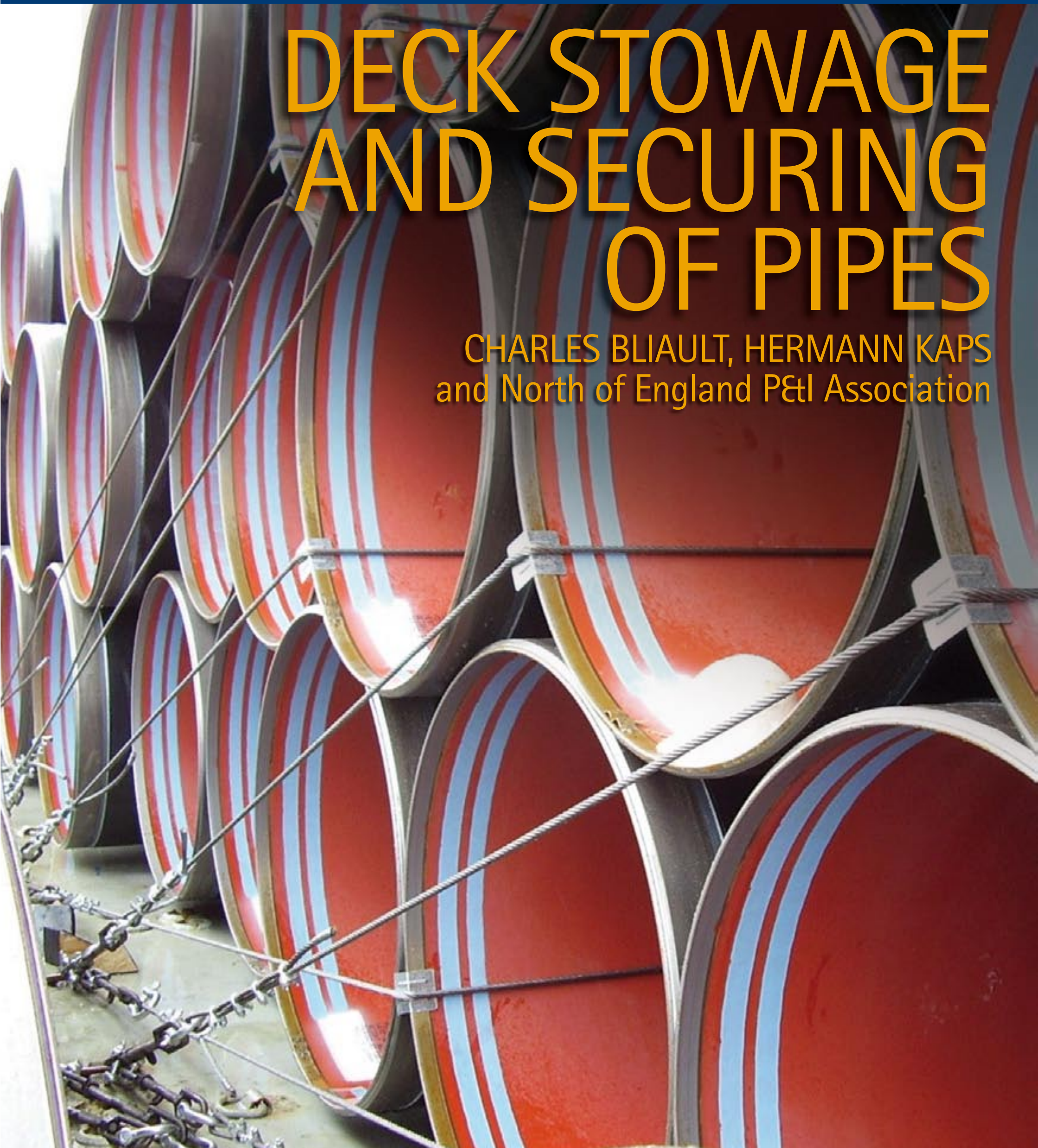
NORTH

LOSS PREVENTION

GUIDES

DECK STOWAGE AND SECURING OF PIPES

CHARLES BLIAULT, HERMANN KAPS
and North of England P&I Association



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DECK STOWAGE AND SECURING OF PIPES

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This publication is intended for general guidance only to assist in the avoidance of disputes and problems arising from stowage and securing of pipes on the decks of cargo ships, though pipes should wherever possible be stowed under decks. Readers should take care to ensure that the recommendations contained in this publication are appropriate for a particular situation before implementing them. Whereas every effort has been made to ensure that recommendations are comprehensive, the authors and the North of England P&I Association Limited do not under any circumstances accept responsibility for errors, omission and mis-statements or for the consequences of implementing or attempting to implement recommendations.

