maintenance in an appendix attached at the back of the manual that should be kept updated. It must be remembered that pieces of lashing equipment must be kept in good working order without defects that might detract from their strength.

Chapter 3 – Stowage and securing of non-standardised and semi-standardised cargo

Chapter 3 includes information on the proper handling of securing devices and safety instructions about handling those devices. The chapter should include a section on the evaluation of forces acting on cargo units. This section should include tables or diagrams giving acceleration for the ship in the transverse, vertical and longitudinal lines. The tables may be used for calculation of the forces as set out in section 7 of annex 13, advanced calculation method. A worked example will be given to illustrate how to progress with the calculation and determine the end result. The next section will give guidance with regard to the stowage and securing of non-standardised cargo and this is usually a re-write of annexes given in the CSS Code.

Chapter 4 – Stowage and securing of containers and other standardised cargo

Chapter 4 gives details of the stowage and securing requirements for standardised cargoes, essentially containers and other unitised cargoes. There will be guidance on the use of container securing devices and on where and how containers may be stowed and stacked. Stack weights and the arrangement of containers within a stack are of great importance and proper securing, appropriate to the stack of containers in the stowage position on board, is similarly of great importance; these factors must always be borne in mind. Tables of acceleration will also be included in this chapter.

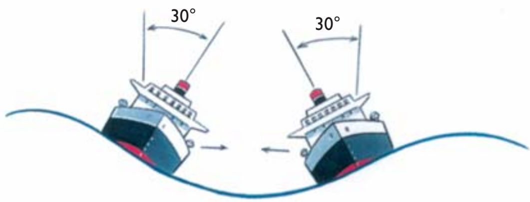
Appendices

Lastly the manual should include appendices giving a safety checklist for entry into enclosed spaces, a record of inspection and maintenance of securing equipment, and any appropriate drawings or sketches.

MOVEMENT OF A SHIP IN A SEAWAY

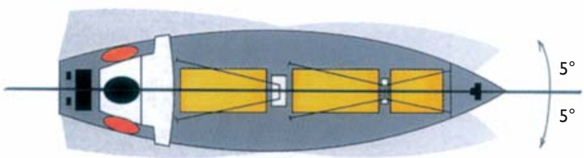
When a ship is at sea the wind, wind waves and swell waves cause its to move. The greater the strength of the wind and the greater the height of the sea and swell waves the more the ship will move. There are six types of motion, three are rotational and three are linear. Roll, pitch and yaw are the three rotational motions and sway, surge and heave are the three linear movements (Fig. 1).

Fig. 1. Ship motions – (a) rolling and swaying, (b) pitching and surging, (c) yawing and (d) heaving



(a) Rolling to 30° to port and to 30° to starboard, and swaying to port and to starboard, as each wave passes.

(b) Pitching to 10° bow up and surging astern, and pitching to 10° bow down while surging ahead, as each wave passes.



(c) Yawing 5° port and 5° starboard as each wave passes.

(d) Heaving up and down as each wave passes.

The type, or types, of motion will depend upon the direction from where the wind and waves are approaching the ship, relative to its course line. If the wind and swell are from ahead, the ship will pitch and surge but will roll only a little. If the ship is experiencing a strong wind on the beam with associated high beam swell conditions, it will roll and sway heavily but will not pitch very much. Usually a ship will experience all six motions at the same time, some to a greater extent and some to a lesser extent.

Generally speaking, the motions that are felt most by those on board, and therefore experienced most by the cargo being carried, are roll, pitch and heave. When considering the effect that a particular motion has on a piece of cargo it should be remembered that the three linear movements affect all parts of the ship equally, irrespective of location, whereas the three rotational movements have a greater effect further from the ship's centre of motion, which is normally close to the ship's overall centre of gravity.

It is of course one of the responsibilities of the bridge team to monitor the actual sea conditions being experienced continuously. The bridge team must also monitor the weather forecasts and other warnings to predict what weather and sea conditions the ship is likely to encounter, so that adjustments can be made to the course and speed of the ship in the short term, and in order that the passage plan can be adjusted to avoid sea areas of adverse weather or high swell conditions in the longer term, so as to keep the ship's motions to a minimum at all times. Keeping the ship's motions to a minimum prevents the likelihood of accidents on board and minimises the possibility of items of cargo shifting.

THE SHIP AND ITS MOVEMENT – EFFECTS ON CARGO

The motions of a ship in a seaway combine and produce three forces that act upon everything on board the ship. Those three forces are perpendicular to each other and are, of course, in the vertical, athwartships and fore-and-aft line.

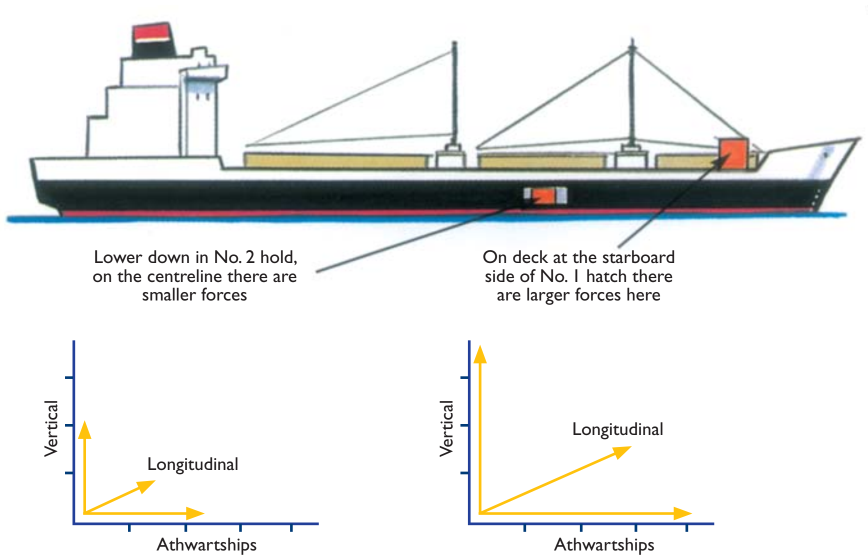


Fig 2. The combination of forces on board.

The magnitude of the forces, or accelerations, will depend upon the dimensions of the ship (length, beam, depth and draught), its metacentric height (GM) and the wind and sea conditions being experienced. The smaller are the ship's dimensions, the higher will be the accelerations; the larger the GM, the higher the accelerations, and, of course, where sea conditions produce larger ship motions, so the accelerations will be proportionally larger (Fig. 2).

The acceleration forces act upon items of cargo and increase and decrease as the ship rolls and / or pitches in one direction and then in the other. So, in fact, the accelerations are constantly changing from acceleration in one direction to acceleration in the other direction. These acceleration forces are transferred from the ship's structure through the lashings, the chockings and the dunnage under the item of cargo, which causes friction between the cargo and the deck, into the item of cargo. So long as the securings are of sufficient strength the item of cargo will not move relative to the ship and the lashings, chockings and dunnaging will not fail. But where are the acceleration forces greatest?

When the ship rolls the ship's side plating moves through a greater distance than does the hatch coaming, because the side plating is further outboard. When a ship pitches the windlass on the forecastle moves up and down through a greater arc than does number one hatch. Thus, it can be concluded that the further the piece of cargo is from the ship's centre of motion, in each of the three directions of motion – that is in the athwartships line, in the fore-and-aft line or in the vertical line, or in a combination of the three – the greater will be the acceleration forces acting on that item of cargo. Conversely, the acceleration forces are less the closer the item is to the ship's centre of motion. If a piece of cargo that is sensitive to acceleration forces is to be carried on an ocean voyage, it should be carried as close as possible to the ship's centre of motion, which is likely to be fairly close to the ship's centre of gravity.

When considering the lashings and dunnaging of a piece of cargo, its position on board should be borne in mind, and therefore the likely distribution of acceleration forces that will be experienced by that item of cargo during the forthcoming ocean voyage. A piece of cargo stowed outboard to port or to starboard, or right forward or right aft, will need more lashings and dunnaging than will an item positioned inboard and amidships. The advanced calculation method in annex 13, section 7, of the CSS Code (details of which should be in the ship's Cargo Securing Manual) takes these factors into account when the formula is used to assess whether or not the chosen securing methods are sufficient.

As every seafarer knows, rolling causes more problems than any other motion. The ship's natural rolling period is determined from its metacentric height (GM) and by its radius of gyration, these being determined by the structure of the ship itself and the position of cargo and liquids on board. The radius of gyration is, in simple terms, the distance from the ships centreline out to the circle that represents the distribution of the rotational inertia of the ship and its cargo about that centreline. It is well known that winging-out the cargo will increase the roll period; this is because by loading cargo further to port and to starboard the radius of gyration is increased.

If the GM and radius of gyration are known, the roll period of the ship can be calculated by the use of a simple formula. However, although the GM is calculated during each voyage, the radius of gyration is not often accurately known. For this reason, and after much experimentation, a simplified formula to calculate the roll period using GM, or to determine the GM of the ship using its roll period, was developed, as follows.

Calculation of roll period

$T = C \times B / \sqrt{GM}$

Where T = roll period in seconds, B = ship's beam in metres, C = constant, GM = metacentric height

The constant is generally within the range 0.7–0.9, and 0.8 is often used when no other information is available. Smaller and finer-lined ships will, generally speaking, have a constant closer to 0.7 whereas larger ships and those with a larger block coefficient will have a constant closer to 0.9. In effect, C × B is the diameter of the imaginary circle of gyration.

STABILITY

It is essential that the cargo should be stowed in such a way that upon completion the ship has adequate stability for the intended voyage. The term 'stability' is used when describing the ship's initial static stability and its dynamic stability that includes calculation of information such as righting levers at certain angles. The initial GM of the ship is important because it is that figure which is used in calculations for basic roll period and in lashing calculations.

Definition of initial metacentric height

The ship's calculated metacentric height (GMo) after the free surface effect has been applied.

Minimum GM

To ensure that the ship has a satisfactory GM for the voyage, at both the time of departure from the load port and arrival at destination, masters often have to cope with the weights of deck cargo, under-deck cargo, ballast and fuel when they are carrying out his pre-loading calculations. This is particularly so when a deck cargo of timber or containers is to be loaded and a maximum deadweight of that cargo is to be carried. It may often be the case that some deck cargo must be shut out in order that sufficient ballast can be taken into double-bottom tanks to compensate for the top weight, to achieve a satisfactory GM.

The Code on Intact Stability gives, in chapter 3, the general intact stability criteria for all ships; that is to say, the requirements that must be met in terms of static and dynamic stability prior to the ship's departure at the beginning of a passage. At section 3.1.2.4, the following is required.

Minimum metacentric height

The metacentric height (GM) should be not less than 0.15 m throughout the voyage, unless a value greater than 0.15 m is necessary to fulfil other criteria.

The other criteria that should be met are also given in chapter 3 of the Code on Intact Stability and include minimum areas under the righting lever curve (GZ curve), minimum righting lever (GZ) and that the maximum righting arm should occur at an angle of heel preferably exceeding 30º but not less than 25º. That figure is, therefore, the minimum initial GM required for any ship proceeding to sea. The only exception is in the case of a cargo ship carrying a timber deck cargo when the GM should not be less than 0.10 m in the departure condition (chapter 4, section 4.1.3.3 of the Code on Intact Stability).

Maximum GM

With regard to the maximum GM, guidance is given for ships carrying timber deck cargoes, but no other specific guidance is given in the regulations for any other situation. For timber ships, paragraph 2.5 of the Timber Deck Cargoes Code states that the GM should preferably not exceed 3% of the breadth to prevent excessive accelerations in rolling.

For a ship having a beam of 25 m, for example a typical logger, the GM should not be more than 0.75 m. The requirements for the securing of a deck cargo of timber are based on a philosophy slightly different from that for other cargoes (see the section in Chapter 3 on timber cargo). For this reason it is essential that the GM of a timber ship is not excessive such that, in turn, the accelerations associated with the rolling of the ship are kept small.

For ships not carrying timber on deck, what is an acceptable range within which the GM of the ship should be kept? Clearly, the size of the acceptable initial GM will depend on the size and type of the ship. However, a guide for the upper limit is given in the advanced calculation method in the CSS Code where a correction factor must be applied when the ship's breadth divided by GM is less than 13.

Guide to maximum metacentric height

A guide for the upper limit of the metacentric height (GM) is that the ship's breadth divided by GM should be 13 or greater.

The correction factor takes into account the fact that if a ship has a large GM, and therefore the ratio of B / GM is smaller than 13, the rolling period will be short and the forces and acceleration generated will be large. For a ship of a breadth of 30 m this means GM should be less than 2.3 m, and for a ship of breadth 20 m GM should be less than 1.5 m to avoid the correction factor.

Using the roll-period formula, $T = C \times B / \sqrt{GM}$, the breadths and GMs translate into roll periods of, for the larger ship, 15.8 seconds and, for the smaller ship, 13.1 seconds. This is all in line with the practice of good seamanship where a short roll period should be avoided. Taking all of this into account it may be said that ideally the GM of a smaller ship should be within the range of about 0.5–1.5 m and that the GM for a larger ship should be within the range of about 0.5– 2.3 m. Masters should always seek guidance from the ship's trim and stability book that will contain various examples of loaded conditions for which the ship was designed, giving the GM, trim and other stability criteria,.

STOWAGE ARRANGEMENTS

There is a very wide variety of types of cargo, from steel products, through containers to transformers, but all items must be stowed in a manner that is appropriate and that allows the items to be secured, and such that they will not move significantly or suffer damage. There are three main stowage arrangements (Fig. 3)

- cross stowage
- side stowage
- single stowage.

Cross stowage is where cargo items are stowed in an athwartships block extending continuously from ship's side to ship's side or to a fixed structure such as a longitudinal bulkhead. If the stowage is compact a minimum of securing arrangements will be necessary to act against transverse forces. Securing against longitudinal forces will, however, be necessary, particularly in forward and aft compartments. Types of cargoes suitable for cross-stowage arrangements include cases of machinery, pallets, coils of steel sheet and bales.

Side stowage is where cargo items are stowed against the ship's side or a longitudinal bulkhead so that the ship's structure provides support against transverse forces on one side only. Securing arrangements will be needed to act against transverse forces in the other direction and to act against longitudinal forces. Break-bulk items such as drums, pallets or cases of machinery might be given side stowage in one side of a 'tween deck while the square is occupied by containers or units in single stowage.

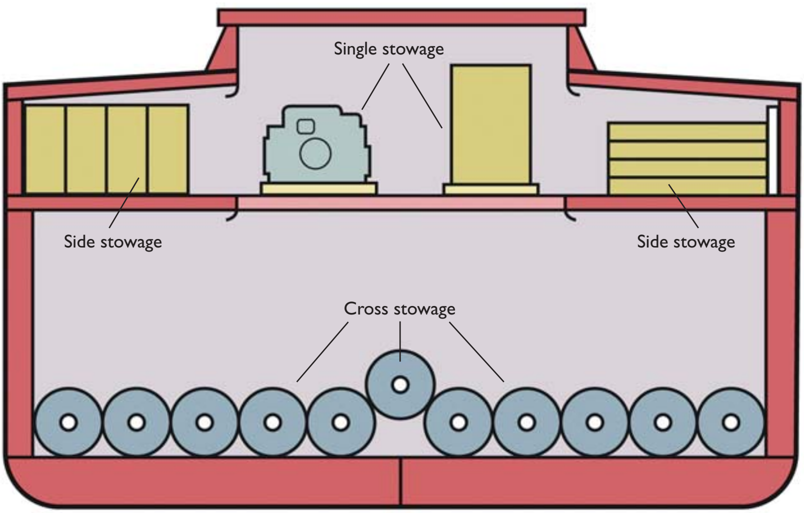


Fig 3.The three main stowage arrangements

Single stowage is for units of cargo that must be secured individually and must, therefore, be stowed alone, and with space all around on the tank top, 'tween deck or on deck. Examples include heavy-lift items, containers on non-container ships and ro-ro items.

LASHINGS, DUNNAGE, FRICTION AND SLIDE OR TIP OVER

When the appropriate stowage location for a particular item of cargo has been decided upon, thought must then be given to dunnaging and securing the item so that it will not move. Items of cargo will either slide or tip over depending upon their shape and size, the position of the centre of gravity and the coefficient of friction between the cargo and the deck. There are many types of lashing equipment and many different types of dunnaging material, and only those that are appropriate for the particular cargo should be used, and used correctly, to increase friction, to support the piece of cargo and to prevent it from moving. The different types of lashings and dunnage are described below.

Lashing materials

Wire rope

Wire is a material very commonly used at sea, and a construction that is widely used is 16 mm diameter, of 6 × 12 construction, with seven fibre cores (FC). Such wire usually has a minimum breaking strength of about 7.7 t. The construction of the wire, and therefore, its strength, must always be carefully checked to avoid mistakes. As an example, a 16 mm diameter wire rope of 6 × 19 construction with one fibre core might have a minimum breaking strength of 11 t, rather than the 7.7 t of the 6 × 12 + 7FC of the similar, but softer wire of the same diameter.

The size of the wire should always be appropriate to the size and weight of the cargo items being secured and it should also be borne in mind that for ease of use the wire should be flexible (for example, wire of diameter greater than 24 mm and of construction 6 × 37 is not flexible enough for lashing purposes).

Wire does stretch when in use; new wire will initially permanently stretch while it is settling and compacting, and will display an elastic stretch while in use, as load increases. The permanent constructional stretch is likely to be between about 0.25% and 1% of the length of rope, and the elastic stretch will be up to about 1% when the rope is under a load that is close to its nominal breaking load. When a new wire rope is used to lash a piece of cargo the lashing might stretch by as much as 2% of its original length when subjected to a high loading. For this reason and because the cargo itself might move a little and settle, lashings must be checked and re-tightened as necessary at intervals throughout the voyage.

As is described in the section on maximum securing load (MSL), wire will stretch and deform when subjected to high loadings in excess of 55% of the breaking strength. Therefore, wire rope used for lashings is considered to be either *single-use* when it is discarded at the end of just one voyage or *reusable* when it is not discarded until it is visibly worn but is not exposed to high loadings that would cause weakening.

When wire is used to make lashings the wire must be formed into eyes or into loops by the use of wire rope grips. A rope grip comprises a U-bolt, two nuts and a cast steel saddle (Fig. 4). There is only one correct manner in which an eye can be made in a wire using grips.

Rules for making a wire rope eye with grips

- The grips must be the correct size for the diameter of the wire in use.
- The correct number of grips must be used (see Table 1).
- All grips must be the same way round, with the saddle on the weight bearing part of the wire.
- The first grip must be close to the thimble if one is used.
- The other grips must be spaced six rope diameters apart.
- The cut end must be whipped or secured in some way and there must be no unlaying of the dead end of the wire and the dead end must be of length about six rope diameters.
- The nuts should be tightened until the U-bolt bites into the wire.

When an eye is made up correctly the wire will not slip through the grips until the load on the wire is about 70% of its nominal breaking strength.

Table 1 – Minimum number of wire rope grips to be used.

Nominal diameter of wire rope	Minimum number of wire rope grips
Up to and including 19 mm	3
Over 19 mm, up to and including 24 mm	4

Fig. 4. An eye in a wire rope properly made up using four grips

Shackles and turnbuckles

Shackles and turnbuckles are supplied in a number of types, shapes and sizes. These are used in conjunction with wire rope and chain lashings. A size appropriate to the size of the wire or chain, and appropriate to the lashing points on the piece of cargo and on deck, should be chosen. All threads should be well greased and free. The items should be in good condition, without defect or deformity.

Chains

Chains are, generally speaking, used for specific purposes only. Their main uses are for the securing of containers, items of ro-ro cargo, heavy-lift items and timber deck cargoes. The chain will, in many cases, have been manufactured to the appropriate length and of the appropriate link size and type, and will have end fittings already in place, if appropriate. Chains can, of course, be used for the securing of other types of cargo but they are more difficult to use than are wire lashings and they do not render when led through or round items of cargo or lashing points.

The main advantage of chain is that it does not stretch appreciably under normal loadings and can therefore be set tight when being fitted. However, it must be remembered that throughout the voyage the forces acting on the cargo will cause it to move slightly and this may cause the chain lashings to stretch slightly and slacken a little, and may also cause the cargo to settle onto foundations and dunnaging and thereby lead to slackening. Chains, like other lashings, must be checked and re-tightened as necessary at intervals throughout the voyage.

Fibre rope

There are many different types of fibre rope, of both natural fibre and synthetic fibre, and most are produced in a wide range of diameters. Larger sizes are used for mooring purposes, variously on small craft and ocean ships, with smaller sizes being used, amongst other things, for securing items of cargo. Fibre ropes have, however, characteristics that mean that they are not ideal for lashings. They stretch, both initially, when first tensioned, and during use. They are weakened when knotted or spliced, and deteriorate when exposed to sunlight and sea water. Consequently it is sometimes difficult to tension and keep a fibre rope tight.

They should, therefore, only be used to secure lighter items, either alone or in conjunction with other materials, such as wire rope. Fibre rope can be used as frapping to tighten a wire rope, but a rigging screw should not be used to tension a fibre rope. Frapping is the use of a number of turns of fibre rope between, say, the eye in a wire rope and a D-ring to gain mechanical advantage to tighten the wire and to achieve strength in the number of turns. Fibre ropes have many uses but their limitations must be borne in mind.

Webbing

Webbing lashings are now widely used. They are easy to use, easily tightened and are manufactured in a range of different sizes and strengths. Webbing lashings are manufactured with a range of different end attachments and can be provided with ratchet tensioners.

Their most common use is for the securing of cargo onto road vehicles carried as ro-ro cargo. They may also be used for the securing of a wide range of cargo items on board, many of which cannot be secured by other means. These include contact-sensitive pipes and cylinders, yachts and other small craft, and cases or other items that are not provided with lashing points. Webbing has stretch characteristics similar to those of wire rope.

Steel bands

Steel bands or straps are widely used for the securing of steel products in open stowage in the holds of ships, and for the securing of many types of cargo items in closed containers or on flat-rack containers, and on road trailers. Steel bands are lighter and easier to use than wire of the same strength and banding is much cheaper than is wire. For these reasons the securing of a stowage of coils can be completed in less time and at a lower cost when using steel bands rather than wire lashings, and riggers are likely to fit a greater number of steel band lashings than they would wire lashings. Thus, the stowage is better lashed. Similarly, steel bands are easier to use and more convenient for use with containers and trailers.

The main disadvantage of steel band lashings is that they cannot be re-tightened, but they have the advantage that they do not stretch significantly and can be satisfactorily tightened so that the need to re-tighten them is eliminated. Steel bands must be fitted using the appropriate equipment, as recommended by the band manufacturer, that is by pneumatic tools (hand operated tools must never be used in conjunction with steel bands for the securing of cargo items) and that equipment must be operated at the correct compressed-air pressure and the riggers using the equipment must be properly trained.

Sea fastenings

The term sea fastenings is given to securing arrangements that comprise large-section timber and / or steel girders that are variously bolted or welded together and to the ship's structure to form chocks either against, under, over or around a piece of cargo to support that piece of cargo and to prevent it from moving.

Sea fastenings are used for the securing of heavy items, those without sufficient lashing points and those which cannot be secured by any other method. Also, sea fastenings may be used in conjunction with conventional lashings of wires, chains or webbing straps.

Container lashing equipment

Container ships are provided with specialised container lashing equipment. That equipment may comprise lashing rods or chains, turnbuckles, twistlocks, single and double cones, bridge-fittings, deck studs and corner locators. Some ships will be fitted with cell guides and others with tension-pressure elements for the securing of under-deck containers.

There are also various other fittings, both fixed and portable, which can be supplied. Container lashing equipment is only to be used for the lashing of containers, and containers on container ships must only be secured using the specially designed equipment as specified in the ship's approved Cargo Securing Manual.

Choice of lashing equipment

It is of great importance that the lashing materials chosen for the securing of a particular item or shipment should be appropriate. For example, chains and wire ropes should not be used to secure rolls of tissue paper because the lashings will cut into the paper and cause damage when the cargo moves as the ship rolls and pitches in the seaway. Similarly, webbing straps or steel bands are likely to be unsuitable for the securing of a 200 t piece of machinery simply on the basis of the number that would be required.

Lashings appropriate to the size, weight and type of cargo must be used and those lashings must always be used in conjunction with appropriate pieces of dunnage material.

Choice of lashing arrangements

The lashing arrangements must have the desired effect – they must prevent the cargo from moving as the ship rolls and pitches in the seaway. The arrangements must be efficient, there is no point fitting a lashing that has no effect, and the arrangements must be appropriate to the type of cargo. Lashings applied to cargo are of various types (Fig. 5)

- direct lashings
- loop lashings
- compacting lashing.

Direct lashings

When a piece of cargo is provided with lashing points or fittings that can be used to take lashings, direct lashings can be fitted to those points or fittings and then led to the ship's lashing points or strong fittings. The most efficient lashings are those that are set up in the direction of the force, transverse or longitudinal, against which the lashing is to act.

Lashings fitted at an angle to the fore-and-aft line and to the athwartships line will have components that act in both of those lines but careful calculation of the effects must be made. Lashings to prevent transverse or longitudinal sliding should be fitted at a lower angle, whereas lashings to prevent transverse tipping should be fitted at a higher angle.

Loop lashings

Loops can be fitted to single units that have no lashing points and to blocks of cargo stowed against the ship's side. However, they must be carefully set up so that they have a securing effect and do not simply increase friction, unless the desired effect is to increase friction. Loops can be led horizontally or vertically, but they must begin and end on the same side of the cargo to have a securing effect, if not the lashing is just a friction loop.

A *half loop* is a lashing that is led around a cargo unit or block, vertically over the top or horizontally around, and both ends are secured to the ship's structure on the same side, either to port or to starboard. These lashings have a positive securing effect in one direction only, and both parts of the lashing can be counted for the balance of forces calculation. However, they must be fitted in pairs, one acting to port and one acting to starboard.

A *head loop* is a closed loop of lashing material, or grommet, which is fitted around one side of the upper part of a cargo unit and thereby produces a fixture point for direct lashings.

A *friction loop*, or over-the-top lashing, is a lashing led vertically over the top of a cargo unit from one side of the unit to the other side. When the lashing is set tight it will increase the friction between the base of the unit and the tank top or deck but will provide no security against either tipping or sliding. As the coefficient of friction in the balance of forces calculations cannot be changed from that given in the appropriate table, and as there is no effective lashing strength, friction loops must be ignored during any assessment of the overall securing arrangements. Thus, friction loops should not be used alone.

A *silly loop* is a rope that is led over and round a cargo unit and its ends are secured on opposite sides of the unit. Such a lashing might achieve an increase in friction but it does not provide any securing capacity. It might look as though it provides two independent lashings but it does not, and it should not be used.

Compacting lashings

Cargo items stowed in a cross-stowage arrangement and which, by their nature, have no lashing points may be provided with compacting lashings to hold individual items together to form more solid blocks within the stowage. Such compacting lashings will be led through and / or round adjacent items to hold them together. These arrangements provide no direct or indirect transfer of forces to the ship's structure.

Coils of steel sheet stowed in athwartships rows should be secured by the use of compacting lashings.

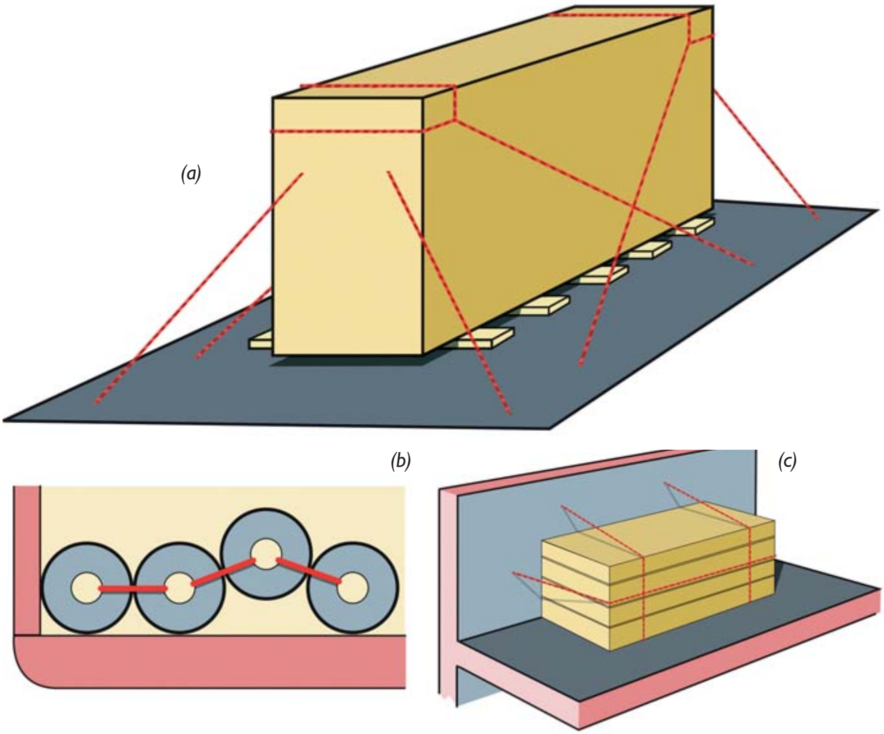


Fig. 5. Types of lashing – (a) direct, (b) compacting and (c) loop

Care of lashing materials

When not in use lashing materials must be kept in a suitable clean, dry storage area away from chemicals or other stores items that might cause them damage. Moving parts of items such as shackles and turnbuckles should be kept lubricated and free. All pieces of lashing equipment should be thoroughly inspected at regular intervals and all damaged, heavily worn or otherwise defective pieces should be discarded or put to one side pending repairs.

Whenever items are brought out of storage and into use to secure cargo, an examination should be carried out to confirm that they are still in satisfactory working order. When new pieces are brought on board they should be inspected to confirm that they are the items that were ordered and that they are in good condition.

The Cargo Securing Manual should be updated as appropriate. Whenever the ship's outfit of portable cargo securing devices changes, those changes should be recorded in the appropriate section of the Cargo Securing Manual. An appropriate record should be completed whenever routine visual examinations or periodic detailed examinations and re-testing of the devices are carried out.

Dunnage

The term dunnage includes the various materials that are used to protect, separate and support items of cargo. Dunnage includes the following.

Types of dunnage

- Timber in the form of flat boards, large-section balks and the full range of sizes in between.
- Various types of paper including reinforced and water-resistant.
- Polythene sheeting and other synthetic or natural fibre material sheeting.
- Air bags in a range of sizes.
- Various types of poles and woven mats made and used predominantly in the Indian sub-continent and the Far East.

Dunnage has many functions, but in connection with stowage and securing these are as follows.

Role of dunnage in stowage and securing

- To protect cargo from contact with the ship's steelwork, to avoid contact with water that might form as ship sweat or that might run down from above, for whatever reason.
- To support one shipment of cargo loaded on top of another, in the form of timber, plywood sheets or steel sheets and plates.
- To support cargo against tipping, in the form of timber shores or buttresses.
- To spread the load of the cargo across the hatch, deck or tank-top.
- To increase the friction between the base of the cargo item and the hatch, deck or tank top upon which it is stowed.

As with lashings, dunnage material that is part of the ship's outfit, and is not discarded at the end of a voyage, should be stored in a suitable clean and dry storage space, away from any chemicals or other items that might cause damage. At appropriate intervals the dunnage materials should be visually examined to determine whether or not any damage has been sustained. Damaged pieces should be discarded. Whenever dunnage materials are brought into use, and when new dunnage is brought on board, the items should be thoroughly inspected for defects and for their suitability for the intended purpose.

A large proportion of the dunnage brought on board is for use during the current voyage only and must be disposed of after the off-loading of cargo, the so called *one-trip dunnage*. Careful thought must be given to its disposal. Increasingly the regulations of port states require the master to provide a certificate to demonstrate that any dunnage materials that are to be landed have been appropriately treated, either by heat or chemicals, to eliminate the possibility of the dunnage harbouring unwanted insects and pests before any of the materials are landed. Such a certificate must be obtained by the master when the dunnage materials are delivered to the ship and it must be ensured that the certificate covers the materials delivered and that the materials have, so far as can be determined, been treated in the manner shown on the certificate and are not in any way infested.

If it is intended that any dunnage materials are to be dumped at sea, the appropriate provisions of the regulations, that is primarily annex V of the International Convention for the Prevention of Pollution from Ships (MARPOL) – Regulations for the Prevention of Pollution by Garbage from Ships – and any other local requirements, must be followed.

Friction

Whenever two surfaces are in contact and are either static or sliding over each other, there will be a friction force acting against any force which is causing or is likely to cause movement. That friction force is dependent upon the coefficient of friction (μ) between the two surfaces.

For a piece of cargo placed on the deck of a ship the friction force, or rather the force required to overcome that friction force and therefore required to move that piece of cargo across the deck, can be calculated by multiplying the weight of the item (mass × gravitational pull) by the coefficient of friction of the two surfaces.

Calculation of friction force

$$F = \mu \times m \times g$$

Where F = friction force, μ = friction coefficient, m = mass, g = acceleration due to gravity

Thus, the larger the friction coefficient of the contact surfaces, the larger will be the force required to slide the item of cargo across the deck.

The magnitude of the coefficient of friction is dependent upon the nature of the two surfaces and whether or not they are lubricated. In paragraph 7.2. of annex 13 of the CSS Code the most useful friction coefficients, so far as the securing of cargo are concerned, are given as in Table 2.

Table 2. Coefficients of friction from the CSS Code.

Materials in contact	Friction coefficient (μ)
Timber to timber (wet or dry)	0.4
Steel to timber or steel to rubber	0.3
Steel to steel (dry)	0.1
Steel to steel (wet)	0.0

Definition of coefficient of friction

The coefficient of friction (μ) between two surfaces is the tangent of the angle to which that contact surface must be raised in order that movement between the two surfaces will occur as a result of gravitational force alone, without any other external forces acting.

The coefficient of friction between timber and steel is 0.3. The friction coefficient is independent of the weight of the object pressing down on the surface and is also independent of the area of the contact surface. This means that a piece of timber dunnage, of any size or weight, lying on the deck of a ship will move to the low side of the ship when it is listed to about 17°; 0.3 being the tangent of 16.699°. Similarly, a heavy piece of machinery, of whatever weight, placed on ample timber dunnage on the deck of a ship will also slide to the low slide when the ship is healed to 17° (Fig. 6). That is, of course, with no lashings fitted.

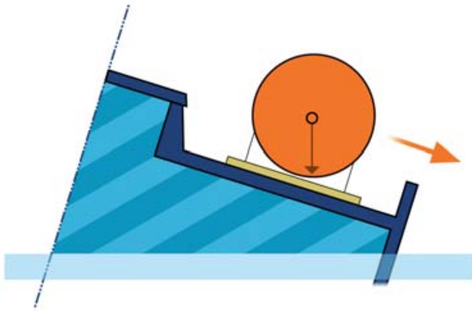


Fig. 6. Cargo sliding on deck

From the CSS Code table of coefficients it is clear that if there were no dunnage between the steel base of the piece of machinery and the steel deck the piece of machinery would slide at a much smaller list angle. If the steel deck is wet it is apparent from the table in the CSS Code that the piece of machinery would slide across the deck if the ship were to list over to any very small angle, the coefficient being 0.0. That figure has been given in the table more to represent the dynamic situation, with the ship rolling and pitching, than a static situation. Of course the piece of machinery would not move simply because the deck is wet, but once the ship starts to move the coefficient of friction may be considered to be zero and it is the dynamic situation against which the cargo is to be secured. Therefore it is also clear that when timber dunnage is fitted below pieces of cargo, but with no lashings fitted, those pieces of cargo would slide across the deck at an angle greater than if there were no timber at all.

When a ship is in a seaway, and it is rolling and pitching, the angle of the deck to the horizontal will be changing throughout and therefore the relationships between the item of cargo and the deck upon which it is stowed are dynamic and external forces will be acting upon the cargo in all directions, as given above; see again Fig. 1.

The additional external forces will cause a piece of cargo to slide over the deck at an angle less than that which is equivalent to the friction coefficient of the two surfaces. Lashings, when properly fitted and tensioned, will stop the piece of cargo from sliding across the deck. This is done by the components of the lashings acting variously vertically down and horizontally. Vertical components will effectively increase the friction coefficient, which will mean that a larger external force will be necessary before movement takes place. Horizontal components will act in line with the external forces, again meaning that larger external forces will be needed before movement takes place.

The components of the lashings will also prevent a piece of cargo from tipping over.

Slide or tip

Items of cargo that have a low centre of gravity and a large base area are likely to slide before they tip over, whereas items of cargo with a small base area and a high centre of gravity are likely to tip over at a roll angle far less than that required for the piece of cargo to slide (Fig. 7). This being the case, when deciding upon the type of lashings and dunnage to be used in the securing of the piece of cargo, its size, shape and the position of its centre of gravity must be taken into account.

To prevent a piece of cargo from sliding, the coefficient of friction between its base and the deck must be increased as much as possible, for example by the fitting of rubber matting below the piece, if appropriate, and by fitting low-level chocking or lashings to act against the forces that will produce the sliding motion.

To prevent an item with a high centre of gravity from tipping over, the item must be fitted with timber buttresses or shores, and / or lashings, fitted to the upper part of the cargo item. These, of course, being in addition to other chocking or lashing at lower levels that must be fitted to counter the always-present sliding forces.

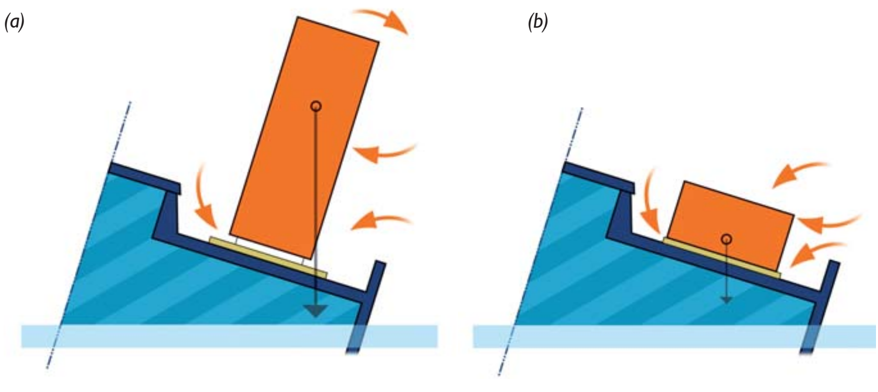


Fig. 7. (a) Cargo pieces with a high centre of gravity and narrow base are more likely to tip before sliding, while (b) pieces with a low centre of gravity and wide base pieces will slide before tipping

RULE-OF-THUMB AND ADVANCED METHODS

Annex 13 of the CSS Code gives the two methods of accessing the efficiency of securing arrangements of non-standardised cargo (not container lashings). Either of the two methods – the rule-of-thumb method or the advanced calculation method – may be used to establish whether or not the chosen system of lashings is sufficient to prevent the piece of cargo moving during an ocean voyage, provided severely adverse weather conditions are not encountered and provided the ship is navigated in a proper and seamanlike manner.

It should be noted that both methods take into account the strength of lashings, the effectiveness of dunnage in place below the piece of cargo to increase friction and, if appropriate, any anti-tipping or anti-sliding forces set up by timber shores, buttresses or chocking fitted against the piece of cargo. However, no account is taken in the calculations of the anti-tipping or anti-sliding forces set up by any sea fastenings. Also, the methods are for the assessment of arrangements fitted to a single item of cargo that is free standing upon the tank-top, deck or hatch covers. Sea fastenings and timber chocking are dealt with in the section on heavy-lift items and project cargo in Chapter 3.

A presentation of the methods described in annex 13 will be given in the Cargo Securing Manual of a ship in a form suited to that particular ship and the equipment on board.

Maximum securing load

For the purposes of the calculations here, the maximum securing load (MSL) of any device is used rather than its breaking strength.

Definition of maximum securing load (MSL)

Maximum securing load (MSL) is defined in the CSS Code as the load capacity for a device used to secure cargo.

The MSL of a securing device is a proportion of its breaking strength, as is the safe working load of a cargo gear wire, but here the proportion depends upon the type of device.

The MSL proportions for different devices are given in Table 3.

Table 3. Determination of MSL from breaking strength

Material	Maximum securing load (MSL)
Shackles, rings, deckeyes, turnbuckles of mild steel	50% of breaking strength
Fibre rope	33% of breaking strength
Web lashing	50% of breaking strength
Wire rope (single use)	80% of breaking strength
Wire rope (re-useable)	30% of breaking strength
Steel band (single use)	70% of breaking strength
Chains	50% of breaking strength

The CSS Code suggests that where a particular device has been assigned a safe working load, then that load should be substituted for the MSL, provided the safe working load is equal to or exceeds the MSL as calculated from its breaking strength. Similarly, some devices will be given a permissible working load, for example lashing chains provided on board a log-carrying ship, in which case the working loads should be used as the MSL of the device.

It should, of course, be remembered that any lashing is only as strong as the weakest link, and that the MSL value of the weakest part of any combined lashing must be used in any calculation. For example, if a wire is shackled to a strong point on a piece of cargo and attached via a turnbuckle and a shackle to a deck D-ring, the MSL of the weakest device, which might be one of the shackles or the D-ring, must be used in any calculations.

The MSL percentages were derived from consideration of a number of factors. First of all, they are based on the understanding that the devices are in satisfactory working and lubricated condition, and not in any way damaged, corroded or wasted. Any damaged, corroded and wasted securing devices should be set to one side for repair or should be discarded by the appropriate method. They should not be used for the securing of cargo. Experiments were conducted at testing establishments on a range of lashing devices, both fixed and portable, and a set of results was evolved. Those results were re-checked by experts in a number of maritime nations. Safety factors were then applied, as appropriate, to the findings obtained by the tests and experiments, and the final table of MSLs, given as percentages of breaking strength, was produced.

The explanation as to how the percentages were derived is as follows.

Mild steel shackles, rings and chains

A mild steel shackle or ring has a yield strength of about 60% of its breaking strength. That is to say, those items will start to deform at a loading that is equal to 60% of its breaking strength. The MSL was therefore set at 50% of the breaking strength so that mild steel items, and chains that are made of high-tensile steel, will not deform during usage and can therefore be used time and again.

Wire rope – single use and re-usable

Wire rope has no specific yield limit but elongates steadily until it fails. Experiments with lashing wires have shown that to keep a wire in good condition and therefore to avoid any permanent elongation, it must not be exposed to peak loadings in excess of 55% of the breaking strength. Also, frequent loadings of more than 15% should be avoided. That is to say, if a wire is not exposed to loadings of more than 55% and loadings of more than 15% are not frequent, the wire will remain in good condition without any deformation of the wires.

From the findings and following the application of safety factors, it was decided that wires that were part of the ship's outfit, and therefore would be re-used time and again, should have an MSL of 30% of their breaking strength to avoid the possibility of damage to the wire. For a wire that is brought on board for a single, one-trip use and therefore would be discarded at the end of the voyage, whether or not any deformation of the wire had been suffered, an MSL of 80% of the breaking strength was appropriate.

With regard to the use of wire rope grips to form eyes in wire lashings, experiments have disclosed that wire will slip through the grips at a load of about 70% of its nominal breaking strength. It is recommended here that when single use wire rope is being used in conjunction with rope grips, the MSL should be considered to be 70% of the breaking strength.

Fibre rope

Fibre rope is often knotted and tensioned by the use of the Spanish windlass method (tightening turns of rope by twisting them by means of a stick). Thus, when in use, it will not retain its full breaking strength and one-third of that strength appeared to be a commonsense figure for the MSL.

Steel bands

Steel bands are also a one-way material. During use, slight permanent elongation of the bands might occur, permanently weakening the bands. The bands will be discarded at the end of the voyage, in any event. Thus, an MSL of 70% of the breaking strength of the steel band is reasonable.

Web lashings

Web lashings are usually reusable. Webbing has stretch characteristics similar to wire rope but does not deform at high tension as wire rope does. The figure of 70% of breaking strength was originally used for the MSL but the 2002 amendments recommend 50% of the breaking strength, as noted in the table above.

Rule-of-thumb method

The rule-of-thumb method is a simple method that may be used for the assessment of lashings fitted to a piece of cargo anywhere on board the ship. The method does not take into account the size of the ship, its stability or loaded condition, or the season or area of operation.

The method assumes that the item of cargo is adequately dunnaged to provide friction against sliding and assumes that lashings are fitted at an angle no greater than 60° to the horizontal. Any lashings that are at angles greater than 60° to the horizontal should not be included in the number of lashings in the assessment calculation.

Rule-of-thumb method for calculating lashing requirements

The total of the MSL values of the securing devices on each side of the unit of cargo (port as well as starboard) should be equal to the weight of the unit.

The units used in annex 13 are SI, where force is expressed in kilonewtons (kN) and mass in tonnes (t). For simplicity it is assumed that 1 kN ≈ 100 kg or 0.1 t. However, when using the rule-of-thumb method, so long as everything is in the same units it does not really matter which unit is used, and indeed to work out everything in tonnes might be easier.

The process of assessing the efficiency of the securing arrangements by this method is therefore quite simple and straight forward. The total weight of the unit must be established and the total of the MSLs of the lashing devices on each side must equal that total weight. An amount of commonsense and good seamanship practice must be observed in order for the rule to work efficiently. It is also important to remember some basic requirements, as follows.

Basic requirements for rule-of-thumb method
• There must be a balanced number of lashings on each side of the unit, that number depending upon the size, shape and weight of the unit.
• Some of the lashings should have a fore-and-aft component as well as an athwartships component.
• Lashings that are led directly forward or directly aft, and therefore have no athwartships component, should not be included in the assessment calculations.
• Lashings that lead down from the unit at an angle of more than 60° to the horizontal should not be included in the assessment calculations. Such lashings prevent tipping but not sliding.
• All lashings should be made up in the same way, comprising the same components, so that they have the same elasticity.

The rule-of-thumb method ensures that, when a ship rolls heavily to port and to starboard, the item of cargo will be sufficiently secured such that it will not shift under normal circumstances. It is an assessment of the effectiveness of the athwartships components of the lashings.

Whenever using the method, the overall arrangement of the lashings should be borne in mind to ensure that there are sufficient fore-and-aft lashings as well as the required number leading athwartships.

40:40:10:10 rule for lashing directions
A tried-and-tested formula is to have 40% of the lashings' strength to port and 40% to starboard, with 10% leading forward and 10% leading aft.

Advanced method

The advanced calculation method, given in section 7 of annex 13 of the CSS Code, is a more precise calculation that assesses the efficiency of securing arrangements in both the athwartships line and the fore-and-aft line. The method is a calculation in four parts. The four steps progressively set out and determine the basic information needed, the external forces acting on the cargo, the anti-sliding and anti-tipping components of the securing arrangements and, finally, whether or not the securing arrangements are sufficient to keep the cargo from shifting.

The four steps are as follows.

Advanced method for calculating lashing requirements

- *Step one* – all the basic information about the ship, the piece of cargo and its stowage location should be obtained and listed, and the primary calculations completed.
- *Step two* – the external forces that are likely to act upon the item of cargo are calculated.
- *Step three* – the effect of friction and the effectiveness and strength of all the individual lashings in each of the four directions is calculated.
- *Step four* – an assessment is made to establish whether or not the effectiveness of the combination of the friction and lashings exceeds the likely external forces.

If the combinations of friction and the lashing strength exceed the external forces in both the athwartships line and the fore-and-aft line, then those lashings are sufficient for the voyage. But if any of the combinations of friction and lashing strength is less than the external force in that direction, then additional lashings must be added or the friction must somehow be increased.

Sub section 7.1 of annex 13 provides methods for the assessment of the external forces acting upon an item of cargo and gives tables for use in determining accelerations – step two.

Sub section 7.2 of annex 13 provides methods for the assessment of friction and the securing arrangements to be used to the balance calculation. The calculated strength (CS) of each securing device is taken as MSL divided by 1.5. The angle between the horizontal and the line of each device that affects the effectiveness of the device is taken into account by the factor f, which can be determined from table 6 for the transverse sliding and longitudinal sliding assessments. The angle between the fore-and-aft line of the ship and line of each device, which affects the effectiveness of the device for the longitudinal sliding assessment, is not taken into account formally, the effectiveness of the devices should be estimated but should not be assumed to be greater than 0.5 × ***CS***.

Sub-section 7.3 of annex 13, new in the 2003 edition of the CSS Code, gives an alternative method for the estimation of the balance of forces and takes into account the angle between each device and both the fore-and-aft and the athwartships line of the ship. If this method is used, the ***CS*** of each securing device is taken as MSL divided by 1.35.

There are examples of the use of both methods in appendix 1 of annex 13.

Appendix III of this book provides a detailed description of how the advanced calculation method works and how it can be used in practice. Appendix IV gives a worked example and calculation sheet setting out the assessments. Appendix V provides a blank version of the calculation sheet.

Which method to use

The worked example and the calculation in Appendix IV show that a boiler is satisfactorily lashed in all four directions because the six anti-movement actions, acting against sliding and tipping, are all greater than the external forces by an acceptable safety margin.

If the voyage in the example had been earlier in the year, such that the ship was crossing the Gulf of Arabia during the south-west monsoon season, or if adverse conditions were forecast for the North Atlantic, consideration would have to be given to increasing the number or strength of the lashings to take into account the probability that the adverse weather conditions would cause an increase in the basic acceleration data that would, in turn, increase the external forces acting upon the boiler.

Weather conditions likely to be encountered on the voyage must always be taken into account when determining the number and strength of the lashings.

The worked example in Appendix IV shows that the boiler is very satisfactorily lashed using seven lashings on each side. But would the same lashings satisfy the rule-of-thumb method?

The rule-of-thumb method states the total of MSL values of the securing devices on each side of the unit of cargo should equal the weight of the unit.

Example of rule-of-thumb method

Weight of boiler = 81.7 t

Total MSL each side = 81.7 t or 817 kN

Securing devices' MSL = 9.24 t or 92.4 kN

Seven devices each side = 64.68 t or 646.8 kN each side

Conclusion = insufficient lashings

Requirement = nine devices of MSL 9.24 t to give 83.16 t or 831.6 kN each side

The exercise shows that if it is possible to use the advanced method, it is likely to mean that fewer securing devices are needed, but the calculation can only be used if all the information to complete the calculation is available, otherwise the rule-of-thumb method must be used.

Caution

The calculations have been formulated with a number of basic understandings in mind, most of which are good seamanship practice.

It is assumed that the ship will not roll to an angle greater than 30º to port and to starboard and that it will not pitch heavily or slam into on-coming swell waves. Also, it is understood that the ship will not be running before large stern or quartering seas such that excessive rolling and pitching motions are experienced. If the ship's motions are very large then clearly the accelerations used within the calculations will be incorrect. The good seamanship answer to this is that when the ship is approaching an area of adverse weather and / or high sea and swell conditions, actions should be taken to minimise the motion of the ship by an alternation of course and / or speed. Chapter 6 of the Timber Deck Cargoes Code states, 'the lashings were not designed to provide a means of securing against imprudent ship handling in heavy weather. There can be no substitute for good seamanship.'

The advanced calculation method uses the worst-case approach, and therefore there ought to be ample reserve of strength to allow for unavoidable excessive motions of the ship and errors in the estimation of the strengths of the lashing devices, the imbalance of the lashing devices and the angles and distances involved. However, it must be remembered that when measuring the securing angles and the lengths of levers, the more accurate those measurements are the more accurate will be the results of the calculations.

The object of the advanced calculation method is to establish whether or not the external forces are exceeded by the anti-sliding and anti-tipping forces. If it is found that there is no excess, then clearly additional lashings need to be fitted. If in doubt, play it safe and fit more lashings.

The advanced calculation method allows a reduced number of lashings to be used when compared with the rule-of-thumb method (see the comparison given in the worked example above). However, to take advantage of the reduced number of lashings, the advanced calculation method must be done correctly and completely.

When considering the securing devices, only those that are attached to fixed securing points marked on the cargo unit or strong supporting structure and led directly to a ship's lashing point, or those taken as a loop around the unit such that both ends are secured to a ship's lashing point to the same side, should be used in any calculations. Lashings going over the top of the cargo unit, which have no securing direction but only act to increase friction, sometimes referred to as 'friction loops', cannot be used in any evaluation.

If all of the information is not available, for example the exact position of the centre of gravity of the item of cargo, the advanced method calculation cannot and must not be used. If there is any doubt whatsoever, the rule-of-thumb method and all the guidance given in the sub-section above must be used to assess the lashings applied to the item of cargo.

TANK-TOP STRENGTH CALCULATIONS

During the design stage of a newbuilding, the size of the various structures is decided upon. Those structures include the deck and tank-top plating, under-deck stiffening members, double-bottom longitudinal and athwartships stiffening members and so on. From the scantlings of those members, the naval architects calculate the strength of the ship's weather deck, 'tween decks if it has any, and the tank-top. Such a calculated strength is, of course, an absolute strength and cannot be used for cargo loading purposes.

However, from the strength figures, and using safety factors (for example for corrosion) and other considerations, agreement will be reached between the naval architects of the shipbuilder and the naval architects of the classification society providing the necessary approvals, as to maximum permissible loadings, given in tonnes per square metre (t/m^2) for each deck and the tank-top, and also, usually the hatch covers. Those figures will remain in force throughout the lifetime of the ship, so long as no structural changes are made.

The maximum permissible load figures are given on various ship's plans, for example the capacity plan, the midship section plan, and possibly also on-deck plans, and will also be quoted in the ship's trim and stability booklet and in the Cargo Securing Manual.

If the maximum permissible loading is exceeded by cargo items or blocks of cargo units, there is a strong possibility that the deck, 'tween deck or tank-top plating, and the under-deck stiffening members, will sustain damage when the ship rolls or pitches in the seaway, if not before. It is thus essential to know the loading rate of heavy items of cargo and to ensure that the weight of cargo is spread out evenly over the deck, 'tween deck or tank-top plating to reduce the loading rate to below the maximum permissible loading rate. Similarly, it is essential to know the loading rate of blocks of cargo.

The maximum permissible weight of a cargo item or a block of cargo units is calculated as follows.

Calculation of maximum permissible cargo weight

Maximum permissible cargo weight (t) = area of deck or tank-top (m^2) × maximum permissible loading (t/m^2)

The formula can of course be used in reverse to establish the minimum area over which the weight of an item of cargo or block of cargo units must be spread.

Calculation of minimum area of deck or tank-top

Minimum area of deck or tank-top (m^2) = cargo weight (t) / maximum permissible loading (t/m^2)

Deck and tank-top maximum permissible loadings range from around 1.5 t/m^2 for hatch covers, through to around 5 t/m^2 for weather decks and ’tween decks, to within the range 10–25 t/m^2 for tank-tops. A bulk carrier designed for alternate hold loading of heavy bulk cargoes will have the strongest tank-top structures.

Chapter 3

CARGO-SPECIFIC INFORMATION

BREAK-BULK ITEMS

Fig. 8. Stowing break bulk cargo (Graig Ship Management Ltd)

Break-bulk cargo items include all classes of cargo that do not come under a specific heading, as do heavy-lift items and ro-ro cargo, and therefore do not have specific requirements in terms of stowage and securing (Fig. 8). That does not mean, however, that there are no rules to be followed with regard to the safe carriage of such items. The CSS Code includes some guidance on the safe stowage and securing of portable tanks, portable receptacles and unit loads, in annexes 2, 3 and 12 respectively, and that guidance can be applied to the carriage of most break-bulk or general cargo items.

The items dealt with in this section include cartons, pallets, cases, crates, rolls, reels, bales, tanks, vessels and unit loads (although there are many other types of commodity). These items have two things in common: they have no lashing points, and they either cannot be loaded one atop another or they have a limited over-stow load. Many types of carton might be suitable for a maximum stacking of nine high, whereas large reels of cable cannot be stowed one on top of each other.

The fundamental rule with break-bulk cargo is as follows.

Fundamental rule for break-bulk cargoes
Establish the strengths and weaknesses of the items in terms of possible over-stowing capacity and susceptibility to damage from horizontally aligned forces, motion or contact, and then decide upon the best manner in which the items are to be stowed and secured.

As is the case for all types of cargo, there are a number of points to be remembered and basic rules to be followed when stowing and securing break-bulk items. These can be summarised as follows.

General advice for break-bulk cargoes
• The cargo compartment should be clean and dry so that the cargo items are not contaminated or wetted.
• The strength of the tank-top or deck area should be borne in mind when loading heavy items in order that the maximum permissible loading is not exceeded. Appropriate timber dunnage should be used where necessary to spread the load of the cargo items.
• Appropriate types and amounts of dunnage materials should be used to increase friction and to protect, support and separate the items of cargo.
• The best method of securing the items of cargo should be decided upon; this might be direct lashings to the item or items, it might be lashings around the pieces of cargo, or maybe timber supports against blocks of cargo, or a combination of these.
• The way in which the cargo is stowed will depend upon the type of cargo. Some items should be stowed in blocks against a bulkhead and other types should not be stowed against each other or against bulkheads but should be stowed and secured individually.
• When stowing different types of cargo in blocks, ensure that the items lower down in the stowage have sufficient strength to support the items higher up. Never stow heavy items over soft items of cargo.
• Items such as tanks or modules that have a long side and a short side should be stowed with their long side in the fore-and-aft direction.
• There should be a means of safe access into the cargo compartment or along the deck so that inspections of the cargo and their securing arrangements can be carried out safely by ship's staff during the ocean voyage.

Guidance with regard to different types of break-bulk cargo is set out below.

Cartons, pallets and drums

Small-sized and medium-sized regular items such as cartons, pallets and drums can be block-stowed together against a bulkhead or against the ship's side, or both, and then secured to that bulkhead and / or ship's side structure. When shipments of cargo are stowed in blocks, the following points should be remembered.

Advice for cartons, pallets and drums stowed in blocks
• The deck or tank-top should be flat and flush. If it is not, timber or other dunnage materials should be used to level the surface so that the stowage block is itself level overall.
• Individual units should be stowed hard up against each other and hard up against the bulkhead and / or ship's side structures.
• Timber and / or paper dunnage should be used as appropriate against bulkheads and ship's side structures.
• The block should be stowed such that there are no void spaces between the cargo items. If spaces exist these should be filled with dunnage, which might include timber, air bags or whatever is appropriate.
• At each appropriate tier of cartons or pallets, timber or plywood sheets should be used, both to spread the load of the upper tier cargo over the top of the lower tier of units and to ensure that the top of the lower tier is a flat and level surface onto which the next tier can be safely stowed.
• The lower tier units should not be overloaded by the weight of upper tier units.
• The block should be secured by a combination of dunnage and lashings. Dunnage, perhaps gratings or plywood sheets, should be positioned vertically against the block faces and then lashings, of wire, webbing straps or whatever, should be lead around the dunnage at all levels of the stowage and then set tight to hold the dunnage in place and to minimise the possibility of movement of the block. Additional lashings to brace the primary lashings back to the bulkhead or the ship's side structure should be used as appropriate. The lashings should not pass directly over the cargo items because chafing damage might occur if direct contact is made.

Reels of cable

Reels of cable come in a range of sizes and are dealt with here in isolation because they have special needs. Most are of timber construction although a small proportion of the larger size reels are of steel construction. The reels on which the cable is wound are, usually, for single-trip use and will therefore be discarded when the cable is taken into use. This means that the reels are not heavily constructed and will suffer damage if mishandled.

It should also be borne in mind that the cable wound onto the reels will be of high value.

Advice for reels of cable

- Reels of cable should be stowed in the fore-and-aft line of the ship and should be chocked with timber, appropriate to the size of the reels, to prevent movement of the reels and chafage.
- Small reels tend to be more strongly constructed, and may be block-stowed with the flat surface of one against the flat surface of the next. Such a block stowage must be tight and compact without any vacant space. The block should be adequately timbered and secured by the use of appropriate lashing materials.
- Larger dimension reels should be stowed and secured individually. Large reels sometimes have cradles fitted, which can mean stowage is made easier. If the reels are not fitted with cradles, then either a suitable timber cradle must be constructed or wedges of suitable size must be fitted to prevent the reels from rolling in the fore-and-aft line.
- The rules with regard to lashing, for the prevention of sliding and tipping over, must always be followed.
- Reels of cable must not be stowed with their axes in the fore-and-aft line, like coils of steel. If they are stowed like coils extensive damage might easily result. This is because when slight movement of the reels occurs in the fore-and-aft line in the direction of their axis, the rims of adjacent reels, which might be only a few centimetres in breadth, will move out of alignment and the reels will then be free to roll athwartships and cause damage to the cables.

Reels of paper

Paper carried as reels comes in a number of forms and a variety of reel sizes. The type of paper ranges from fibre board or liner board that might be quite thick and is used in the construction of cartons, through newsprint and other printing paper that might be very thin, to tissue paper which is delicate. Sizes range from small reels of diameter and height less than 1m in the case of printing paper, up to possibly more than 1.5 m diameter and 2 m high reels in the case of tissue paper.

All reels are provided with minimal packaging that might be in the form of cling-film or shrink-wrap polythene in the case of tissue-paper reels, or a liner board wrapping with head disks glued in place for other types of paper.

Advice for reels of paper

- Whatever the size or packaging, reels of paper are susceptible to contact damage and wetting damage.
- Reels must be stowed upon a flat smooth surface covered with paper and a block of reels must be protected on all sides. The most appropriate stowage is in a box-shaped compartment.

- When stowing reels in other shaped compartments, or together with other break-bulk items, care must be exercised to ensure that the surface on to which the reels are being stowed is horizontal, level and stable, and that the block is adequately secured on all sides. Such securing arrangements might include the fitting of fencing, in the form of gratings, plywood and timber, around the open faces of the block stowage with lashings of wire, webbing or fibre rope, as appropriate, around the block and led to bulkheads or the ship's side structure.
- It must be remembered that the reels are highly susceptible to damage and therefore the lashings must not touch the reels and the fencing must be constructed and arranged such that the possibility of chafage and rubbing of the reels is minimised. Fitting of additional soft packing might be appropriate in some cases.

Tanks and vessels

Tanks, vessels and other such items might have no lashing points, might be offered for shipment without any form of cradle or support structure and might have an external coating that must not be contacted by the securing arrangements. It might, therefore, be appropriate to have discussions with the shipper's representatives to establish how best to secure the items. The pieces might have flanges or support feet and it might be possible to use such fittings for the attachment of lashings or to put timber chocking against, but it might not. In the absence of any appropriate fittings a timber framework or crib, combining cradles and support structures, must be constructed beneath and around the base. Lashings can then be fitted to the support structure and, where and how appropriate, to the item itself.

In the CSS Code the method of securing portable tanks and receptacles having no securing points is by the use of loops around the unit such that both ends of each loop are secured to the same side of the unit. Each unit must, of course, be fitted with a balanced number of loops leading variously to port and to starboard. A loop will prevent the item of cargo from shifting in the direction away from the lashing securing point and therefore such loop lashings can be counted in the evaluation of securing arrangements. The alternative of leading lashings over the top of the cargo unit in the form of a round-turn, such that the two ends of the lashing are secured to lashing points on either side of the unit, will increase the friction as a result of their vertical component but it is likely that the possibility of movement of the unit within such lashings will not be eliminated. For this reason such round-turn lashings cannot be included in any evaluation calculations.

Advice for tanks and vessels

- Tanks, vessels and the like are often longer than they are broad. This being the case they should be stowed in the fore-and-aft direction.
- The weight of the item should be borne in mind and calculations should be carried out to ensure that the loading rate in way of the base-structure, be it cradles or foot-supports, does not exceed the maximum permissible loading of the deck or tank-top. Timber dunnage should be used to spread the load.

- When lifting points are used as securing points, first establish that those lifting points can be used for lashings and establish their strength and the arc over which they can be used. If they only have strength in the athwartships line they cannot be used for lashing in the fore-and-aft line.

Suitability for shipment

The advice given in the preceding sections, although given for specific types of commodity, can be used for the stowage and securing of other items not listed. Care must always be exercised when taking a shipment on board for carriage to its destination. However, the suitability of the items of cargo for shipment to destination must always be borne in mind.

If the items of cargo cannot be satisfactorily stowed and adequately secured on board the ship, in a way that will not lead to the items of cargo suffering damage, then those items are not suitable for shipment on board the particular ship and therefore they should not be taken. It is better to decline to carry cargo than to carry it knowing it is likely to sustain damage during the voyage.

STEEL PRODUCTS

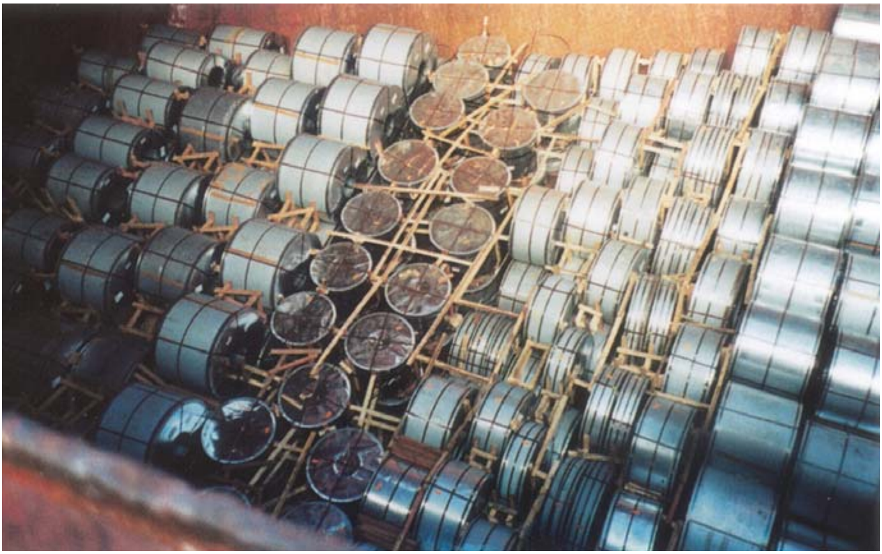


Fig. 9. Steel products being stowed in the hold of a bulk carrier

Steel products can be divided into two types; those that are packaged or wrapped and those that are shipped without any form of packaging. Generally speaking, those products that are wrapped are finished or semi-finished products and those that are not packaged are unfinished products. Some types of steel products, for example coils of steel sheets (Fig. 9), can be either finished and wrapped or unfinished and not wrapped, whereas other types, for example billets, are only unfinished. The main types of steel products are as follows.

- *Coils of steel sheets* – hot-rolled steel sheets are unfinished and therefore hot-rolled coils are not wrapped and are merely secured in coil form by steel bands. Cold-reduced steel sheeting, galvanised steel sheeting and any other sheeting with a surface preparation are finished products and therefore cold-reduced coils and so on are packaged with an inner waterproof paper liner and with outer steel-sheet wrappers, all held in place by steel bands.
- *Top-hat coils* – a top-hat coil, sometimes called a stillage, is a coil of steel sheet that is placed, with its eye vertical, onto a timber pallet base or timber rickers that have been nailed to form a strong timber base, such that it looks something like a top-hat. The coil will be of cold-reduced sheeting, galvanised steel sheeting or any other finished steel sheeting and is therefore packaged with an inner waterproof paper liner and with outer steel wrappers, all held in place by steel bands and with further steel bands to hold the coil onto the pallet base or rickers.
- *Cut steel sheets* – as with coils of steel sheets, bundles of cut-steel sheets might be of hot-rolled, unfinished, sheets, or of cold-reduced, galvanised or surface-finished sheeting. Bundles of hot-rolled sheets, which might for example be diamond plate, will be secured by longitudinal and transverse steel bands and might have transversely aligned timber rickers. Finished sheets will be packaged with an inner waterproof paper liner over which there will be steel-sheet wrappers, and the package will be fitted onto transversely aligned timber bearers and all will be held in place by steel bands.
- *Steel plates* – plates are of thickness, generally speaking, above about 3 mm and up to possibility 250 mm. They are unfinished and therefore not wrapped. They are sometimes secured by steel bands into bundles, although thicker plates are carried individually. They can be small, of dimensions 1 m × 2 m or larger up to 12 m × 3 m, or even larger on occasion.
- *Steel slabs, billets and blooms* – these are unfinished products that will be heated and rolled to form plates or bars and so on. They are not wrapped and are carried either singly or in bundles, depending upon their size.
- *Structural steels* – this category includes beams, angles, flats, channels and other shapes of bar. These are mostly unfinished and carried in unwrapped bundles, but finished and coated sections are often carried either singly or in bundles.
- *Merchant bars* – these are small cross-section bars; round, square, channels, T-bars and so on, which are for the most part unfinished and therefore carried in unwrapped bundles, but sometimes they are semi-finished bright bars or are oiled, and are then wrapped in some form of sheeting that might be hessian or synthetic.
- *Pipes and tubes* – these come in a range of types and sizes, some formed into bundles and others carried individually. Most are unfinished and therefore shipped without packaging but small-section tubing, which is often called hollow section, is a semi-finished product and is often carried oiled and wrapped in either hessian or synthetic sheeting.
- *Wire rod* – wire rod is sometimes carried in coil form and sometimes in cut lengths in bundles. Included in this category is reinforcing wire rod, or re-bar, which might

be profiled for use in concrete structures. It is an unfinished product and therefore not packaged, being merely retained in coil or bundle form by either steel bands or wire ties.

- *Railway iron* – rails are loaded at specialised ports individually and unwrapped.

All steel products are, by their very nature, heavy and require an amount of pre-planning before loading can commence.

Pre-planning for steel cargoes

- The cargo compartment must be clean and dry and a pre-loading inspection of the compartment might be carried out on behalf of the shipper of the cargo before loading begins. Such a pre-loading inspection might include an inspection and test of the weather-deck hatch covers.
- A stowage plan must be drawn up showing the arrangement of the cargo on board, and strength and stability calculations should be completed to demonstrate that the maximum shear force and bending moments are not exceeded and the ship's stability is satisfactory for the entire voyage. Calculations should be completed with regard to the distribution of the cargo to establish that the maximum permissible tank-top or deck loading is not exceeded.
- Sufficient quantities of the appropriate types of dunnage materials should be available for use.
- All of this pre-planning should be completed before loading starts.

Coils of steel sheet

Coils are shipped in a range of weights up to around 30 t and in a range of sizes. Coils should be stowed as follows.

Advice for coils of steel sheet

- Coils should be stowed on the round with their axis in the fore-and-aft line of the ship in athwartships rows, on lines of flat-board or square section timber dunnage laid athwartships on the tank-top, preferably laid above inner bottom transverse stiffening members.
- Each coil should be stowed hard up against coils to port and to starboard and wedges should be inserted against the inboard bilge of each coil and preferably nailed to the tank-top timber dunnage. Timber dunnage should be fitted between outboard coils and the ship's structure.

- If the coils are to be stowed in a single tier only, the last coil to be placed into stowage should be positioned as a locking coil, at a higher level so as to act like a wedge, in the space remaining in the middle of the row that must be of breadth about one-third of the diameter of the coil such that the locking coil will tend to force the coils to port and to starboard outboard. The locking coil will sink a little as the stowage settles during the voyage. The locking coil should be lashed to the two coils supporting it.
- If there is a longer space left in the middle of the row then that space should be split in two by moving middle coils and then two locking coils should be fitted and lashed in place.
- If second and third tiers of coils are to be carried those second-tier and third-tier coils should be stowed in the cantlines (grooves) formed by the coils in the tier below. Top-tier coils should be secured to the coils of the next tier below by the use of wires set tight by rigging screws or by metal strapping bands, tensioned correctly.
- Void spaces within the upper tiers should be avoided but, if spaces are unavoidable, then more timber dunnage should be put in place to ensure that the coil stowage is ridged and such that the timber chocking will not be displaced during the voyage.
- Each transverse row should be separated from the next by a gap of at least 150 mm to prevent contact between coils in adjacent rows because this would cause damage. Similarly, end rows should be kept well clear of bulkheads. Timber may be inserted between adjacent rows and against end bulkheads if thought appropriate.
- When loading coils of steel sheets, the deck or tank-top strength must not be exceeded and the height to which coils can be stowed, depending upon their weight, must not be exceeded; this height of stowage is often given in the ship's Cargo Securing Manual. Guidance on stowage height and tank-top strength calculations is given in a subsequent part of this chapter.

Diagrams showing correct stowage and lashing systems should be found in the ship's Cargo Securing Manual.

Top-hat coils

Top-hat coils are shipped in a range of sizes and weights, although not as large and heavy as coils on the round, and are up to about 15 t in weight. Great care should be taken when placing top-hat coils into stowage because it is often the case that the timber base is wider than is the diameter of the coil. This means that when two top-hat coils are placed such that their base-units are hard up against each other the coils upon those bases are not touching. These products should be stowed as follows.

Advice for top-hat coils

- It should be ensured that the stevedores' handling equipment is suitable for the size and weight of the product so that no damage is sustained by the timber pallets. If damage is sustained by the timber-work, the unit should be returned ashore for repair and not placed into stowage because an unsound base will lead to movement of the stowage during the ocean passage and damage to coils.
- The units should be placed directly on to the tank-top or deck plating although timber dunnage should be used as and where appropriate to level the tank-top or deck, such that the top-hat coils are stowed vertically and level with one another and such that the ground onto which the coils are placed is firm. The units should be stowed in athwartships rows and hard up against one another. Coils in adjacent rows should also be hard up against one another in the fore-and-aft line.
- Timber chocking should be used between adjacent coils in the fore-and-aft line and in the athwartships line such that the coils are chocked against one another and such that the stowage as a whole is a solid unit. Flat-board dunnage should be used to connect vertical chocks to eliminate, so far as possible, the likelihood of those chocks falling away during the voyage.
- Top-hat coils placed into a second and third tier must be placed squarely onto a coil in the lower tier and those second-tier and third-tier coils should be similarly chocked against adjacent coils. Staggering of coils in second and third tiers should be avoided because damage to lower-tier coils will result.
- Outboard to port and to starboard, substantial timber shores should be set up between the outboard coils and the ship's side structure to support those outboard coils over the full height of the stowage.
- Open athwartships faces should be secured by a combination of wire lashings led around groups of coils and to lashing points or ship's structure, and large-section timber dunnage or timber gratings in a fashion similar to that used to secure blocks of break-bulk cargo, and clearly of adequately substantial nature.
- Lashing wires should be set up around the blocks of coils to tie them together; such wires should be led around lengths of large-section timber such that the wires do not come into contact with the coils.

Packages and bundles

These include all products that have square ends and sides, including cut sheets, small plates, small-diameter pipes, hollow section and so on. These should be stowed in stacks hard up against each other, either in athwartships lines in the case of smaller-dimension products such as cut sheets, or in the fore-and-aft direction in the case of bundles of hollow section and the like.

Advice for packages and bundles

- Dunnage should be used to level the tank-top or deck plating as and where appropriate and to level the stowage in way of intermediate tiers. Timber should also be used at intermediate tiers to lock adjacent stacks together.
- The packages or bundles should be stowed hard up against each other such that there is no void space within the stowage. If spaces are unavoidable, timber chocks should be fitted to prevent movement of the cargo.
- Outboard to port and to starboard, and adjacent to the end bulkheads, appropriate timber chocking should be fitted to prevent any of the steel products coming into contact with the ship's structure and to ensure a tight and secure stowage.
- It is often the case that stowage of packages and / or bundles requires no securing by wires or steel bands because the products are adequately chocked against movement being hard against end bulkheads and side structures. However, when there is an open face of smaller-dimension packages at one end of the stowage, that face will require securing to prevent movement during the voyage. Securing should be by a combination of wire lashings led to lashing points or ship's structure used in conjunction with large-section timber dunnage, timber pallet boards or timber gratings, in a fashion similar to that used to secure blocks of break-bulk cargo, and clearly of adequately substantial nature.

Bundles of bars

These bundles include reinforcing bars, merchant bars and small-diameter tubes and pipes. They are likely to be irregular and cannot therefore be stowed in regular tiers.

Advice for bundles of bars

- The bundles should be stowed in the fore-and-aft line of the ship upon timber dunnage laid athwartships on the tank-top or deck plating.
- The bundles should be stowed compactly so that there are no void spaces within the stowage.
- Timber dunnage should be used as necessary to level the stowage and outboard to port and to starboard so that the bundles are kept clear of the ship's structure.

Steel slabs, billets, blooms and plates

These are heavy items that are often of irregular dimensions and will need particular care when positioning in stowage, and will require a lot of dunnaging.

Advice for steel slabs, billets, blooms and plates

- Sufficient timber dunnage should be used on the tank-top or deck plating satisfactorily to spread the load of the products.

- Plates may be stowed either athwartships or longitudinally but in such a manner as to produce a tight, even and level stowage with a minimum of void space.
- Ample timber dunnage should be used within the stowage: as chocking in void spaces; between plates to level the stowage; and around its perimeter to prevent contact between the steel products and the ship's structure.
- Stacks of plates should be avoided unless such stacks are surrounded and supported by other stacks of plates that can be tied together by timber dunnage at intermediate levels. Staggered stowing with plates overlapping each other will produce a tight and secure block of cargo that is more stable and therefore less likely to shift during the voyage.

Steel slabs present their own specific needs. These products weigh up to 20 t, are of thickness around 250 mm and dimensions of 6 m × 1.2 m or more.

Additional advice for steel slabs

- Steel slabs should be stowed in a similar fashion to that for plates, with ample dunnage on the tank-top (in line with transverse floors).
- The slabs should be aligned mostly fore-and-aft.
- The slabs should be staggered so that they overlap one another and with others athwartships to form a good stable locking stow.
- The slabs should be winged out over the hopper tanks of a bulk carrier.
- There should be plenty of good quality, substantial timber between the tiers and as chocking in void spaces between adjacent slabs.

The principle is to produce an interlocking block stowage that will not shift.

California block stowage

An alternative stowage arrangement that significantly reduces stevedoring costs is known as the 'California block stow' (Fig. 10). This arrangement requires the slabs to be stowed squarely on top of each other to produce a stowage of many individual vertical stacks of slabs. Timber dunnage is used on the tank-top and between each tier, and as chocking between the stacks. Finally, steel bands are used around each stack to secure the slabs together.

The method of stowage is only acceptable for ships with box-shaped holds, and only then when the stowage extends to both port and starboard sides, and is sufficiently chocked against the hold side plating and throughout the full breadth and length of the stowage. This method cannot be used in the holds of other ships because it cannot be adequately secured and the slabs are therefore likely to shift and cause severe damage to the structure of the cargo compartment when the ship rolls and pitches in the seaway.

Fig. 10. California block stow

Structural steel

This might be in bundles but, if the sections are of large dimension, they will be loose.

Advice for structural steel

- These products should be stowed in the fore-and-aft line of the ship on timber dunnage laid athwartships on the tank-top or deck plating and timber dunnage should be laid athwartships between each tier in line with the timber on the tank-top or deck.
- The products should be stowed on their flanges so that their webs are vertical. This will avoid damage to the webs caused by over-stowed cargo.
- The stowage should be tight and compact and, when space between the products is unavoidable, timber dunnage should be used to chock the steel against movement.
- If it is necessary, because of the dimensions of the cargo compartment or the steel, for part of the cargo to be stowed in the athwartships line, other cargo should be stowed outboard to port and to starboard, either structural steel products or other suitable cargo, and the athwartships aligned steel should be stowed against that other cargo with adequate timber chocking between the two stows.
- Blocks of structural steel often require lashing in addition to timber chocking. Such securing should be by steel wire of suitable size, led round upper-tier products and down to appropriate securing points or the ship's structure.

Pipes

Pipes are shipped either in bundles or loose. Bundles of pipes should be stowed in the fore-and-aft line in a manner similar to that described for packages and bundles, above. Large-dimension pipes should be stowed in the fore-and-aft line and never in the athwartships line. Ample dunnage and lashing materials will be needed.

Pipes may be stowed under-deck or on deck – usually on the hatch covers. Whereas all sizes and types of pipes are stowed in holds and 'tween decks, it is usual for only large-diameter pipes to be stowed on deck.

Under-deck stowage of pipes

Advice for pipes stowed under deck
• As with other steel products, timber dunnage should be laid athwartships on the tank-top or deck plating so far as possible in line with under-deck athwartships stiffening members.
• Steel pipes will be stowed in a number of tiers. Second-tier pipes will normally be stowed in the cantlines of the lower-tier pipes. Subsequent tiers are similarly stowed, such that a sort of brick pattern is formed.
• Whenever possible only pipes of the same diameter should be stowed together. This will ensure that the stowage is tight and neat and without any space between pipes in each tier. Such a stowage of same size pipes will, however, require timbering outboard to port and to starboard and such timbering should be substantial and strong. Skimping of such chocking is likely to lead to collapse of the stow.
• Securing of the top tier or upper tiers should be completed using wire rope of adequate diameter set tight by riggings screws. Timber should be placed between such lashing wires and the pipes to prevent damage to the pipes and to give the wire a better grip on the pipes' surface.
• Where pipes of different diameter have to be stowed together, all gaps between adjacent pipes should be chocked by the use of ample quantities of timber dunnage.
• When pipes with special characteristics, such as a paint coating or end fitting, are to be loaded the shippers should be contacted for information with regard to their stowage requirements, and additional information from local surveyors might be necessary to achieve a satisfactory and appropriate stowage for the pipes.

Deck stowage of pipes

Deck stowage of large-diameter pipes might look like a stowage of logs, but the differences are substantial and a pipe stowage must be secured in accordance with the provisions of annex 13 of the CSS Code. The characteristics of pipes to be borne in mind are as follows

- pipes are relatively light compared with logs
- pipes are round and may roll
- pipes have a low coefficient of friction
- pipes are hollow, unlike logs.

A ship carrying pipes on deck may have a relatively large GM and therefore the transverse forces acting on the deck stowage may be large. A stowage of pipes should be of a single size of pipe and should be constructed with adequate and suitable timber and packing to support and chock the pipes in the stowage and to increase the coefficient of friction where possible. During the voyage, if seas are shipped on deck, sea water may collect in the pipes, particularly those in stowages further forward, and the weight of that water will further increase the transverse forces. This should be borne in mind during the voyage and particularly when adverse conditions are forecast, and what is stated in the Timber Deck Cargoes Code should always be remembered: **the lashings were not designed to provide a means of securing against imprudent ship handling in heavy weather.**

Pipes should be stowed as follows.

Advice for pipes stowed on deck

- Pipes should be stowed in the fore-and-aft line of the ship on lines of soft timber dunnage laid athwartships on the hatch top, preferably laid above hatch-cover transverse stiffening members.
- Each pipe should be stowed hard up against the adjacent pipes and wedges should be inserted against the inboard and outboard bilge of each pipe, and nailed to the base-timbers, to prevent rolling.
- Second-tier and third-tier pipes, if carried, should be stowed in the cantlines of the pipes in the tier below with friction-increasing material, preferably rubber matting, fitted between each successive tier.
- The block stowage of pipes may be considered to be a single unit for securing purposes, provided it is a well-formed tight stowage. Calculations should be completed to determine the strength of the securing arrangements that are required to prevent transverse and longitudinal sliding; transverse tipping is considered not to be a problem.

There are three alternative arrangements for the securing of a pipe stowage on deck, and all three are designed to include elements that prevent transverse sliding, elements to compact the stowage and elements to prevent longitudinal sliding.

- *Securing alternative 1* – Transverse sliding is prevented by a sufficient number of pairs of vertical half-loop lashings of wire rope of appropriate size set tight by turnbuckles set up to port and to starboard. The half loops, set up at appropriate spacing, are led from securing points below the stowage on the hatch top at one side, vertically over the stowage and down to securing points at the deck at the other side of the stowage. Suitable packing materials should be used under the lashings. Compacting of the stow, holding it down bodily, is satisfactorily achieved by the vertical half-loop lashings. Longitudinal sliding is prevented by stoppers welded to the hatch top, lined with suitable timber against the forward and after ends of bottom-tier pipes. The friction-increasing material fitted between the tiers of pipes, for example rubber matting, should be sufficient to prevent sliding of upper-tier pipes.
- *Securing alternative 2* – Transverse sliding is prevented by a sufficient number of pairs of horizontal half-loop lashings of wire rope of appropriate size set tight by turnbuckles set up to port and set up to starboard. The half loops, which might be called 'spring

lashings', are led longitudinally through individual pipes and down and inboard to securing points on the hatch top. Such spring lashings should be rigged through a sufficient number of pipes in each tier outboard to port and to starboard. Suitable packing materials should be used under the lashings. Compacting of the stowage is achieved by an appropriate number of suitably spaced over-the-top lashings. Longitudinal sliding is prevented by stoppers welded to the hatch top, lined with suitable timber against the forward and after ends of bottom-tier pipes. The friction-increasing material fitted between the tiers of pipes, for example rubber matting, should be sufficient to prevent sliding of upper-tier pipes.

- *Securing alternative 3* – Transverse sliding is prevented by a sufficient number of side stanchions with appropriate buttresses, appropriately spaced, to port and to starboard of the stowage, or equivalent structures of sufficient strength. Compacting of the stowage is achieved by an appropriate number of suitably spaced over-the-top lashings. Longitudinal sliding is prevented by stoppers welded to the hatch top, lined with suitable timber against the forward and after ends of bottom-tier pipes. The friction-increasing material fitted between the tiers of pipes, for example rubber matting, should be sufficient to prevent sliding of upper-tier pipes.

The three alternatives give different ways of securing the block stowage of pipes in the athwartships line. The three methods achieve the prevention of transverse sliding and compacting in different ways and are based on different principles.

The elements of the alternative methods of securing pipes must not be mixed or combined: one of the alternatives must be chosen and used in its entirety.

When the alternative has been decided upon, calculations as set out in annex 13 of the CSS Code should be completed to determine how many lashings or stanchions will be needed adequately to secure the stowage by use of the advanced calculation method or by the rule-of-thumb method.

The stowage and securing of steel pipes on deck is a complicated process and must be carried out in compliance with the results of calculations for the determination of the securing requirements. If there are any doubts, the advice and assistance of an expert should be sought.

As with a stowage of logs on deck, a stowage of pipes will settle a little during the first hours of the voyage. The pipes will bed into the timber base-dunnage and the friction matting will be flattened somewhat. This will lead to slight loosening of the lashing wires of all three alternatives. Also, the wires used to secure the stowage are, unavoidably, long and wire rope stretches in proportion to its length. Bearing these factors in mind it is recommended that the lashings be set up and tended as follows.

Advice for pipe lashings

- All eyes in the wires to be properly made with an appropriate number of bulldog grips.
- All equipment, turnbuckles, shackles, bulldog grips and so on to be well-greased and without defect.

- All lashings should be set up carefully to ensure they are straight and not leading over edges without protectors.
- All lashings should be tightened, so far as possible, when rigged and re-tightened when all lashings have been fitted to the stowage.
- All lashings should be carefully examined and tightened at the beginning of the voyage, within hours of the ship's departure.
- All lashings should be examined and tightened as necessary throughout the voyage.
- Entries should be made in the log book, recording details of all inspections.

Consideration should be given to the planning of the voyage and likely weather and sea conditions. Weather reports and forecasts should be obtained and consideration should be given to contracting the services of a weather-routing agency. If severe weather or sea conditions are encountered, a reduction in the ship's speed and / or an alteration in the course to minimise the motion of the ship, and the forces imposed on the securing arrangements and the cargo, should be considered.

Wire rod

Wire rod is shipped in either coils or in bundles. Bundles will be stowed as described for bundles of bars, above. Coils of wire that have been formed correctly with correctly applied securing bands are fairly rigid and can be stacked satisfactorily. However, coils made up with slack bands will be floppy and cannot therefore be stacked satisfactorily.

Advice for wire rod

- The coils should be stowed in athwartships rows with their axes in the fore-and-aft line of the ship upon timber dunnage laid on the tank-top or deck plating in the athwartships line.
- The coils will be stowed in a number of tiers. Second and higher tiers should be stowed in the cantlines of the lower- tier coils to form a tight stowage.
- Adjacent athwartships rows of coils should be stowed hard up against each other to form a solid block of coils.
- Timber dunnage should be used outboard to port and to starboard and adjacent to end bulkheads to support the block of coils and to prevent contact between coils and ship's structure.
- If the block of coils does not fill the cargo compartment and an open face is left, that face must be secured by the use of wire lashings in conjunction with timber, pallets or fencing in a fashion similar to that used to secure blocks of break-bulk cargo.

Tank-top strength calculations

Bulk carriers are commonly used for the carriage of steel products and even though some bulk carriers have strong tank-top structures and high maximum permissible tank-top loadings care must be taken to load steel products to an acceptable height, with sufficient timber dunnage laid out on the tank-top plating, in order that the maximum permissible loading rate is not exceeded. When the cargo includes steel plates, bundles of bars or steel billets, the calculations are relatively easy and the spacing of the timber dunnage can be easily assessed. However, for steel coils the calculations are not so straightforward and a great deal of research has been done to establish how best to stow coils without damaging the tank-top structure.

When a steel coil is placed on the tank-top plating without any timber dunnage, for example during loading and discharging, the contact area is very small and therefore the loading in way of that contact area is large, possibly over 70 t/m^2 for a 25 t coil. The weight of the coil will, of course, be transferred outward and down, through the steel plating of the tank-top into the longitudinal and athwartships stiffening members within the double-bottom tank below. Therefore, although the point loading might exceed the maximum permissible loading given in the ship's documents, structural damage will not result from the weight of that single coil while the ship is stationary and not rolling in the seaway. When timber dunnage is laid athwartships on the tank-top, the weight of the coil is spread further to port and to starboard into the ship's structure and therefore the actual loading rate is reduced.

Classification society naval architects are often asked to what height coils of steel sheet of a given size and weight can be safely stowed on the tank-top plating of a given ship. To answer the question, the naval architects will carry out calculations using details of the coils, various arrangements of dunnage, a range of numbers of tiers, the area of structure taking the weight and certain factors, and then produce tables stating, for a range of coil weights and sizes and a range of tier heights, whether or not the coils can safely be stowed on top of a range of arrangements of dunnage.

For example, on board a particular ship with a tank-top strength of 22 t/m^2, it might be acceptable for coils of weight 15 t and width 2.5 m to be stowed three high on four lengths of good-quality timber dunnage, but not acceptable if those 15 t coils were of width 1.5 m. However, the tables would perhaps also show that the 15 t coils of width 1.5 m can safely be stowed three high if eight lengths of good-quality timber dunnage are provided for each athwartship row. Such tables produced by classification societies will, of course, be applicable only to the ship for which they were produced, and the requirements with regard to dunnaging must be strictly adhered to.

Experience has shown that, when no specific calculations have been carried out for the ship, a simple rule can be used as follows.

Tank-top load limit for steel coils

Ensure that the weight imposed on the tank-top by the bottom-tier coil does not exceed about 30–35 t.

This can be developed into a simple table for the weight and stack height of coils, as shown in Table 4.

Table 4. Weight and height ratio of steel coils

Weight of individual coils	Maximum stack number
Up to about 10 t	3
Up to about 15 t	2
More than 15 t	1

Clearly, if coils of a range of sizes are to be loaded together, with larger coils in the bottom tier and smaller coils on top, a compromise must be found such that the bottom-tier coils do not impose more than 30 t onto the tank-top plating. This simple rule and the table are based upon the tank-top strength being unknown, or not high, and there being only two or three lines of timber dunnage. Clearly, as can be seen above, if more lines of good-quality timber dunnage are provided, heavier coils can be stowed to a greater height without overstressing the tank-top structures.

It is often the case that calculations for coil stowages are carried out by the naval architects during the design stage and therefore a table of weight and height ratios is given on the ship's plans and in the ship's trim and stability booklet. Also, such a table might be given in the ship's Cargo Securing Manual. Such a table should be complied with unless the stowage of the coils being loaded cannot be matched to any arrangement in the table, in which case other calculations need to be completed.

If, on the other hand, substantially more timber dunnage is to be used than is allowed for in the table, it might be permissible to stow coils to a height greater than given in the table. It must always be remembered that if a departure from anything in the ship's Cargo Securing Manual is to be contemplated, the basic rules of good seamanship practice must always be observed, and if in doubt call for assistance.

When a bulk carrier is chartered for a single voyage to carry steel products, there will generally be a description of the ship within one of the clauses of the charterparty and that description might include maximum permissible tank-top loadings. It is recommended that the following should be borne in mind.

Charterparty information on tank-top loading

- Many bulk carriers will be designed to carry heavy cargo in alternate holds, with the other holds empty, and might be assigned maximum permissible loadings for the loaded holds that are higher than the maximum permissible loading rates assigned to those holds that would remain empty. For example, 22 t/m^2 for the loaded holds (nos.1, 3, 5 and so on) and 14 t/m^2 for the holds that would remain empty (nos. 2, 4 and so on). Such ships might also be assigned a second set of tank-top loading rates for the homogenous loaded condition (that is with cargo, be it bulk cargo or break-bulk cargo, in all holds), and that loading rate might be 14 t/m^2 as given for the empty holds despite the 22 t/m^2 rate for the alternate loaded holds. Both loading rates should be quoted in the charterparty.

- When a table or list of weight and stowage height ratios for steel-coil loading is given in the Cargo Securing Manual or in any of the ship's documents, that table should be given in the charterparty to avoid any confusion as to how high coils can be stowed.
- If there is any other information in the Cargo Securing Manual or ship's documents with regard to the stowage of steel products, that also should be given in the ship's description.

HEAVY-LIFT ITEMS AND PROJECT CARGO

Fig. 11. Project cargo (Gordon Line)

Heavy-lift items and project cargo are often of high value and great weight (Fig. 11). They may have delicate parts that must not be contacted and they may or may not be suitable for carriage on deck, which will undoubtedly mean wetting by rain and sea water. They must be fitted with lifting points and lashing points that are of adequate strength and positioned in appropriate places. The carriage of these items should be planned in great detail from origin to destination. Of particular interest here is the planning of the stowage and securing.

Voyage planning

The voyage must be planned to ensure that the piece of cargo can be safely transported from origin to destination. The points to be borne in mind are as follows.

Voyage planning for heavy-lift items
• The ship must be able to berth safely alongside at the load port and at the destination port, and safely take on board and finally land the item, bearing in mind mooring arrangements, stability requirements, crane capacity and crane outreach.
• The load port and destination port must be suitable for the carrying ship. They must also be suitable for carrying vehicles, that is the dockside must be suitable in terms of strength and accessibility.
• Sufficient lashing materials and dunnaging materials must be provided on board after appropriate calculations have been carried out to determine the requirements (see pre-planning below).
• Professional securing contractors should be employed, if appropriate, to carry out the necessary calculations and to secure the items in place.

Pre-planning

The shippers of the cargo should provide the master, or representative of the carrier, with information about the cargo so that the stowage and securing can be properly planned in advance.

The information should include the following.

Pre-planning information for heavy-lift items
• A general description of the cargo.
• The gross mass of the item or of each item if there are more than one.
• The principal dimensions of the item or items and, if possible, scale drawings.
• The location of the centre of gravity of each item.
• Particulars of the bedding area of the cargo units and details of any precautions with regard to the bedding of the item(s).
• Details of lifting points or slinging positions and if possible information on how best to lift each item.
• Details of securing points, including their strength and radius of strength.

Some heavy-lift items are not fitted with any form of bedding arrangements apart from foundations or legs upon which they would ordinarily stand. Others will be completely cased in timberwork and will be provided with a timber floor that is capable of taking and spreading the weight of the item, while others will be fitted with cradles of limited strength. Information about the construction of base-units is required so that appropriate arrangements can be made on board to bed and support the item adequately and appropriately.

General requirements for heavy-lift items
• The lifting points should be fitted symmetrically on either side of the centre of gravity and should also be fitted with sufficient spread, to be not less than half the length of the unit, to enable safe and level lifting of the unit without the use of additional sling/lengthening equipment. Lifting points should be clearly marked.
• Securing points should be of adequate strength and their minimum strength must be advised. Lashing points should be so constructed as to have a wide arc of strength because lashings will not necessarily be led directly in line with the plane of the lashing point. All lashing points should be suitably marked.
• The strength and base area of any cradles, foundations or bedding provided must be known to establish what else is needed for the support of the load atop the ship's hatch cover, deck or tank-top, bearing in mind the maximum permissible load.

Stowage planning

When details of the base-structure or cradles is known, a suitable stowage location can be chosen and suitable bedding material can be ordered. With regard to the stowage location, the following points should be borne in mind.

Stowage location for heavy-lift items
• Cargo stowed on the weather deck or hatch covers will be exposed to rain and seawater wetting and to the wind. Only items that the shippers have confirmed are suitable to withstand exposure to the elements may be stowed on deck.
• The accelerations generated by the ship are less lower down at the mid-part of the ship than they are further from that centre of motion. Heavy items of cargo should, when possible, be stowed close to the ship's centre of motion.
• Distribution of the weight of the item should be considered together with the maximum permissible loading of the deck or tank-top on to which the piece is to be stowed. The extent to which the weight of the item must be spread must then be calculated and, from that, the bedding requirements can be assessed.
• The purpose of bedding is to provide a solid base onto which the item can be placed and secured down onto and to distribute the weight of the unit evenly over the stowage area so as to keep loading below the maximum permissible loading rate. Also, bedding provides a high friction coefficient between the cargo unit and the deck or tank-top.

- Bedding materials include flat-board dunnage, square-section timber beams, especially manufactured platforms and steel beams. The most appropriate type of platform material should be used bearing in mind the required area of weight distribution, the weight of the item to be carried and the strength of any cradles, foundations or legs.
- Cradles, foundations, legs and so on might be designed for transport by road or rail, or for installation on site, but might be of insufficient strength for sea transport. The item of cargo itself thus might require additional support arrangements in the form of timber and / or steel brackets and buttresses. If there is any doubt about the strength of cradles and so on, additional support should be provided below the cargo item.
- Heavy-lift items should be stowed in the fore-and-aft line of the ship.

Cradles and cribbage supports

Some items of cargo comprise a main body and an extension piece or overhanging section that is separate from and is not wholly supported by the main body. Examples include cranes with a jib, yachts with a horizontally laid mast and pieces of machinery with appendages. Those extending parts must be properly and adequately held and supported to avoid damage being sustained by the parts as a result of movement during the voyage. Such support structures are often referred to as cradles or cribbage supports. Such structures should be thoughtfully planned and properly constructed, usually of either timber or steel with adequate and appropriate packing materials, and should be as follows.

Requirements for heavy-lift cradles and cribbage

- Of sufficient strength to support the total load imposed by the unit.
- Of sufficient size such that its base has sufficient area to spread and load over the deck to less than the maximum permissible loading.
- Of sufficient size such that its top has sufficient area to spread the weight of the unit so that damage is not sustained by the unit when it is placed on the support.
- Of sufficient rigidity such that it will not buckle or move after it has taken the load.
- Sufficient in number to support the load and prevent it moving, twisting, buckling or distorting in any way.
- Adequately secured against movement during the voyage.
- All of the above bearing in mind that the ship will roll and pitch in the seaway. The rolling and pitching to be considered should be the most extensive motion in the worst weather conditions likely to be encountered, bearing in mind the ship's GM for the voyage.

Securing planning

When the detail of a piece of heavy-lift or project cargo is known, calculations can be carried out to determine how many lashings are required to secure the cargo adequately against movement. Also, the required distribution of those lashings can be assessed. Points to be borne in mind during such an assessment are as follows.

Securing planning for heavy-lift items
• The method of securing should be decided upon, that is by the use of wire lashings, chain lashings, or whatever. Because different materials have different characteristics with regard to flexibility and elasticity, all lashings should be of the same make-up, that is all wire lashings, all chain lashings, or all chains with wire grommets, if applicable. If a combination of types of lashing is used, those with low elasticity will take more load than those that have a higher elasticity.
• Calculations should be carried out to determine how many lashings of the type decided upon are needed by use of the advanced calculation method or, if insufficient information is available, by use of the rule-of-thumb method.
• Lashings should be fitted in an arrangement that will withstand transverse and longitudinal forces which may give rise to sliding or tipping of the item.
• The optimum lashing angle to act against sliding is about 25° to the horizontal, whereas the optimum lashing angle to act against tipping is in the range 45–60° to the horizontal.
• If necessary, additional lashing points should be welded to the ship's structure in appropriate places. The surface where the lashing point is to be welded should be in suitable condition and welding should only take place in accordance with proper hot-work procedures. Welding to ship's structural members such as frames, and welding to fuel tanks, should be forbidden unless classification society approval is obtained.
• Where appropriate, welded-steel sea fastenings or dogs should be considered. Sea fastenings are usually made from steel profiles such as I-beams welded to the deck plating or tank-top close to the base-structure of the item to allow chocking of the unit by the use of timber wedges or timber blocks. The rules for welding to ship's structures as given above should be followed.
• Where appropriate, timber shores and buttresses should be fitted against the sides and ends of items of cargo and against adjacent items of cargo or against ship's structural members, to support the item of cargo against movement. Such shores and buttresses should be constructed from good-quality timber of adequate cross-section; small-dimension timber will give way and bend and prove to be of no use.

- If the item of cargo has no securing points, or an insufficient number of securing points, lashings must be secured in loops that pass around the item. Such loops should be arranged such that both ends of the lashing are secured to the ship's structure on the same side of the unit. An even number of opposing lashings must be fitted.
- If calculations are carried out by professional securing contractors, they will be able to calculate the strength of sea fastenings, timber shores, buttresses and so on and the strength of those arrangements can be taken into account when deciding upon the overall lashing requirements.

Loading and discharge operations

When all of the pre-planning has been completed, information with regard to the items of cargo obtained, stowage location decided upon and method of securing planned and checked by calculations, consideration needs to be given to the loading operation.

On board a ship that often carries heavy-lift items or project cargoes, either as part of the ISM procedures or within the Cargo Securing Manual, there might be a checklist to be completed when a heavy or awkward piece of cargo is to be loaded. The ship's checklist should be used to ensure the completion of a safe loading operation and a safe discharge operation. The following list covers all the main points to be borne in mind by the master of a ship during an operation where ship's crane(s) will be used.

Checklist for loading and discharging heavy-lift items

- Centre of gravity and lifting points of cargo unit to be confirmed and marked.
- Lifting points to be checked for adequacy.
- Lashing points, any packaging and the base-support structures to be checked for adequacy.
- Tank-top / 'tween deck / weather deck maximum permissible loading to be adequate for cargo unit, and adequate dunnage to be available.
- Stability calculations to be completed to ensure adequate GM throughout the operation.
- Ballast transfer procedures to be agreed between the master and officer in charge of ballasting operations.
- Ballast pump and piping system to be proved operational before cargo operation.
- Cranes and their wires to be checked to ensure they are in good operational condition and any limits to be appropriately set.
- Condition and capacity of spreaders, shackles and slings to be checked, safe working load to be adequate for planned lift. All equipment to be used is to be certified.

- Briefing meeting to be held to ensure that all crew members are aware of their duties and the procedures, and of the system of signals and orders. A dedicated signalman to be appointed.
- All communications systems to be tested and proved to be adequate.
- Master to supervise the deck operation. If masters are not available, they should delegate the duties to another deck officer.
- Chief engineer to supervise the ballasting operation. If chief engineers are not available, they should delegate the duties to another engineer officer, but only with the agreement of the master.
- Double-bottom tanks and other tanks with a large surface area to be full or empty to avoid free surface.
- Moorings to be checked and adequate, and to be tended throughout the operation.
- Gangway to be tended or lifted / turned in as appropriate.

When all of the preparatory work has been completed the operation can be started, but if any one of the items of the checklist has not been verified, the operation should not begin. The master or master's deputy must be and remain in overall charge of the operation with the signalman in an appropriate position.

The lifting of the cargo unit should be steady and controlled and the hoist wire(s) of the crane(s) must be vertical throughout the operation. When two ship's cranes are used in tandem, the operation should be carried out only in daylight. Tag lines should be fitted to the cargo unit to allow control of any rotational movement, if appropriate. The ballasting operation should be carried out in conjunction with the cargo transfer operation to maintain the ship as near to upright as possible, and any list should not exceed 3°.

If, when the cargo unit is first lifted from the quay, it is found that either the weight is in excess of that declared or the centre of gravity is not where it is shown to be such that the lifting points are incorrectly positioned, the operation should be abandoned and the cargo unit should be carefully placed back on the quay. The situation should then be carefully considered; expert advice should be sought and further information should be obtained to devise a system for the safe loading of the cargo unit. If a programme for the safe load of the unit cannot be devised the cargo unit should not be loaded at all.

Use of sea fastenings and timber shores

Fig. 12. Sea fastenings (Graig Ship Management Ltd)

For the securing of some items of cargo, such as transformers, tanks and heavy pieces of machinery, it might be appropriate to fit some sea fastenings and / or timber shores in addition to, and to complement lashings of chain or wire (Fig. 12). Some items of project-type cargo, such as concrete structures and flat-sided tanks, might have no lashing points and no means of applying lashings to the item of cargo itself. Such items might be adequately secured by the use of sea fastenings and / or timber shores alone.

Sea fastenings, sometimes referred to as dogs, are lengths of steel section, for example I-beam, which are welded to the deck plating or tank-top hard against the base-structure of the item of cargo or with a small clearance to allow the fitting of timber wedges or blocks. Timber shores, buttresses or chocking are carefully constructed from good-quality timber of adequate cross-section and are set up against the sides and ends of the item of cargo and against adjacent items of cargo or against the ship's structural members. Sea fastenings and timber shores correctly set up at appropriate places around the base of the unit will assist in the prevention of sliding of the unit in both the athwartships and the fore-and-aft line. Timber shores and buttresses can also be fitted at high level against the sides and ends of the unit to prevent it from tipping over.

The strength of sea fastenings and timber shores can be calculated and therefore the load capacity of the fittings can be allowed for in any lashing calculation.

Sea fastenings are welded to the deck plating or tank-top and their strength is determined from the area of welded connection. The welded connection should be of good quality, with good penetration. Such a weld, of possibly three runs of welding along each leg, should have a thickness of about 1 cm. The general rule is as follows.

Calculating MSL of a welded sea fastening

Maximum securing load (MSL) of a welded sea fastening = 10 kN (or 1 t) per cm of weld run

For example, if an I-beam of length 20 cm and flange breadth 10 cm is placed on the deck and welded along both sides and the front end with runs forming a 1 cm thickness of weld metal, the effective MSL would be calculated as

MSL = (2 x 20 + 10) x 10 = 500 kN or 50 t

It must be remembered that the MSL as calculated in this way is the strength of the sea fastening only at a low level at or close above the tank-top or deck and the strength reduces significantly if the point of loading is at a level of more than 10% of the length of the base of the fitting above the deck. If there is any doubt whatsoever, or if it is thought that assistance is required, do not hesitate to get help and advice from an expert.

The strength of timber shores and buttresses is somewhat easier to determine, using the guidance in section 4 of annex 13, which gives that the MSL of timber should be taken as 0.3 kN/cm² normal to the grain. Thus, shores and buttresses must be aligned with the grain of the timber running in the direction the support is required, and the MSL of each support can be determined by multiplying the minimum cross-section area of the timber by 0.3. If the timber used is of cross-section 250 mm × 150 mm, which equates to 25 cm × 15 cm, it has a cross-section area of 375 cm² and therefore has an MSL of 112.5 kN, or 11.25 t. Any such timber supports should, of course, be adequately supported at both ends and along its length as appropriate, and timber pads should be fitted at both ends to help to stabilise the structure and to spread the load.

RO-RO CARGO ITEMS

Fig. 13. Ro-ro container trailer secured on trestle

Ro-ro cargo items include all the various types of commercial vehicles for road transport, roll trailers and other pieces that are driven aboard the ship (Fig. 13). Commercial vehicles include semi-trailers without a towing tractor unit, combination vehicles comprising a tractor unit with one or more towed vehicles, and other commercial vehicles that are not articulated. Roll trailers are used within port areas and on board ro-ro ships for the carriage of large, awkward or heavy pieces of cargo via the stern or side door. Other pieces include caravans, boats, trailers and so on and construction or road-building machinery, farm machinery and so on, either wheeled or on tracks.

Road vehicles

There are extensive recommendations and requirements with regard to the safe carriage of road vehicles aboard ro-ro ships. The recommendations and requirements can be divided into four parts: those applying to the basic standards of acceptance of the vehicle; lashing equipment on board; stowage and securing of the vehicle; and consideration of the voyage.

Basic standards for acceptance of vehicles

All vehicles should be inspected before they are loaded to ensure that they are in a seaworthy condition and suitable for carriage on the intended voyage. This means that the vehicle must be suitable for securing on board and must have adequate strength to withstand the rigours of the voyage, and the cargo on the vehicle must not shift during the voyage. The requirements are as follows.

Requirements for road vehicles

- The cargo on the vehicle must be properly stowed and adequately secured such that it will not move during the voyage. Machinery on a flat-bed trailer must be properly secured as if it were on the deck of the ship, and pallets or other units within a box van must be adequately chocked. Items of whatever type must be secured to the bed of a curtain-sided trailer; the side-curtains are not there to secure the cargo, they are there to keep the rain out.
- The trailer should be fitted with an equal number of lashing points to each side, and of minimum strength, in accordance with Table 5.
- The lashing points should be fitted at suitable places on the vehicle so as to ensure efficient restraint of the vehicle by the lashings, such that the lashing point is capable of transferring the forces from the lashings to the chassis of the vehicle, and such that lashings can be readily and safely attached.
- When a semi-trailer is shipped unaccompanied, that is without a tractor unit, its front end will be supported on a trestle placed below the chassis close to the rear of the draw plate. That area of the chassis should be suitably re-enforced for the purpose and that area should be clearly marked.
- Some times it will be necessary to jack-up the chassis in way of the axles – such jacking-up points on the chassis should be suitably strengthened.

Table 5. Number and strength of trailer lashing points

Gross vehicle mass (GVM)	Minimum number of securing points on each side of the road vehicle	Minimum strength (without permanent deformation) of each securing point in kN (n is the actual number of securing points on each side of the road vehicle)
3.5 t ≤ GVM ≤ 20 t	2	$\frac{GVM \times 10 \times 1.2}{n}$
20 t < GVM ≤ 30 t	3	
30 t < GVM ≤ 40 t	4	

Lashing equipment on board

Ro-ro ships designed for the carriage of vehicles will have their decks laid out and fitted for the purpose and they will have on board suitable lashing and stowage equipment. The primary items are as follows.

Road vehicle lashing equipment

- The decks will be laid out in lanes with securing points fitted along each lane. Those securing points should be not more than 2.5 m apart in the fore-and-aft direction and the lane should not be less than 2.8 m, nor more than 3.0 m wide.
- The lashing points should have a MSL of not less than 100 kN or 10 t. If the securing points are designed to accommodate more than one lashing, then the strength of the lashing points should be 100 kN times the number of lashings it can accommodate.
- Lashings of chain or any other material having suitable elongation characteristics should have a MSL of not less than 100 kN or 10 t.
- Lashings should be designed with a hook or other devices for attachment to the vehicle and an appropriate fitting to engage the deck securing point. They should also be fitted with an attachment that allows for initial tightening after attachment and further tightening if they become slack during the voyage.
- There should be sufficient trestles for the supporting of semi-trailers and sufficient jacks for the support of chassis in way of axles.

Stowage and securing of the vehicle

Vehicles should be stowed in the fore-and-aft line of the ship with sufficient space around the vehicle for examinations to be carried out during the voyage. Each vehicle should be adequately and properly secured for the intended voyage. The primary points to be borne in mind are as follows.

Advice for road vehicles

- Only proper securing points on vehicles should be used for lashing purposes. Lashings should not be attached to lamp brackets, bumpers, side-guards and so on unless they have been specifically designed for use as securing points on the vehicle.
- Only one lashing should be attached to any one securing point. Lashings are most effective on vehicles when they are made at an angle with the deck of between 30º and 60º. When these optimum angles cannot be achieved, additional lashings might be required.
- Lashings should be fitted such that on each side of the vehicle there is at least one lashing leading forward, one lashing leading aft and one, so far as possible, leading athwartships.
- Lashings should not be crossed from side to side; they should lead from the lashing point outboard and down to the deck fitting.
- The master should take into consideration the weather conditions likely to be encountered during the intended voyage and should decide upon the number of lashings to be fitted to each side of each vehicle.
- Consideration should be taken into account with regard to the position of individual vehicles on board when deciding upon the number of lashings to be fitted. Vehicles stowed right forward or right aft and outboard to port or to starboard may require the fitting of additional lashings in view of the large accelerations that will be experienced by vehicles at those locations.
- The parking breaks should be applied and locked and vehicles with diesel engines should not be left in gear during the voyage.
- The front end of the chassis of semi-trailers should be supported by a trestle positioned such that it does not restrict the connection of the fifth wheel to the kingpin. Landing legs should be lifted clear of the deck.
- Road vehicles should be secured in such a way that they are kept as static as possible by not allowing free play in the suspension system. Compressed air suspension systems may lose air and therefore the air pressure should be released on vehicles fitted on such a system when necessary. If the air pressure is not released, the vehicle should be jacked-up to prevent any slackening of the lashings that would result from air leakage.

Consideration of the voyage

A cargo of road vehicles is, basically no different from any other cargo when it comes to actions to be taken during the voyage. These are as follows.

Advice for road vehicles during voyage

- All vehicles must be properly stowed and properly and adequately secured before departure, as required under SOLAS chapter VI regulation 5(6).
- All lashings should be examined at frequent and regular intervals and all lashings found to be slack should be re-tightened.
- Trestles and jacks should also be examined to ensure they are properly positioned.
- The load of each vehicle should, so far as is possible, be examined to ensure that it is not moving on the vehicle. If movement of loads on vehicles is found re-securing of that cargo should be carried out. If adverse weather is predicted for a later part of the voyage additional lashings should be fitted to vehicles as appropriate.

Roll trailers

Roll trailers are specifically designed for use within port areas and on board ro-ro ships and are not taken outside such areas. They are of typically of lengths 20 ft (6.1 m), 30 ft (9.1 m), 40 ft (12.2 m) and 42 ft (12.8 m), have small-diameter solid rubber wheels at the rear on axles that do not have suspension and have a ridged support bar at the front, such that they are horizontal when set down on to that bar. At the front end they have a coupling mouth that accepts the gooseneck of specially designed tractor units such that the trailers can be lifted at their front end and towed without the tractor unit being actually coupled to the trailer. The trailers are used for the carriage of large, awkward or heavy pieces of cargo and have safe working loads in the range 20–200 t.

The appropriate size and strength of trailer should be used for the particular piece of cargo or pieces of cargo that are being shipped.

Advice for roll trailers

- Trailers are fitted with numerous lashing points and the cargo must be appropriately and adequately secured to the trailer for handling on the deck and on board. The type and number of lashings will depend upon the cargo being carried. It might be appropriate to use wire rope, chains, webbing or steel bands. Whichever type of lashing material is are chosen, a suitable number of lashings, variously leading to the front, to the rear, and to both sides of the trailer should be fitted.
- The trailer should be stowed on board on the fore-and-aft line of the ship. The support bar of the trailer should rest upon pieces of good-quality timber dunnage or upon rubber matting supplied for the purpose.
- The trailer and its cargo should be secured to the deck of the ship by either chain or wire rope. The required number of lashings should be calculated using the gross weight of the trailer, that is the trailer and the cargo, using either the rule-of-thumb method or the advanced calculation method.

- Lashings should be led from the trailer and from the cargo, as appropriate, to deck lashing points, variously leading forward, aft and athwartships. Lashings are most effective when they make an angle with the deck of between 30º and 60º. When the optimum angles cannot be achieved, additional lashings might be required.
- If the height of the cargo and trailer is great, say more than 2.5 m, additional lashings should be fitted to prevent tipping. Such additional lashings should be led from the top of the cargo and, if there are no securing points, such lashings can be attached in conjunction with 'head loops' (see section on loop lashings). It should be remembered that simple 'friction loops' will not prevent tipping.
- As with other cargo, all lashings should be examined at frequent and regular intervals and all lashings found to be slack should be retightened.
- The load of each trailer should, so far as possible, be examined to ensure that it is not moving on the trailer. If movement is found to be taking place, all slack lashings should be re-tensioned and additional lashings to the trailer and / or the deck should be fitted.
- If adverse weather is predicted for a later part of the voyage, additional lashings should be fitted to the trailer and to the cargo.

Other pieces on wheels or tracks

Fig. 14. Tracked vehicle secured on vehicle deck

This category includes smaller items on wheels such as caravans, boats and trailers; wheeled vehicles that are not road vehicles, such as building machinery and farming machinery; and tracked vehicles and machinery (Fig. 14). All of these items have one thing in common, which is they do not have specifically designed lashing points. Some of them are very heavy and of strong and substantial construction, while others are light in weight and of light construction.

Caravans, boats and trailers

These are generally of light construction and might need to be supported from below as well as being tied down. Some points to bear in mind are as follows.

Advice for caravans, boats and trailers
• It might be appropriate to fit lashings to axles, chassis members or towing bars. Other fittings such as bumpers, awning fittings, or other fittings that appear to be lashing points might not have sufficient strength for the requirements of a lashing point. Lashings must not cause damage to the fitting being used. Lashings should not be crossed from side to side; they should lead from the lashing point outboard and down to deck fittings.
• The suspension might be fairly light and therefore it might be necessary to fit chocks below chassis members or jacking points before fitting the lashings, so that those lashings will hold the vehicle or trailer down onto the chocks rather than acting against the suspension.
• The item might not have any brakes and therefore chocking around the wheels to prevent movement might be appropriate.
• If there are no points for lashings at all, such as on a boat, it will be necessary to lead lashings over the top of the piece. Before this is done the shippers should be contacted and asked for guidance as to where best to lead the lashings.
• Lashings of webbing or fibre rope might be more appropriate for some light construction pieces but chains or wire rope might be needed for other types.
• As with all lashing systems, lashings should be lead forward, aft and to both the port and the starboard sides of the ship.

Building and farming machinery on wheels

Such machines will be more heavily built with substantial chassis numbers, axles and tow bars, but they might also have light construction cabs or machinery housing extending to a considerable height. Points to be remembered with these vehicles are as follows.

Advice for building and farming machinery on wheels
• These items are carried on ro-ro ships and on conventional ships both on and under deck.

- These vehicles are often of considerable weight and therefore the maximum permissible loading of the ro-ro deck, hatch cover, weather deck, or 'tween deck, whichever is in use, must be borne in mind. On a conventional ship it will be necessary to spread the weight of the vehicle in way of the wheels by providing sufficient good-quality timber dunnage beneath the wheels. It might be appropriate to construct timber gratings upon which the wheels can be landed.
- To restrict the movement of the vehicle it might be appropriate to fit chockings or wedges around each of the wheels and to fit timber chocking or jacks beneath the axles and jacking points.
- Calculations should be carried out using either the rule-of-thumb method or, if sufficient information is available, the advanced calculation method, to determine the number of lashings required.
- Lashings should be fitted where appropriate to the chassis, axles, towing points or any lashing points that are fitted. Lashings must not cause damage to the fitting being used. These lashings should be lead variously forward, aft and to port and to starboard.
- Lashings are most effective when they make an angle with the deck of between 30º and 60º. Lashings should not be crossed from side to side; they should be lead outboard and down in a well balanced arrangement.
- The parking brakes should be applied and locked if fitted, and machines with diesel engines should not be left in gear during the voyage.
- As with road vehicles carried on board, lashings should be examined at frequent and regular intervals and all lashings found to be slack should be re-tightened. If thought appropriate, because of movement of the vehicles or adverse weather predicted for later in the voyage, additional lashings should be fitted as appropriate.

Tracked vehicles and machinery

Such machines are carried on ro-ro ships and conventional ships. They are, mostly, heavy items and should be treated as such. Things to remember are as follows.

Advice for tracked vehicles and machinery

- Details of the dimensions, location of centre of gravity and so on should be obtained from the shippers.
- Calculations to determine the required number of lashings should be carried out using the advanced calculation method. If shippers cannot provide all the necessary information, then calculations using the rule-of-thumb method should be carried out.
- Calculations to determine the area over which the weight of the machine should be spread over the hatch cover, deck or tank-top to be used must be completed.

- Good-quality timber dunnage should be provided and laid out in way of where the vehicles or machines are to be carried.
- Lashings should be fitted to strong points on the items and should be lead variously forward, aft and to both sides, such that the strength of the lashing system complies with the requirements of the advanced calculation method or the rule-of-thumb method. Lashings must not cause damage to the fitting being used.
- The positioning of the items, one adjacent to the next, and the arrangements of lashings, should satisfy good seamanship practice. There should be sufficient room between adjacent items and between lashings so that ship's staff can carry out routine examinations and tighten lashings that are found to be slack. If movement of the items is found, or if adverse weather is predicted for later in the voyage, additional lashings should be fitted as appropriate.

TIMBER CARGOES – ON AND UNDER DECK

Fig. 15. Timber cargo being loaded on deck

The Code of Safe Practice for Ships Carrying Timber Deck Cargoes, 1991 is published by the IMO. This Code is referred to throughout this section. Additionally, maritime nations issue their own regulations, recommendations and requirements with regard to the loading and stowage of timber cargo at their own ports. For example, Canada Transport issues the Canadian Timber Regulations that must be followed when loading at Canadian ports. Before loading a timber cargo (Fig. 15), be it of logs, cants, packaged timber, or a combination of these, the IMO Code and the national requirements must be studied and all of the requirements and recommendations must be complied with and / or followed.

The provisions of the IMO Code are described but requirements published by maritime nations are not be dealt with here.

The Code and its appendices give recommendations on the various aspects of timber cargoes, including the following.

Topics covered by the Timber Deck Cargoes Code
• The general preparation of the ship before loading timber on deck.
• The height and extent of the deck cargo, depending upon the load-line assigned to the ship.
• Specifications for the strength of lashings, the minimum tension in those lashings when used to secure the cargo, the spacing between the lashings and means to adjust them during the voyage.
• Specification and spacing of uprights.
• Guidance on the stowage and securing of different types of timber cargoes.
• Matters relating to personnel protection and safety devices, including means of access to and from the deck.
• Action to be taken during the voyage, both if no incident occurs and if things go wrong and there is a shift of cargo for whatever reason.
• Stability of the ship throughout of the voyage.
• As appendix B, general guidelines for the under-deck stowage of logs.

Throughout the previous sections of this guide, recommendations are given on how to secure items of cargo such that they will not shift unless there are exceptional circumstances. In other words, the philosophy has been to 'secure the item such that it should not shift'.

The philosophy behind the stowage and securing of a timber deck cargo is somewhat different and may be summarised as follows.

Stowage philosophy for timber deck cargoes
Timber cargo stowed on deck is satisfactorily secured for normally expected circumstances, but lashings are not so strong as to retain the cargo on board if it shifts, and those lashings are fitted with quick-release devices for use in an emergency situation.

When compared with the rule-of-thumb method for calculating the number of lashings, the Timber Deck Cargoes Code requires a very small number of lashings for the weight of a full deck cargo of timber. To ensure that a timber deck cargo is carried safely, therefore, all of the provisions of the Code that apply to the carrying ship and the particular type of cargo must be followed completely. Departure from the requirements and recommendations might lead to a shift of cargo and the development of a very dangerous situation.

There are a number of fundamental issues that must be borne in mind when planning the loading and stowage of timber on deck. These are as follows.

Pre-planning issues for timber deck cargoes
• The type of ship and whether or not it has been assigned a timber load-line.
• The type of timber to be carried.
• The height and the forward and aft extent of the stowage.
• The type of lashings required and their spacing along the deck, and whether or not uprights are to be used.
• The stability of the ship throughout the voyage.
• The stowage of the cargo must be such that the cargo, the securing arrangements and ship's fittings are variously accessible by the crew, closed beforehand and / or kept clear. Also, visibility from the navigation bridge must be acceptable.
• Cargo jettisoning.

These various points must be considered together, not in isolation. A shipment of timber cannot be accepted for loading on the basis that the height to which it will be stowed will not interfere with the navigation of the ship only to find at a later time that the maximum permissible deck loading has been exceeded, and the ship has a negative GM.

Type of ship

It is believed that a complete stowage of tightly stowed timber will increase the ship's reserve of buoyancy. This being the case, a ship with such a stowage of timber may be safely loaded to a deeper draught than would normally be allowed. Turning that around, a ship that is fitted and capable of carrying a full deck cargo of timber may be assigned a timber load-line. When a timber deck cargo is to be loaded such that the ship will make use of its timber load-line, the stowage must extend, as given in paragraph 3.2.3 of the Code, over the full length of the well or wells between superstructures and athwartship as close as possible to the ship's sides. The cargo stowed in the holds has no bearing upon whether or not the timber load-line may be used. The use of the timber load-line is only dependent upon the stowage of a timber deck cargo.

If the ship does not have a timber load-line, then it cannot load deeper than the appropriate load-line for the load port and the voyage.

Types of timber

Timber carried by ocean vessels is categorised into two types: loose or packaged sawn timber; and logs, poles, cants or similar cargo. These two categories of timber require different lashing arrangements because they are stowed in different ways and the resultant stowages are somewhat different.

Loose and packaged sawn timber is stowed in regular tiers across the ship with outboard packs in the athwartships line and inboard packs variously longitudinal or athwartships as appropriate. Some of the packs might be ragged at one end and large gaps might exist around deckhouses, masts and so on. Additionally, owing to the dimensions of the packs, it is unlikely that they will be capable of being stowed compactly between and up against uprights to port and to starboard. This being the case, it is likely that there will be a large amount of vacant space within a stowage of packaged sawn timber and this in turn means there is a possibility of shifting of packs into adjacent vacant spaces.

Logs, poles and so on can be stowed compactly together, upper items stowing neatly in the cantlines formed by lower items, and densely between the uprights to port and to starboard such that there is a minimum of vacant space into which any of the logs or poles can shift. However, a stowage of logs will settle as individual logs move slightly when the ship rolls and pitches during the voyage.

'Cants' are defined as being logs that are slab-cut, ripped lengthwise so that the resulting thick piece of timber has two opposing, parallel flat sides and, in some cases, a third side that is sawn flat. Cants might be shipped loose or in packages. The packages might retain their integrity but might be only loosely bounded and therefore might have a tendency to assume a rounded cross-section within the bands. Under the circumstances, cants might sometimes be considered to be loose or packaged sawn timber, but might otherwise be categorised together with logs. If in doubt seek advice.

Height and forward and aft extent of stowage

The only specific height restriction is that given for a ship operating within a seasonal winter zone in winter, when the height should not exceed half the extreme breadth of the ship. Otherwise, the height of a timber deck cargo should be restricted so that the following is achieved.

Height of timber deck cargo

- Adequate forward visibility is assured.
- A safe margin of stability is maintained at all stages of the voyage.
- Any forward-facing profiles do not present overhanging shoulders to a head sea.
- The weight of the timber deck cargo does not exceed the designated maximum permissible load of the weather deck and hatches.

There are, however, other factors that may affect the height to which timber can be stowed on deck. The ship might have substantial fashion plates to port and to starboard at the forward shoulders and therefore there may be no overhanging shoulders to the stowage. A timber deck cargo should not be stowed above the height of derricks or crane jibs when these are stowed. Also, the stowage should not be to a height at the sides greater than the height of the uprights. If the ship is designed for the carriage of timber deck cargo, there is probably on board a timber deck stowage plan that gives details of lashing arrangements and the height to which timber may be stowed. There will also be guidance in the Cargo Securing Manual.

With regard to the forward and aft extent of the cargo, the only restrictions are with regard to stowage on board a ship when the timber load-line is being used. The Timber Deck Cargoes Code requires that the timber should be stowed so as to extend over the entire available length of the deck and outboard as close as possible to the ship's side, as given in paragraph 3.2.3 of the Code. When a timber cargo is being stowed on the deck of a ship without a timber load–line, that cargo should be stowed compactly and, so far as possible, over the entire available space on deck in order that lashing arrangements in accordance with the Code can be set up.

Lashings and uprights

Lashings

Lashings can be of chain or wire, with other components such as shackles, rigging screws, snatch blocks, slip hooks and so on. These components must have a breaking strength of not less than 133 kN (13.3 t). The lashings should pass over the timber deck cargo and be shackled to eye plates or other strong points of adequate strength, that is more than 133 kN. Each lashing should be provided with a tightening device so that the lashing can be tightened initially and can be tightened as required during the voyage. All such equipment should be in good condition with all threads and other moving parts well-greased. All lashings are to be fitted with quick-release mechanisms, either slip hooks, in the case of chain lashings, or wiggle wires in the case of wire lashings. These systems are all described in the Timber Deck Cargoes Code.

All timber deck cargoes should be secured throughout their length by independent lashings. The lashing requirements for loose or packaged sawn timber are different from those for logs, poles, cants or similar cargo. The requirements for loose or packaged sawn timber are as follows.

Lashings for loose and packaged sawn timber

- The maximum spacing of lashings should be 3 m for stowage height up to 4 m, and 1.5 m for heights of more than 4 m.
- Packages stowed at the upper outboard edge of the stow should be secured by at least two lashings each.
- If the timber items are of length less than 3.6 m, the spacing of the lashing should be reduced as necessary.
- Rounded angle pieces of suitable material and design should be used along the upper outboard edge of the stow to bear the stress and permit free reeving of the lashing.

The requirements for logs, poles, cants or similar cargo are as follows.

Lashings for logs, poles and cants

- The maximum spacing of the independent lashings should be not more than 3 m, irrespective of the height of the stowage.
- Uprights should be rigged and athwartships lashings (hog lashings) joining each port and starboard pair of uprights should be rigged; one near the top of the stow and others at other levels appropriate to the height of the stow.
- A lashing system to tighten the stow comprising a combination of wiggle wires and foot-wires should be fitted. Foot-wires should be set up leading from pad-eyes on deck up to the top of the stowage, terminating in a snatch block, and the wiggle wire should be passed from side to side over the top of the stowage, zigzagging between the foot-wire snatch blocks, being made fast at one end and being led to a winch or other tensioning device at the other.
- If appropriate for cants, rounded angle pieces of suitable material and design should be used along the upper outboard edge of the stow to bear the stress and permit free reeving of the lashings.

Uprights

Uprights are required when a cargo of logs, poles and so on is to be carried because there is a requirement for hog lashings between the pairs of uprights. There is no requirement for hog lashings between uprights – and therefore no absolute requirement for uprights – when a cargo of loose or packaged sawn timber is carried. However, uprights should be fitted when required by the nature, height or character of the timber deck cargo. It is clear, therefore, that if logs are to be carried, uprights must be rigged and hog lashings fitted.

With regard to loose and packaged timber, if the ship is fitted with collapsible steel uprights that can be easily rigged, these should be rigged for the intended voyage. If the ship has on board timber uprights and these can be rigged, they should be rigged. If the ship is not fitted with any form of upright, then it is not essential to arrange for uprights to be provided and fitted. If uprights are fitted for a stowage of loose or packaged sawn timber, it is recommended that – unless there is an overriding reason for the fitting of hog wires – hog wires should not be fitted. This is because on the one hand they provide no benefit in the way that they do for a cargo of logs by producing an inboard pull on the respective uprights, whereas on the other hand they might restrict a jettisoning operation by holding back on board packs that have shifted only a small amount.

Inspections and maintenance

All equipment, lashings, hog wires, uprights, deck fittings and so on should be in good condition when taken into use. Routine inspections of all loose equipments should be carried out and all moving parts should be lubricated as appropriate in accordance with the requirements set out in the Cargo Securing Manual and the appropriate inspection and maintenance record sheets should be completed.

Pieces of lashing equipment that are worn, stretched, deformed or otherwise defective should be discarded, to be sent ashore for destruction as appropriate, and replacement items should be taken into use. Uprights and their base-foundations, lashing points and all other fixed equipment should be routinely examined and, as with the loose gear, the appropriate inspection and maintenance record sheets should be completed. Whenever defects are found, such as worn or damaged lashing points or wasted or deformed uprights, repairs should be completed without delay, with classification society supervision as appropriate.

When equipment is taken into use before loading begins and as loading progresses, all devices should be examined again to confirm that they are in good and well-lubricated condition, suitable for the intended voyage and not in any way defective.

Stability during the voyage

The requirements for stability are set out in the Timber Deck Cargoes Code and must be followed. From paragraph 2.5 and appendix C of the Code:

Initial metacentric height for carrying timber deck cargoes

The initial metacentric height (GMo) for ships carrying timber deck cargoes should preferably not exceed 3% of the breadth of the ship and should not be less than 0.15 m, or 0.10 m if certain additional provisions are met, at all times during the voyage while other criteria should be complied with.

It is essential that the ship must have an acceptable measure of stability while not being too stiff. If the ship has a large GM its roll period will be short, and heavy rolling in a short period might put excessive loading on the securing arrangements. A balance must be achieved between the weight of the deck cargo and the amount of ballast water taken to give the ship the required amount of stability.

Stowage

The loading and stowage of a deck cargo of timber must be carried out and completed in such a way that all hatches, doors and so on that must be closed for the voyage are closed before they are over-stowed and such that any parts of the stowage or the ship that must be accessible by the crew during the voyage remain or are made accessible before departure.

It must also be remembered that the stowage must not interfere with visibility from the bridge and the navigation of the ship.

Cargo jettisoning – considerations

When timber is stowed on deck, the lashings will incorporate slip hooks or other devices that allow quick release of the lashings. The advantages of heaving devices such as slip hooks are that they allow quick release and re-connection of the lashings during the important process of regular re-tightening at sea and the quick removal of the lashings after the ship's arrival at the destination port. Those devices can, of course, also be used when it is considered necessary to jettison part or all of the deck stowage.

Guidance is given in paragraph 6.3.3 of the Timber Deck Cargoes Code.

Jettisoning timber deck cargoes

As any cargo shift will in most cases occur in adverse weather conditions, sending crew to release or tighten the lashings on a moving or shifting cargo may well represent a greater hazard than retaining an overhanging load. A moving or shifting timber deck cargo should only be jettisoned after careful consideration; jettisoning is unlikely to improve the situation as the whole cargo stack would probably not fall at once. Severe damage may also be sustained by the propeller if it is still turning when timber is jettisoned.

Thus, careful consideration must be given to the overall situation when a shift of cargo has occurred, and before a decision upon actions to be taken can be made.

If the cargo shifts and it becomes necessary and advisable for all, or part of the cargo to be jettisoned, release of lashings might be necessary. If circumstances mean that access to the slip hooks, or other devices, is impossible or dangerous, or if the slip hooks become strained and inoperative, it might be necessary to use other means to let the lashings go. Consideration should be given, at the commencement of the voyage, depending upon the size of the lashings in use, to the use of cutting devices including axes, wire or bolt cutters and electrical cutting equipment. Consideration should be given to what equipment might be needed if jettisoning becomes necessary, and such equipment should be kept in a suitable place ready for use.

Precautions during the voyage

During the voyage it will be necessary for members of the crew to proceed on deck and onto the stowage of timber to check the lashings and tighten them where necessary and to make other inspections. Some points to remember are as follows.

Advice for timber deck cargoes during voyage

- Members of the crew should wear suitable protective clothing when working on deck.
- Equipment used by the crew should be suitable for the intended task and in good, serviceable condition.
- If there is no convenient passage on or below the deck guide lines or rails, and where appropriate an even walking surface, should be provided on each side of the deck cargo. Additionally a lifeline should be fitted at the centre line of the ship. Ladders, steps or ramps should be fitted to provide access from the deck to the top of the stowage.
- Lashings should be carefully examined and tightened at the beginning of the voyage. Lashings should be examined and tightened as appropriate at regular intervals throughout the voyage. Entries should be made in the log book, recorded details of inspections.
- The voyage should be planned so as to avoid areas where severe sea conditions are predicted. Weather reports, weather facsimile or weather routeing agencies should be consulted to achieve this.

- If severe weather or sea conditions are encountered, a reduction in the ship's speed and / or an alternation in the course should be considered to minimise the motion of the ship and the forces imposed on the cargo, structures and lashings. The lashings are not designed to provide a means of securing against imprudent ship handling in heavy weather. There is no substitute for good seamanship.
- If there is a major shift of deck cargo that causes the ship to list, examinations should be carried out to determine the precise cause or causes of the list and then appropriate action should be taken.
- If timber deck cargo is jettisoned or is accidentally lost overboard, masters must advise the appropriate authorities, they should also notify the owner of the ship and any charterer.

Timber stowed under-deck

Fig. 16. Logs stowed under-deck

Appendix B of the Timber Deck Cargoes Code gives some general guidelines for the under-deck stowage of logs (Fig. 16). The guidelines give recommended safe practices to be carried out prior to loading, during loading operations and during the voyage. Logs can range in size from small poles to large hardwood logs weighing more than 20 t. Logs are sometimes relatively dry and others are saturated, being lifted from rafts brought alongside. The loading and stowage of logs present particular problems that must be addressed.

Logs are heavy and are awkward to handle and stow. Water may run off or out of the logs and that water must be pumped overboard. The recommendations are specifically for the stowage of logs but most apply just as much to other timber cargoes such as loose or packaged sawn timber, cants, poles and any other products. In brief, points to be remembered are as follows

Advice for timber cargoes towed under-deck

- The cargo compartment should be clean and dry before loading and the bilges should be clean and dry, and tested for satisfactory operation, before starting loading.
- All lifting equipment should be examined prior to use and determined to be in satisfactory condition. Any defects should be rectified before starting cargo operations.
- Lifts should be brought on board carefully without excessive swinging to avoid the possibility of damage to ship's fittings or injury to personnel.
- Stowage should be tight and compact without avoidable gaps and areas of vacant space.
- Items should be stowed in the fore-and-aft line of the ship so far as possible, with items aligned athwartships to fill gaps and vacant space within and around the stowage.

Because logs are wet, to a greater or lesser degree, microbiological organisms (moulds and so on) will grow on and in the timber, and the respiration of those organisms will use oxygen that in turn will lead to oxygen depletion of the atmosphere within the cargo compartment.

Proper precautions and procedures for entry into enclosed spaces should be followed before any persons enter the cargo compartment.

It is stressed that the provisions of the Timber Deck Cargoes Code should be followed whenever a timber cargo, of whatever type, is carried on or under deck.

CONTAINERS – ON AND UNDER DECK – CONTAINER AND NON-CONTAINER SHIPS

Containers can be successfully carried on board ships designed and fitted for their carriage and on board other ships provided there are suitable lashings and fittings for the safe stowage and securing of the containers (Fig. 17).

Containers are mostly either 20 ft (6.1 m) or 40 ft (12.2 m) long with heights ranging from 8 ft (2.4 m) to 9 ft 6 in (2.9 m), but all are of a standard width of 8 ft (2.4 m). Containers are of a variety of types including general cargo units, refrigerated units, flat racks, tank-tainers and so on These various types of unit carry different commodities from cartons of goods, machinery, refrigerated produce or pharmaceuticals, through to all types of liquid.

It should be remembered that containers are not solid boxes of huge strength that can be stowed on board with little care or concern for either the container or its contents. They are, in fact, of fragile construction except for their corner- posts and base-support structure, and they must be stowed, secured and cared for properly and appropriately bearing in mind the type of ship upon which they are carried and the cargo stowed inside.

Fig. 17. Containers loaded on deck

Forces acting on containers

As with all other ships, those that carry containers are affected by the six types of motion, as described in the section on movement of a ship in a seaway. Of those motions, rolling, pitching and heaving generate the highest forces when the ship encounters heavy weather.

Heavy rolling will generate vertical forces in a container that are of greater magnitude further outboard, and athwartships forces that are of greater magnitude higher up in the stack. The vertical forces, alternately in compression and in tension, will primarily affect container corner-posts, twistlocks, hatch-cover foundations and deck- or support- column foundations by greatly increasing or reducing the load. If there is overloading or the structures are weakened or defective, collapse of the container stack might occur. The athwartships forces, alternately to port and to starboard, will primarily affect container corner-castings, lashing rods and end-panels by introducing racking forces. If there is overloading or the structures are weakened or defective, heavy racking of a container followed by the collapse of the stack might occur. In extremely heavy rolling, the forces could cause a stack of containers to tip over.

The forces generated by rolling are resisted by the strength of the containers themselves and by the securing arrangements. The securing arrangements will have been designed to operate within a maximum roll angle of between 22º and 30º and in accordance with classification society rules.

Heavy pitching will generate vertical forces that are greater further forward and further aft, and fore-and-aft forces that are greater higher up in the stow. The vertical forces will, as with the rolling forces, act on corner-posts, twistlocks and foundations, and the fore-and-aft forces will act on corner-castings and side-panels. These pitching forces can cause collapse of corner-posts and longitudinal racking.

When a ship is rolling and / or pitching it will also heave as each wave passes. This, depending upon its extent, will increase the vertical forces and will therefore increase the compression and tension acting on corner-posts, twistlocks and foundations.

When a ship is proceeding in heavy weather, the strong wind will act on outboard or forward / aft containers. Also, if seas are shipped on board, the sea water will crash against exposed containers. The force generated by the wind pressure, and to an extent also the wave pressure, will depend upon the speed and relative direction of the wind and on the height of the stack of containers. The force generated is additional to those produced by the motions of the ship.

Strength of containers

Only the end-framework, particularly the end-corner-posts, and the base-frame of containers are designed to take substantial loadings. All other parts of the container are low-strength members and are there only for the protection and preservation of the cargo carried. The base-framework is designed to have sufficient strength to carry the cargo. The four corner-posts are designed to take the load of any containers stowed on top and the additional forces generated during an ordinary ocean voyage. They are also designed to withstand forces encountered during lifting, variously during loading and discharging operations and during handling ashore. Additionally, the container might be fitted for handling by a fork-lift truck. Cross-members within the end-frames are designed to withstand racking forces. Containers must therefore be stowed bearing the following points in mind.

Advice for stowing containers

- The container must be stowed on all four bottom corner-castings only, either ashore or on board.
- One container must be stowed squarely atop another such that all four corner-posts are vertically in line.
- Break-bulk cargo must not be stowed on top of containers.
- Break-bulk cargo must not be stowed against, secured to or shored against the sides or ends of a container.

If these general rules are not followed, damage will be sustained by the container. If it is not suitably supported on its four corner-castings but is partly supported by the stiffening-members below the floor, those floor stiffeners will buckle and the container will become racked. If break-bulk cargo is stowed atop or beside, or is secured to the container, the top-panel, the sides or ends will be deformed because they are not designed to withstand large loadings; they are simply there to keep the rain out and to retain the cargo inside.

Also, because a container is designed to have strength for handling and stowage purposes only in its end-frameworks and floor, they must be secured in an approved manner. Securing of containers is discussed in the next section.

Stowage of goods in and on containers

The cargo carried in or on a container must be properly stowed and adequately secured such that it will not move during the voyage. Cargo on flats or other open units can be examined prior to loading and the suitability of the stowage and securing arrangements can be determined. If those arrangements are not satisfactory, the unit should be refused shipment. The doors of a closed unit are usually sealed and therefore the cargo within cannot be inspected. However, if there is any doubt with regard to the cargo inside a container, the appropriate personnel should be contacted and the containers should be opened for inspection and for any remedial work to be completed.

The packing of containers should be done in a logical and balanced sequence. The side-panels, the end-panel and the doors have limited strength (around 9 kN/m^2 or around 0.9 t force/m^2 for a side-panel), and the floor has, as the deck of a ship has, a maximum permissible loading. These factors should be borne in mind. Some basic rules are as follows.

Advice for stowage in and on containers

- The weight of the cargo should be spread over the whole of the floor or, in the case of heavy items, over a sufficient area to support the weight of the item, using timber dunnage or other materials of adequate size and strength.
- The weight of the cargo should be distributed evenly over the breadth and length of the container such that the overall centre of gravity is as close as possible to being above the centre of the floor.

- Heavy items should be secured in the container by timber chocking and bracing to the floor, to both sides and to both ends of the unit, and by the use of appropriate lashings, bearing in mind the strength capacity of the sides and ends, and of the lashing points.
- Where different types of cargo are to be stowed together (any combination of drums, cartons, cases, bags and so on), heavy items must be stowed below lighter items, wet items must be stowed below dry items, and non-compatible items should never be stowed together.
- Where two or more tiers of items such as drums are to be stowed in a container, consideration should be given to the fitting of timber, plywood or other sheet separations between tiers to stabilise the stowage.
- Items should be stowed, so far as possible, from side to side and end to end within the unit and compactly tight against each other. If this is not possible, the sides and ends of the units should be adequately chocked or braced, or chocking within the stowage should be completed by the use of appropriate dunnaging; air bags, timber, plywood, matting and so on

Container ships

Container ships are fitted with a system for the stowage and securing of the containers, both on-deck and under-deck, which has been approved by a classification society. That stowage and securing system will therefore have been constructed such that the containers will be satisfactorily held in position throughout the voyage provided that the stowage and securing system has been used in accordance with the requirements laid down by the manufacturer, and as set out the ship's Cargo Securing Manual, and provided that the voyage is completed with the observance of good seamanship and navigation practice. No system can, of course, guard against exceptional circumstances being encountered during the voyage.

Container-securing systems comprise, broadly speaking, either cell guides or a combination of fittings. Containers loaded in cell guides do not need to be separately secured because the cell guides will fully retain the containers. Securing systems comprising various fittings have been designed for both on-deck and under-deck stowages. The ship's Cargo Securing Manual will contain details of all pieces of equipment and where they are to be used. Fittings will include items such as stacking cones, bridge fittings, tension-pressure elements, twistlocks, lashing bars and turnbuckles. The ship might be provided with a system similar to that designed by MacGregor-Conver GmbH (Fig. 18).

Every container ship has a securing system that was designed for the particular ship or ship type. Details of the system, arrangements for a variety of combinations of containers in stowage and the limits of the system will be set out in the approved Cargo Securing Manual. The design of the securing system will take into account the forces that act on the container, as described above, at all positions in a block, but there are limits. The design calculations assume the following.

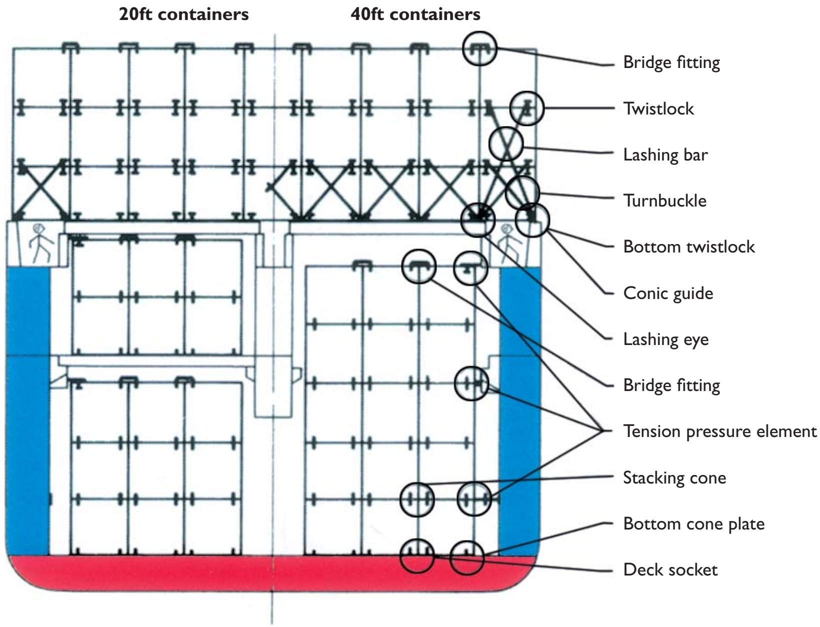


Fig. 18. Types of container fittings (MacGregor-Conver GmbH)

Design assumptions for container-securing systems
• The equipment in use is the correct equipment.
• The equipment is well-maintained and is not defective.
• All containers have been stowed correctly with regard to stack-weight limits.
• All containers have been stowed correctly with regard to tier-weight limits.
• All containers have been stowed correctly with regard to container-height parameters.
• The ship's stability is within normal limits.
• The ship is navigated prudently.

All lashing and securing equipment, both fixed and portable, should be closely examined regularly. Items should be checked for defects such as wear, fracturing and deformation and all defective items, both fixed and potable, should be taken out of service and replacement items should be brought into use at the earliest opportunity. All the moving parts of pieces should be free and well-greased to ensure efficient operation so that the equipment can be used as intended to its full capacity. During the routine inspections, and when containers are being lashed or unlashed, any pieces of equipment that are not of the ship's outfit should be immediately set to one side and should be landed at an appropriate port.

A record of all inspections and maintenance work carried out should be recorded in the appropriate section of the Cargo Securing Manual to keep a check on what is being done and so that subsequent masters and officers can determine what has been done before. If the equipment is not kept in good condition and in good working order, the systems will not retain the strength that the designers had anticipated and some or all of the pieces may become overloaded – that is tensioned to a loading greater than their residual strength – when the ship rolls and pitches heavily, equipment will fail and containers will move and collapse.

When containers are stowed on deck, they must be stowed in accordance with both the stack-weight and tier-weight limits as set out in the Cargo Securing Manual. Forces imparted into the containers themselves and the securing equipments by the ship's rolling and pitching are greatest outboard and higher up in the stow. For this reason there are restrictions on the gross weight of containers outboard and higher up in each stack. The restrictions placed on individual container cells should be followed and not be ignored, even if all other units in the block are well below the limits, because the forces on a particular container in a particular slot are the same, irrespective of the weight of adjacent units.

If the weights of any containers in a tier or stack exceed the limit given in the Cargo Securing Manual, there is a risk that the securing devices will become overloaded when the ship rolls and pitches heavily in the seaway, and the equipment will fail or there will be compression or racking damage to units lower down in stowage, or the stack might tip over, or a combination of these. Many container losses have resulted from heavy units being stowed too high in stacks.

The ship's stability, primarily the initial GM, will depend upon the weight of the containers stowed on and under deck, and the forces acting on the containers stowed on deck will be partly dependent upon the ship's GM. Stowage examples, with the corresponding stack- and tier-weight limits, will include the assumed GM. There will always be a compromise between the weights of containers loaded on deck, any ballast and the initial GM, but the correct balance should be achieved to ensure that the ship's stability is within safe limits to ensure that the motions of the ship are not excessive.

Points to be remembered when using container-securing fittings are as follows.

Advice on using container-securing systems

- All securing devices must be applied as shown in the Cargo Securing Manual.
- All securing devices in use must be in good condition with all moving parts free and well-greased.
- Defective securing devices should be removed from use and placed in a suitable receptacle so that they can be landed for repair or destruction.

- Routine inspections of the equipment should be carried out and records of such inspections kept. Any maintenance work that can be carried out should be completed and details recorded in the appropriate records attached to the Cargo Securing Manual.
- Any equipment found on board that is not from the ship's outfit should be landed at an appropriate port.
- Twistlocks can be either left-locking or right-locking, semi-automatic or fully automatic. The ship's outfit should include only those type(s) of twistlock that are shown in the Cargo Securing Manual. Any twistlocks which lock the wrong way or are not of the type used on board should be immediately set to one side and not used, and should be landed at an appropriate port.

The container-securing system will have been designed on the basis of certain arrangements of containers, that is, with regard to the overall weight of a stack of containers and such that heavier containers are lower down in stowage and lighter containers are further up. When planning the stowage of containers, the following points should be borne in mind.

Pre-planning for containers

- The total weight of each stack of containers should not exceed the permissible stack weight for the position and arrangement of units, this having been determined for the tank-top, deck or hatch cover.
- Tier-weight distributions given in the Cargo Securing Manual should not be exceeded.
- Container-height parameters given in the Cargo Securing Manual should be complied with.

The height of a container can range from 8 ft (2.4 m) to a high-cube unit of 9 ft 6 in (2.9 m). The presence of high-cube units in a stowage can cause problems and their position should be monitored, taken into account and altered when appropriate. The problem with high-cube units is, quite simply, their height. If an under-deck stack of containers includes a number of higher units, it might be that the hatch covers cannot be closed because of the overall height of the stowage, in which case either the top unit must be removed altogether or a number of units must be moved in order for there to be sufficient head space for the cover panels.

The problem with high-cube units on deck is more serious. If a number of 9 ft 6 in units are placed into a stack, the centre of gravity of each unit will be raised by the unit below. Comparing 8 ft 6 in (2.6 m) containers with high-cube units, if there were five high-cube units in a single stack the centre of gravity of the top unit would be 4 ft (1.2 m) higher than if all the units were of height 8 ft 6 in, the centre of gravity of the next below would be 3 ft (0.9 m) higher, and so on. This raising of the centre of gravity might, if the stack and tier weights were at the permissible limit, cause the lashing system and the structures of the container to be overloaded when the ship rolls and pitches heavily. Remember, therefore, to be aware of the position in stowage of all high-cube units so that any adjustments can be made in their position to avoid problems developing.

Flats and open-top containers are often used to carry items such as large pieces of machinery or large cases that extend beyond the top or sides of the unit. Such over-height or over-wide units will need additional space and this must be borne in mind when planning the stowage of such special containers.

Containers with refrigerated goods will also need appropriate stowage such that their refrigeration machinery can be connected to the ship's electricity supply. Another group of specials are containers carrying hazardous goods. The requirements of the International Maritime Dangerous Goods (IMDG) Code must be complied with. There are sections within the IMDG Code that give guidance with regard to the stowage of containers and the necessary segregation between different types of hazardous materials.

Containers are normally stowed in blocks across the breadth of the deck from port to starboard. In the Cargo Securing Manual, examples are given of how to secure such blocks with additional lashings fitted to outboard stacks. However, it is often necessary for part-blocks to be carried to minimise handling. When such part-stowages are carried, care should be taken to ensure that the containers are adequately secured for the forthcoming voyage. The Cargo Securing Manual might give examples of securing arrangements for such stowages. If not, the block should be secured as if it extended from side to side, such that both end-stacks, port and starboard, are secured as if they were extreme outboard-stacks.

The development of container ships, in terms of efficiency and carrying capacity, is on-going and the design of container-securing equipment is always progressing to meet the demands of the trade. All ship design features and stacking arrangements, and all securing equipment, is classification-society examined, tested, approved and certified as appropriate. If any problems are encountered with the stowage of containers, containers shifting during an ocean voyage and / or suffering damage from any cause, or with the container securing devices, particularly any recently designed and supplied pieces of equipment, the classification society should be notified without delay so that an investigation into the problem can be carried out. Also, the equipment manufacturers and designers of the systems should be contacted and replacement equipment obtained where appropriate.

To reduce the risk of incidents re-occurring, consideration should be given to temporary reductions in container stack heights, revision of passage planning and weather routing to ensure fair-weather voyages, reductions in voyage speed and the replacement of suspect securing equipment.

Non-container ships

Containers can be carried by ships that are not container ships, but special attention should be given to the stowage and securing of the containers. Non-container ships can be divided into two types, those which are fitted with container-securing devices and those that have none. The securing devices on board might range from the fittings shown in Fig. 18, through to just bottom-stacking devices on deck and securing chains. If the ship is provided with a full outfit, although it is not classed as a container ship, the recommendations given above for container ships should be followed.

The CSS Code gives some guidance for the stowage and securing of containers on the decks of ships that are not specifically designed and fitted for containers. The illustrations given in the Code show containers stowed two high. However, the UK Department of Trade Merchant Shipping Notice M.1167 – March, 1985 – *Carriage of containers and flats in ships not designed or modified for the purpose* states, 'Containers carried on deck should be stowed one high only, preferably fore and aft, prevented from sliding athwartships and securely lashed against tipping'. It is recommended here that if the ship is fitted with deck or hatch-top stools or other seating devices, containers may be stowed two high, whereas if there are no such fittings containers should be stowed one high only.

When stowing and securing containers on ships fitted with deck or hatch-top stools or other seating devices, the following points should be borne in mind.

Advice for containers in non-container ships with seating devices

- Containers should be stowed in the fore-and-aft direction and squarely supported on all four bottom-corner-castings.
- Containers should be stowed and secured such that there is sufficient space around each container, or stack of two containers, to allow personnel access to all securing arrangements during the voyage.
- The weight of the containers should not overstress the deck or hatch top.
- Container fittings such as twistlocks, bridge fittings, lashing chains and turnbuckles should be in good condition and working order, and adequately greased where appropriate.
- All securing devices should be used in accordance with the information given in the ship's Cargo Securing Manual.
- If wire rope is used to secure the containers, such wire should be of adequate strength, should be in good condition and eyes or grommets should be made up with the appropriate number of wire-rope grips in the correct arrangement.
- On board a ship fitted with deck stools and hatch-top fittings, the containers may be stowed two high and must be secured by the use of twistlocks, chain or wire rope lashings, turnbuckles and other fittings such as bridge fittings, timber shores and chocks.

When containers are to be stowed directly onto a normal deck or hatch top, the following additional points should be borne in mind.

Advice for containers of non-containers ships without seating devices
• Containers should be stowed only one high.
• The corner-castings should be stowed on timber gratings or timber boards of sufficient thickness and rigidity such that the weight of the container is spread over a sufficient area of the deck or hatch top, and so the maximum permissible loading is not exceeded.
• No dunnage should be placed such that it is in contact with the underneath of the floor structure, sills or side frames.
• Containers must be stowed and secured independently.
• Lashings must be of adequate strength for the weight of the container. Lashings should be led from top-corner-castings to deck fitting of appropriate strength, either crossed from side to side or leading down and outboard / inboard from the top-corner-castings. The requirement for the strength of the lashings should be calculated using the rule-of-thumb method or the advanced calculation method, depending upon the amount of information available.
• Foot-lashings or foot-chocks should be fitted in way of bottom-corner-castings. Foot-lashings of either wire or chain should be lead from bottom-corner-castings directly outboard / inboard to deck lashing points. Alternatively, foot-chocks constructed from good-quality timber should be fitted between bottom-corner-castings and the hatch-coaming structure inboard and bulwark structure outboard. Such foot-chocks should be of length no more than 2 m.
• All lashings should be set tight by turnbuckles.

If the container is not adequately secured, it is likely to move and, if the cargo in the container is not secured in the container, that cargo is likely to move as well (Figs 19 and 20).

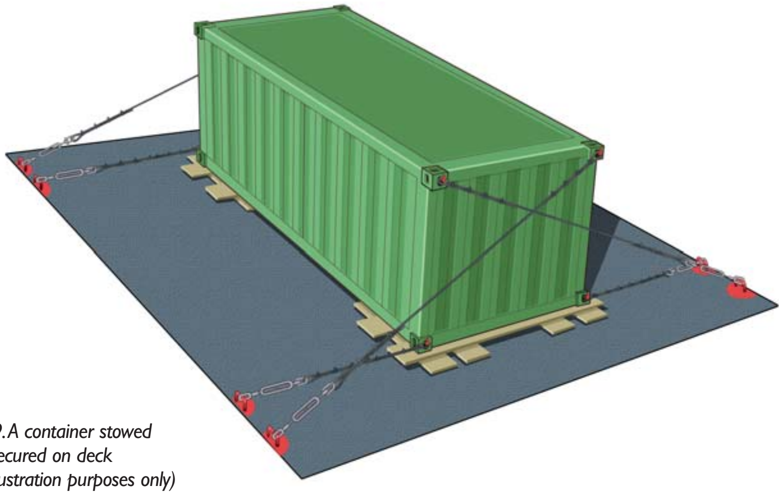


Fig 19. A container stowed and secured on deck (for illustration purposes only)

Fig. 20. Damaged container

Chapter 4

THE VOYAGE

Fig. 21. Setting off on the voyage

Any voyage (Fig. 21) can be divided into three main sections so far as the planning of things, and the checking for departures from those plans, is concerned. These sections are

- loading and securing
- passage planning
- actions during the voyage.

The three are, of course, inter-linked and each depends on the other two.

LOADING AND SECURING

The loading and securing of items of cargo must be carefully planned before operations begin and carried out in accordance with that plan, although some necessary adjustments to the plan might become apparent during the operations. The basic rules to be borne in mind are as follows.

Advice on planning loading and securing
• The cargo compartment should be clean and dry, and in every way prepared and suitable for the intended cargo.
• Detailed information about the cargo should be obtained, including: the types of cargo to be loaded; the weight of cargo items; the dimensions, centre of gravity and so on of individual pieces; the position and strength of lashing points and lifting points; and any other information that is appropriate to the particular cargo.

- The stowage of cargo should be planned in detail bearing in mind load-port rotation, discharge-port rotation, cargo-stowage requirements, cargo-securing requirements and access to items of cargo during the voyage.
- Strength and stability calculations should be completed to confirm that the stowage plan is satisfactory. If it is found that the ship's stability or strength requirements are not met, changes to the stowage plan should be made.
- The stowage and securing of the cargo should be carried out in accordance with the plan and in accordance with the ship's Cargo Securing Manual.
- The stowage and securing of cargo should be completed before the ship leaves the loading port.

PASSAGE PLANNING

Passage planning is the term used for the planning of the route from the load port to the discharge port and the setting of courses and laying them on the appropriate charts. Passage planning also involves the consideration of weather and sea conditions likely to be encountered during the voyage because those conditions will affect the cargo.

For example the master of a ro-ro ferry employed on a service across the Irish Sea will instruct the crew to fit more lashings to the vehicles during winter months, when gales are forecast, than during summer months when there is an anticyclone stationary and centred over Ireland, such that only light winds are forecast.

Passage planning and the planning of loading and securing are clearly closely linked, and must be carried out in conjunction with one another. Points to be borne in mind are as follows.

Advice on passage planning

- Passage planning must include the determination of what weather and sea conditions are likely to be encountered at all stages of the voyage. If adverse weather is likely to be encountered during any stage of the voyage, the stowage and securing arrangements can be adjusted to take into account the probability that the ship will roll and pitch heavily during the voyage.
- If it is believed that the cargo or the lashing arrangements cannot withstand heavy rolling and pitching of the ship, such as might be the case with project cargo, one option might be to adjust the passage plan to ensure that the ship does not encounter adverse weather.

ACTIONS DURING THE VOYAGE

During the voyage, be it a short coastal passage of only a few hours or a long ocean voyage between continents, the master and crew should carry out certain actions to ensure the cargo is carried carefully and safely without endangering the cargo itself, the carrying ship or the crew.

The progress of the ship and the condition should be monitored and the cargo and the securing devices must be inspected and adjusted when and where necessary. If adverse weather or sea conditions are encountered actions should be taken to minimise the motions of the ship to minimise the accelerations acting upon the cargo, and thereby keep to a minimum the loadings on the securing arrangements. Things to be borne in mind are as follows.

Advice on planning actions during the voyage

- Weather forecasts for the voyage should be obtained at an appropriate period before departure from the load port and throughout the voyage until arrival at the discharge port. Those weather forecasts should be studied to determine what weather and sea conditions are likely to be encountered. Such weather monitoring should be a continuous process.
- If adverse weather and sea conditions are forecast, then actions might be necessary. Such actions might include: increasing the number of lashings fitted to items of cargo; ballasting or de-ballasting to improve the behaviour of the ship or an alternation of course and / or speed to minimise the ship's motions; or to avoid the area of adverse conditions altogether.
- If adverse weather and sea conditions develop without much warning, it might be necessary to take urgent action to increase the securing arrangement and an alternation of course and / or speed might be appropriate in the short term, or it might be necessary to heave-to to ease the ship's motion. Ballasting or de-ballasting might also improve the ship's behaviour, but account must always be taken of the ship's stability because such ballasting or de-ballasting must not give the ship excessive or insufficient stability.
- The cargo and the securing arrangements should be monitored throughout the voyage and the securing arrangements should be adjusted as and when necessary. It is normal practice to complete an inspection of the cargo compartments and deck daily during good weather conditions and more frequently, as found necessary and appropriate, during adverse weather conditions.
- If cargo shifts during the voyage, the ship's course and / or speed should be reduced to ease the ship's motion, or it should be hove-to, so re-stowing and re-securing of the cargo can be completed where possible.
- If cargo has shifted and lashings have failed to an extent that the crew cannot re-stow and re-secure the cargo while the ship is at sea, a diversion to a place of shelter should be completed. If appropriate, the ship should be taken to a port of refuge where re-stowage and re-securing can be carried out properly.
- The integrity of the ship should be monitored throughout the voyage to ensure damage has not been sustained by shifting cargo or by lashings, or by any other cause.

Cargo spaces, like any other enclosed spaces, might suffer from oxygen depletion. Proper entry-into-enclosed-space precautions and procedures should always be followed before persons enter a cargo space.

APPENDIX I

SOLAS CHAPTER VI, PART A, REGULATION 5

Stowage and securing

1. Cargo and cargo units carried on or under deck shall be so loaded, stowed and secured as to prevent as far as is practicable, throughout the voyage, damage or hazard to the ship and the persons on board, and loss of cargo overboard.

2. Cargo carried in a cargo unit shall be so packed and secured within the unit as to prevent, throughout the voyage, damage or hazard to the ship and the persons on board.

3. Appropriate precautions shall be taken during loading and transport of heavy cargoes or cargoes with abnormal physical dimensions to ensure that no structural damage to the ship occurs and to maintain adequate stability throughout the voyage.

4. Appropriate precautions shall be taken during loading and transport of cargo units on board ro-ro vessels, especially with regard to the securing arrangements on board such vessels and on the cargo units and with regard to the strength of the securing points and lashings.

5. Containers shall not be loaded to more than the maximum gross weight indicated on the Safety Approval Plate under the International Convention for Safe Containers (CSC).

6. All cargoes, other than solid and liquid bulk cargoes, shall be loaded, stowed and secured throughout the voyage in accordance with the Cargo Securing Manual approved by the Administration. In vessels with ro-ro cargo spaces, as defined in regulation II-2/3.14, all securing of cargoes, in accordance with the Cargo Securing Manual, shall be completed before the vessel leaves the berth. The Cargo Securing Manual shall be drawn up to a standard at least equivalent to the guidelines developed by the Organization.

APPENDIX II

GUIDELINES FOR THE PREPARATION OF THE CARGO-SECURING MANUAL, PREAMBLE

Regulations VI/5 and VII/6 of the 1974 SOLAS Convention require cargo units and cargo transport units to be loaded, stowed and secured throughout the voyage in accordance with a Cargo Securing Manual approved by the Administration and drawn up to a standard at least equivalent to the guidelines developed by the Organization.

IMO's Maritime Safety Committee (MSC), at its sixty-sixth session (28 May to 6 June 1996), considered draft guidelines for the preparation of the Cargo Securing Manual prepared by the Sub-Committee on Dangerous Goods, Solid Cargoes and Containers at its first session (5 to 9 February 1996), and approved the Guidelines presented in this publication, which were originally issued as MSC/Circ.745 (dated 13 June 1996).

These Guidelines are based on the provisions contained in the annex to MSC/Circ.385 (dated 8 January 1985) but have been expanded to include the applications explicit to vessels which are equipped or adapted for the carriage of freight containers, taking into account the provisions of the Code of Safe Practice for Cargo Stowage and Securing (CSS Code), as amended. They are of a general nature and intended to provide guidance on the preparation of Cargo Securing Manuals, which are required on all types of vessels engaged in the carriage of cargoes other than solid and liquid bulk cargoes.

Member Governments are invited to bring these Guidelines to the attention of all parties concerned, with the aim of having Cargo Securing Manuals carried on board vessels prepared appropriately and in a consistent manner, and to implement them as soon as possible and, in any case, not later than 31 December 1997. The Guidelines supersede those presented in MSC/Circ.385.

APPENDIX III

ADVANCED CALCULATION METHOD

The motions of a ship are longitudinal (fore-and-aft), transverse (athwartships) and vertical. In addition, a piece of cargo carried on deck will experience forces produced by wind pressure and by sea sloshing when waves are shipped on deck.

The advanced calculation method assesses the balance between forces and moments in terms of three motions, as follows.

- Transverse sliding forces to port and to starboard.
- Transverse tipping moments to port and to starboard.
- Longitudinal sliding forces in the fore-and-aft direction, both forward and aft.

The basic formula for the calculation of the external forces (step two) is as follows.

Calculation of external forces

$$F_{(x, y, z)} = m \cdot a_{(x, y, z)} + F_{w(x, y)} + F_{s(x, y)}$$

Where

F = longitudinal $_{(x)}$, transverse $_{(y)}$ and vertical $_{(z)}$ external force as appropriate
m = mass of cargo unit in t
a = longitudinal $_{(x)}$, transverse $_{(y)}$ and vertical $_{(z)}$ accelerations (from tables)
F_w = longitudinal $_{(x)}$ and transverse $_{(y)}$,forces produced by wind pressure
F_s = longitudinal $_{(x)}$ and transverse $_{(y)}$ forces produced by sea sloshing

A worked example of an advanced calculation method is given in Appendix IV, together with the calculation set out on the form developed for this guide. A blank version of the form is provided in Appendix V. It is suggested that readers follow the steps of the calculation while reading the description below.

Step one – inputs and primary calculations

The mass of the unit, in tonnes (t), should be listed together with its dimensions in metres (m) (width, length and height), its lever arms of stability and tipping in the athwartships line and its position on board. It would be good practice to also list, for easy reference, the ship's length, breadth, GM and speed.

Having set out all the basic input information, the primary calculations or assessments can be carried out to determine the accelerations and the wind and sea forces needed for step two.

The longitudinal, transverse and vertical accelerations (a_x, a_y and a_z) are obtained from table 2 – basic acceleration data – of annex 13 of the CSS Code. That table is based upon the ship being of length 100 m and having a speed of 15 knots, and being on an ocean voyage at any time of the year, where the voyage is of 25 days duration. The transverse acceleration is of course dependent upon the height and fore-and-aft location of the stowage position, the longitudinal acceleration is dependent only upon the height, and the vertical acceleration is dependent only upon the fore-and-aft position of the unit. Table 2 must, therefore, be entered on the basis of the stowage position in terms of height and fore-and-aft location.

For ships of length other than 100 m and of a speed other than 15 knots, a single correction must be applied to each of the three basic acceleration factors, and that correction can be obtained from table 3 of annex 13 of the CSS Code.

The basic formula is also based upon the roll period of the ship being satisfactorily long for the size of the ship. The roll period of the ship affects the transverse acceleration, and therefore the transverse forces, acting on pieces of cargo and therefore an additional correction based on the beam and the GM of the ship must be applied to the transverse acceleration figure. This correction factor can be obtained from table 4 of annex 13 of the CSS Code.

If the ship's Cargo Securing Manual contains tables for these accelerations, then those tables should be used rather than the tables in annex 13 of the CSS Code to obtain the corrected acceleration.

The longitudinal and transverse forces produced by wind pressure and sea sloshing can be calculated from the dimensions of the unit on the basis that each force is assumed to be 1 kN/m^2 of the exposed forward or side face of the unit, except that sea-sloshing forces need only be applied to a height on the unit of no more than 2 m above the weather deck or hatch top where the piece is stowed.

Step two – external forces

External forces F_x, F_y and F_z can now be calculated using the formula above.

When assessing the transverse tipping of the cargo, the balance calculation is based upon the transverse force (F_y) multiplied by the lever-arm of tipping (a), that is $F_y \cdot a$. This provides the four necessary external actions: F_z is needed in the calculation of the anti-longitudinal sliding force, and F_x, F_y and $F_y \cdot a$ for the final balance assessments.

Step three – friction and lashings

The next step is the calculation for the strength and effectiveness of the lashings.

When the number, type and location of the securing arrangements have been decided upon, their 'holding-down' power and associated frictional forces can then be calculated in terms of forces acting against transverse sliding, transverse tipping and longitudinal sliding.

First, the MSL of each component is found and then the MSL of the weakest link in each lashing is listed. MSLs should be listed in kilonewtons (kN) for use in the calculations, where 1 kN is taken to equal 100 kg (or 10 kN = 1 t).

The strength of each lashing used in these calculations is called the 'calculated strength' (*CS*). The calculated strength of the lashings will be the MSL of the weakest part of the lashing arrangement, as described above, divided by a safety factor of 1.5 (in the calculation form that follows, the multiplying factor of 0.67 is used rather than dividing by the factor of 1.5). This safety factor allows for the possibility of an uneven distribution of the forces among the lashing devices and any reduced strength because of the improper assembly of the devices, or any other unknown factors.

For the calculation of the anti-sliding forces, the '*f* value', which is a function of the angle of the lashing to the horizontal (α) and the friction between the unit and the deck (μ), must be applied to the calculated strength of each device; *f* value are obtained from table 6 of annex 13 of the CSS Code. The *f* value for each lashing can be listed on the calculation sheet.

With regard to the longitudinal anti-sliding force calculation, it must be remembered that the longitudinal component of the transverse securing devices should not be assumed to be greater than 0.5 of the calculated strength of each of those lashings. Bearing this in mind, when calculating the effectiveness of each lashing, only those lashings that have a fore-and-aft component should be used and that component should be reduced by at least 50%. For guidance, only lashings that are at an angle of more than 20° to the athwartships line should be used in the calculation. Also, only those that lead in the direction being considered, either forward or aft, should be used in the calculation for the anti-sliding force for that direction and those lashings that are at an angle to the athwartships line of 20° or less should be ignored in both longitudinal anti-sliding calculations.

With regard to the force acting against transverse tipping, the lever arm for each lashing, that is the perpendicular distance between the tipping point, or tipping axis of the cargo unit and each lashing (*c*), must be applied to the calculated strength of each lashing. These *c* values can be listed for each lashing on the calculation sheet.

With all the necessary parts listed, the corrected calculated strength for each lashing, applying the *f* value or the *c* value where appropriate can be found as follows.

Corrected calculated strength of lashing to resist sliding
$CS{\cdot}f$ = MSL × safety factor × *f* value

Corrected calculated strength of lashing to resist tipping
$CS{\cdot}c$ = MSL × safety factor × *c* value

These can then be added together for each direction and type to give sums ($\sum CS{\cdot}f$ and $\sum CS{\cdot}c$) for inclusion in step four.

Step four – anti-movement forces and balance assessment

The anti-transverse sliding force can be calculated by multiplying together the friction coefficient, the mass of the unit and the acceleration due to gravity (**g**) and then adding to that figure the appropriate sum of corrected calculation strengths ($\sum CS{\cdot}f$). This calculation should be done for each direction, port and starboard.

The total anti-tipping force can be calculated using the mass of the unit multiplied by gravity (**g**) and the lever arm of stableness (*b*), which is the horizontal distance between the tipping point and the centre of gravity of the unit, and then by adding on the appropriate sum of corrected calculated strengths ($\sum CS{\cdot}c$). This transverse-tipping calculation should be done for each side, port as well as starboard.

The anti-longitudinal sliding force can be calculated using the mass of the unit (*m*), gravity (**g**), the external vertical force (F_z) the coefficient of friction (μ) and the appropriate sum of corrected strengths ($\sum CS{\cdot}f$). This calculation should be done for each direction, forward and aft.

The three formulae to be used from annex 13 are as follows.

Transverse anti-sliding force

$= \mu \cdot m \cdot g + CS_1 \cdot f_1 + CS_2 \cdot f_2 + \ldots + CS_n \cdot f_n$

Transverse anti-tipping moment

$= b \cdot m \cdot g + CS_1 \cdot c_1 + CS_2 \cdot c_2 + \ldots + CS_n \cdot c_n$

Longitudinal anti-sliding force

$= \mu \cdot (m \cdot g - F_z) + CS_1 \cdot f_1 + CS_2 \cdot f_2 + \ldots + CS_n \cdot f_n$

When the anti-sliding forces and anti-tipping moment have been calculated, they can be compared to the appropriate external forces and moments. If the anti-sliding forces or anti-tipping moment are greater than the opposing external forces and moments, then the proposed lashing arrangements may be considered sufficient for the voyage. The three balancing equations to be used are as follows.

Conditions for satisfactory lashing

$F_y \leq$ transverse anti-sliding force

$F_y \cdot a \leq$ transverse anti-tipping moment

$F_x \leq$ longitudinal anti-sliding force

To summarise, the advanced calculation method is a series of calculations to determine whether or not longitudinal, transverse and vertical external forces are more than balanced by the anti-sliding and anti-tipping components of the combination of the proposed lashing system and the friction between the base of the unit and the deck upon which it is stowed.

APPENDIX IV

ADVANCED CALCULATION METHOD – WORKED EXAMPLE

Annex 13 of the CSS Code contains a simplified example of how the advanced calculation method is used. This Appnedix provides a more practical demonstration of how the method is used in conjunction with the calculation sheet developed for this guide.

The motor vessel *NEPIA* is scheduled to carry a large boiler of weight 81.7 t, on-deck, from Liverpool, UK to Mumbai, India. The boiler has been prepared for carriage on-deck, that is to say there are no openings that might allow entry of water and wetting by sea or rain will not cause damage; the shipper has confirmed this in writing. The weather-deck hatch covers have sufficient strength, being strengthened for containers, so long as the weight is spread by sufficient timber. Departure from Liverpool will be on 17th September and the estimated time of arrival has been given by the master as 10th October, allowing three days for the Suez Canal transit.

The voyage will be south to Gibraltar, east in the Mediterranean Sea to Port Said, through the Suez Canal into the Red Sea and finally across the Gulf of Arabia to Mumbai. The weather in the North Atlantic to Gibraltar is likely to be moderate with a 5% possibility of winds of Beaufort force 7 or higher and with associated heavy swell conditions. In the Mediterranean Sea conditions should be good. The south-west monsoon begins in the Arabian Sea during June and ends, in the waters off Mumbai at the end of September. Bearing the above in mind, the worst weather likely to be experienced by *NEPIA* will be during the first week of the voyage. Detailed weather forecasts should therefore be obtained and, if adverse weather is forecast, that is winds of more than force 5, the departure from Liverpool can be delayed until severe adverse weather has passed, or additional lashings can be fitted.

The basic details of the ship, the item of cargo and the lashings, which are needed for the calculation, are set out in Table 7.

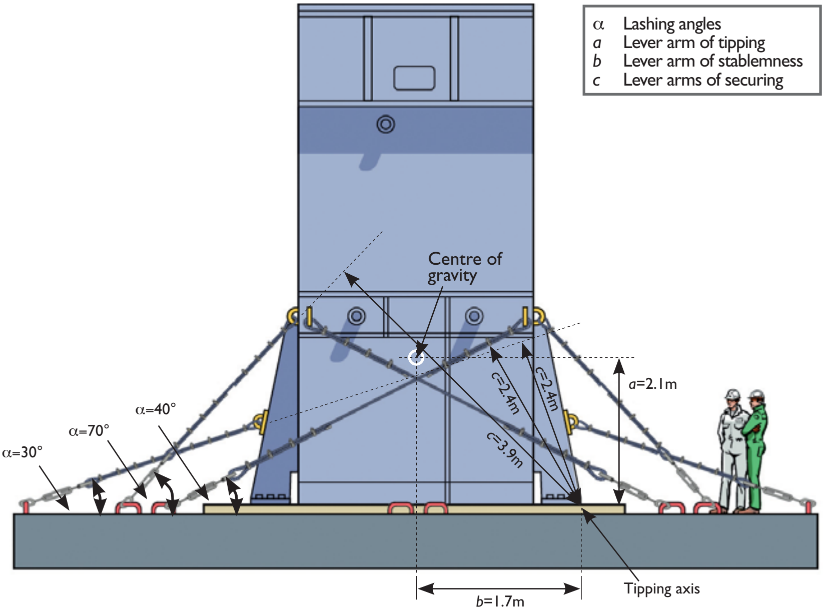
Table 7. Details of ship, cargo and lashings for example cacluation

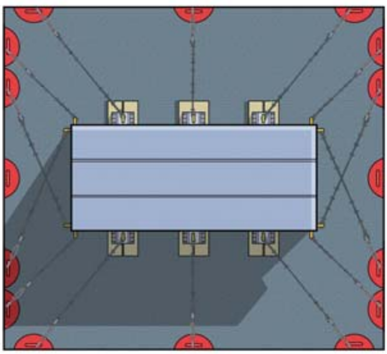
Vessel – NEPIA		**Maximum securing load (MSL)**
Length	157m	
Beam	22m	
GM	1.8m	
Speed	14 knots	
Stowage	120 m from aft (= 0.76 L)	
Stowage on timber friction coefficient (μ)	0.3	
Cargo – Boiler		
Weight	81.7 t	
Length	6.3 m	
Height	6.0 m	
Centre of gravity	2.1 m above base, 1.7 m in from sides	
Lashing point rating	20 t each	50% = 10.00t
Lashings and strengths		
Wire – 18 mm diameter galvanised 6×24	13.2 t	80% = 10.56 t
Wire bulldog grip eyes	13.2 t	70% = 9.24 t
Shackles – large D-type	20 t	50% = 10.00 t
Turnbuckles – Hamburger type, rod length 500 mm, rod diameter 30 mm, bow diameter 18 mm	19 t	50% = 9.50 t
D-rings – container fittings	35 t	50% = 17.50 t

As can be seen from the table, the governing (weakest) component in the calculation is the wire bulldog grip eyes, with a MSL of 9.24 t or 92.4 kN.

Figure 22 shows the layout of the lashings fitted to the boiler, and gives the lashing angles and lever arms.

The calculation using all the above information is set out in the following calculation form. It shows that the boiler is satisfactorily lashed in all four directions because the six anti-movement forces acting against sliding and tipping are all greater than the external forces by an acceptable margin.





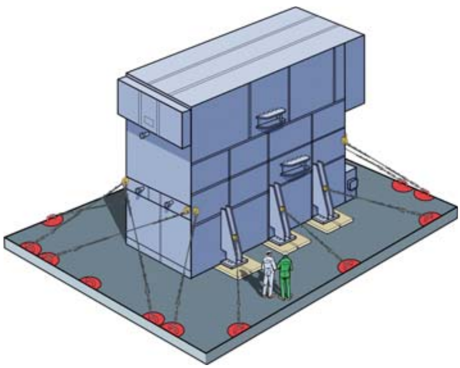


Fig. 22. An 81.7 t boiler stowed on deck – layout of lashings (for illustration purposes only)

ADVANCED METHOD OF CALCULATION FORM

Vessel: NEPIA **Load port: LIVERPOOL, UK** **Load date: 17th September** **Cargo type: BOILER**	**Voyage no. 1** **Discharge port: MUMBAI, INDIA** **Discharge date: 11th October**

STEP ONE – Inputs and primary calculations

SHIP		**CARGO**	
Length (m)	157	Width (m)	3.4
Breadth, *B* (m)	22	Length (m)	6.3
GM (m)	1.8	Height (m)	6.0
Speed (knots)	14	Mass, *m* (t)	81.7
B/GM	12.2	Longitudinal position (m)	0.76
Table 3 correction: T3	0.7	Vertical position (m)	3
Table 4 correction: T4	1.04	Friction, μ	0.3
Longitudinal acceleration – Table 2, a_x (m/s²)	2.9	Lever arm of tipping, *a* (m)	2.1
Transverse acceleration – Table 2, a_y (m/s²)	6.4	Lever arm of stableness, *b* port (m)	1.7
Vertical acceleration – Table 2, a_z (m/s²)	7.04	Lever arm of stableness, *b* starboard (m)	1.7
		Wind load longitudinal, F_{wx} (kN)	20.4
Longitudinal acceleration corrected, a_x (m/s²)	2.03	Wind load transverse, F_{wy} (kN)	37.8
Transverse acceleration corrected, a_y (m/s²)	4.66	Sea slosh longitudinal, F_{sx} (kN)	6.8
Vertical acceleration corrected, a_z (m/s²)	4.93	Sea slosh transverse, F_{sy} (kN)	12.6

STEP TWO – External forces and moments

Longitudinal sliding (kN)	$F_x = m \cdot a_x + F_{wx} + F_{sx}$	81.7	×	2.03	+	20.4	+	6.8	=	193.1
Transverse sliding (kN)	$F_y = m \cdot a_y + F_{wx} + F_{sy}$	81.7	×	4.66	+	37.8	+	12.6	=	431.1
Transverse tipping (kN m)	$F_y . a$					431.1	×	2.1	=	905.4
Vertical (kN)	$F_z = m \cdot a_z$					81.7	×	4.93	=	402.8

STEP THREE – Friction and lashings

Port side	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*		
MSL (kN)	92.4	92.4	92.4	92.4	92.4	92.4	92.4					
Lashing angle, α (°)	40	70	30	30	30	70	40					
f value – Table 6	0.96	0.62	1.02	1.02	1.02	0.62	0.96					
Lever arm of securing, *c* (m)	2.4	3.9	2.4	2.4	2.4	3.9	2.4					
Safety factor	**0.67**	**0.67**	**0.67**	**0.67**	**0.67**	**0.67**	**0.67**	**0.67**	**0.67**	**0.67**		
CS·f (MSL × safety factor × *f*) (kN)	59.4	38.4	63.1	63.1	63.1	38.4	59.4				Σ(sum)	384.9
CS·c (MSL × safety factor × *c*) (kN)	148.6	241.4	148.6	148.6	148.6	241.4	148.6				Σ(sum)	1225.8
Starboard side	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*		
MSL (kN)	92.4	92.4	92.4	92.4	92.4	92.4	92.4					
Lashing angle, α (°)	40	70	30	30	30	70	40					
f value – Table 6	0.96	0.62	1.02	1.02	1.02	0.62	0.96					
Lever arm of securing, *c* (m)	2.4	3.9	2.4	2.4	2.4	3.9	2.4					
Safety factor	**0.67**	**0.67**	**0.67**	**0.67**	**0.67**	**0.67**	**0.67**	**0.67**	**0.67**	**0.67**		
CS·f (MSL × safety factor × *f*) (kN)	59.4	38.4	63.1	63.1	63.1	38.4	59.4				Σ(sum)	384.9
CS·c (MSL × safety factor × *c*) (kN)	148.6	241.4	148.6	148.6	148.6	241.4	148.6				Σ(sum)	1225.8

Longitudinal forward	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*		
MSL (kN)	92.4	92.4	92.4	92.4	92.4	92.4						
Lashing angle, α (°)	30	70	40	40	70	30						
f value – Table 6	1.02	0.62	0.96	0.96	0.62	1.02						
Safety factor	***0.67***	***0.67***	***0.67***	***0.67***	***0.67***	***0.67***	***0.67***	***0.67***	***0.67***	***0.67***		
Longitudinal component proportion	0.5	0.5	0.5	0.5	0.5	0.5						
Corrected ***CS·f*** (MSL × safety factor × *f* × longitudinal component proportion) (kN)	31.6	19.2	29.7	29.7	19.2	31.6					**Σ(sum)**	161.0
Longitudinal aft	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*		
MSL (kN)	92.4	92.4	92.4	92.4	92.4	92.4						
Lashing angle, α (°)	30	70	40	40	70	30						
f value – Table 6	1.02	0.62	0.96	0.96	0.62	1.02						
Safety factor	***0.67***	***0.67***	***0.67***	***0.67***	***0.67***	***0.67***	***0.67***	***0.67***	***0.67***	***0.67***		
Longitudinal component proportion	0.5	0.5	0.5	0.5	0.5	0.5						
Corrected ***CS·f*** (MSL × safety factor × *f* × longitudinal component proportion) (kN)	31.6	19.2	29.7	29.7	19.2	31.6					**Σ(sum)**	161.0

STEP FOUR – Anti-movement forces and moments, and balance assessment											**External forces and moments**	**Balanced (Yes/No)?**
Transverse sliding port (kN)	$\mu \cdot m \cdot \mathbf{g} + \Sigma \mathbf{CS} \cdot f$	0.3	×	81.7	×	***9.81***	+	384.9	=	625.3	431.1	Yes
Transverse sliding starboard (kN)	$\mu \cdot m \cdot \mathbf{g} + \Sigma \mathbf{CS} \cdot f$	0.3	×	81.7	×	***9.81***	+	384.9	=	625.3	431.1	Yes
Transverse tipping port (kN m)	$b \cdot m \cdot \mathbf{g} + \Sigma \mathbf{CS} \cdot c$	1.7	×	81.7	×	***9.81***	+	1225.8	=	2588.3	905.4	Yes
Transverse tipping starboard (kN m)	$b \cdot m \cdot \mathbf{g} + \Sigma \mathbf{CS} \cdot c$	1.7	×	81.7	×	***9.81***	+	1225.8	=	2588.3	905.4	Yes
Longitudinal sliding forward (kN)	$\mu \cdot (m \cdot \mathbf{g} - \mathbf{F}_z) + \Sigma \mathbf{CS} \cdot f$	0.3	(81.7	×	***9.81***	−	402.8)	+ 161.0	=	280.6	193.1	Yes
Longitudinal sliding aft (kN)	$\mu \cdot (m \cdot \mathbf{g} - \mathbf{F}_z) + \Sigma \mathbf{CS} \cdot f$	0.3	(81.7	×	***9.81***	−	402.8)	+ 161.0	=	280.6	193.1	Yes

APPENDIX V

ADVANCED CALCULATION METHOD – BLANK FORM

ADVANCED METHOD OF CALCULATION FORM	
Vessel: **Load port:** **Load date:** **Cargo type:**	**Voyage no.** **Discharge port:** **Discharge date:**

STEP ONE – Inputs and primary calculations			
SHIP		**CARGO**	
Length (m)		Width (m)	
Breadth, *B* (m)		Length (m)	
GM (m)		Height (m)	
Speed (knots)		Mass, *m* (t)	
B/GM		Longitudinal position (m)	
Table 3 correction: T3		Vertical position (m)	
Table 4 correction: T4		Friction, μ	
Longitudinal acceleration – Table 2, $\boldsymbol{a}_x$ (m/s²)		Lever arm of tipping, *a* (m)	
Transverse acceleration – Table 2, $\boldsymbol{a}_y$ (m/s²)		Lever arm of stableness, *b* port (m)	
Vertical acceleration – Table 2, $\boldsymbol{a}_z$ (m/s²)		Lever arm of stableness, *b* starboard (m)	
		Wind load longitudinal, $\boldsymbol{F}_{wx}$ (kN)	
Longitudinal acceleration corrected, $\boldsymbol{a}_x$ (m/s²)		Wind load transverse, $\boldsymbol{F}_{wy}$ (kN)	
Transverse acceleration corrected, $\boldsymbol{a}_y$ (m/s²)		Sea slosh longitudinal, $\boldsymbol{F}_{sx}$ (kN)	
Vertical acceleration corrected, $\boldsymbol{a}_z$ (m/s²)		Sea slosh transverse, $\boldsymbol{F}_{sy}$ (kN)	

STEP TWO – External forces and moments										
Longitudinal sliding (kN)	$F_x = m \cdot a_x + F_{wx} + F_{sx}$		×		+		+		=	
Transverse sliding (kN)	$F_y = m \cdot a_y + F_{wx} + F_{sy}$		×		+		+		=	
Transverse tipping (kN m)	$F_y.a$						×		=	
Vertical (kN)	$F_z = m \cdot a_z$						×		=	

STEP THREE – Friction and lashings											
Port side	1	2	3	4	5	6	7	8	9	10		
MSL (kN)												
Lashing angle, α (°)												
f value – Table 6												
Lever arm of securing, *c* (m)												
Safety factor	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67		
CS·f (MSL × safety factor × *f*) (kN)											Σ(sum)	
CS·c (MSL × safety factor × *c*) (kN)											Σ(sum)	
Starboard side	1	2	3	4	5	6	7	8	9	10		
MSL (kN)												
Lashing angle, α (°)												
f value – Table 6												
Lever arm of securing, *c* (m)												
Safety factor	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67		
CS·f (MSL × safety factor × *f*) (kN)											Σ(sum)	
CS·c (MSL × safety factor × *c*) (kN)											Σ(sum)	

Longitudinal forward	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*		
MSL (kN)												
Lashing angle, α (°)												
f value – Table 6												
Safety factor	*0.67*	*0.67*	*0.67*	*0.67*	*0.67*	*0.67*	*0.67*	*0.67*	*0.67*	*0.67*		
Longitudinal component proportion												
Corrected $\mathbf{CS} \cdot f$ (MSL × safety factor × f × longitudinal component proportion) (kN)											Σ(sum)	
Longitudinal aft	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*		
MSL (kN)												
Lashing angle, α (°)												
f value – Table 6												
Safety factor	*0.67*	*0.67*	*0.67*	*0.67*	*0.67*	*0.67*	*0.67*	*0.67*	*0.67*	*0.67*		
Longitudinal component proportion												
Corrected $\mathbf{CS} \cdot f$ (MSL × safety factor × f × longitudinal component proportion) (kN)											Σ(sum)	

STEP FOUR – Anti-movement forces and moments, and balance assessment											External forces and moments	Balanced (Yes/No)?
Transverse sliding port (kN)	$\mu \cdot m \cdot \mathbf{g} + \Sigma \mathbf{CS} \cdot f$		×		×	9.81	+		=			
Transverse sliding starboard (kN)	$\mu \cdot m \cdot \mathbf{g} + \Sigma \mathbf{CS} \cdot f$		×		×	9.81	+		=			
Transverse tipping port (kN m)	$b \cdot m \cdot \mathbf{g} + \Sigma \mathbf{CS} \cdot c$		×		×	9.81	+		=			
Transverse tipping starboard (kN m)	$b \cdot m \cdot \mathbf{g} + \Sigma \mathbf{CS} \cdot c$		×		×	9.81	+		=			
Longitudinal sliding forward (kN)	$\mu \cdot (m \cdot \mathbf{g} - \mathbf{F}_z) + \Sigma \mathbf{CS} \cdot f$		(	×	9.81	−	)	+	=			
Longitudinal sliding aft (kN)	$\mu \cdot (m \cdot \mathbf{g} - \mathbf{F}_z) + \Sigma \mathbf{CS} \cdot f$		(	×	9.81	−	)	+	=			

APPENDIX VI

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CARGO STOWAGE AND SECURING

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Second Edition

by CHARLES BLIAULT and
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