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TERMS OF USE

Chapter 1

GENERAL INFORMATION

INTRODUCTION

There have been a number of losses or part losses over the last few years of blocks of pipes stowed on deck, principally on the hatch covers. Much consideration has been given to the reasons for those losses and ways by which such stowages may be adequately secured for the rigours of an ocean voyage.

The losses have resulted from one or a combination of the following

- inadequacy of securing arrangements
- inappropriate combination of securing systems
- severely adverse weather and sea conditions.

Before looking at the various technical aspects associated with securing a cargo of deck-stowed pipes, the composition and vulnerabilities of the cargo should be studied.

Large-diameter pipes shipped by sea on deck are, in most cases, not simply pieces of break-bulk but are highly sensitive, even delicate, and valuable items.

The pipes are often manufactured from special high-alloy steel with great precision, are tested to withstand high pressures, have ends finished to comply with a specification (bevelled, threaded, etc.) and are usually coated internally and externally with varnish, paint or cement (Fig. 1).

Any damage to the ends or coating is likely to result in rejection of the pipe or high costs resulting from refurbishment.

As such, large diameter pipes are best stowed under deck, and nothing in this book should be interpreted as encouraging a decision in favour of the shipment of pipes on deck.

Fig. 1. Pipes are often high-value, precision-engineered items with special finishes

APPLICABLE REGULATIONS

When it is not possible to stow pipe cargoes under deck and they need to be carried on deck, they must be stowed longitudinally – similar to logs. One might therefore consider following the recommendations of the International Maritime Organization's (IMO) Code of Safe Practice for Ships Carrying Timber Deck Cargoes, 1991. However, one of the principles behind the securing of a timber deck cargo is that the lashings are satisfactory for normally expected conditions, but not strong enough to retain the cargo on board if it shifts. This principle cannot be used for stowage of pipes.

Code of Safe Practice for Cargo Stowage and Securing

The characteristics of pipes are vastly different from those of logs and stowages of pipes must be secured not as for timber but in accordance with the provisions of the IMO Code of Safe Practice for Cargo Stowage and Securing (CSS Code), particularly annex 13.

The CSS Code incorporates general principles for the safe stowage and securing of cargoes, definitions of terms in general use, some basic recommendations to be followed, and some guidance with regard to actions in heavy weather and when cargo has shifted. Annexes 1 to 12 contain guidance on the stowage and securing of particular types of cargoes and appendices 1 to 5 quote other resolutions and circulars to be considered.

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. Section 7 describes an 'advanced calculation method', which may be used to calculate the external forces acting upon cargo and then whether or not the chosen lashing materials and number of lashings to be fitted are sufficient.

Chapter 2

GUIDELINES ON STOWAGE AND SECURING

CHARACTERISTICS OF PIPES

The characteristics of pipes which need to be borne in mind when planning their stowage and securing are as follows

- pipes are relatively light
- pipes are round and may roll
- pipes have a low coefficient of friction
- pipes are hollow.

The first characteristic has a marked effect on the stability of the vessel and that in turn affects the transverse forces which act on the deck stowage when the vessel rolls in the seaway. When logs are carried both on and under deck, the resultant metacentric height (GM) is likely to be small and close to the lower limit. However, when pipes are stowed on deck and other, perhaps heavy, cargo – such as steel products – is stowed under-deck, this might give the vessel a large GM and a short roll period.

A stowage of pipes should be of a single size and type of pipes, the same diameter, length and finish, so as to produce a uniform block. If different sizes of pipe or with different coatings or end finishes are stowed together, the block will not be uniform, damage to the pipes may result and securing difficulties will be encountered.

The pipes must be provided with adequate and suitable dunnaging and packing materials to support and chock the pipes in the stowage, to increase the coefficient of friction where possible and to protect the ends and surfaces against damage resulting from abrasion between adjacent pipes and between securing arrangements and the pipes (Fig. 2).

Fig. 2. Pipe surfaces should be protected from securing devices by suitable dunnaging and packing materials

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 and loadings on the securing arrangements. This should be borne in mind during the voyage and particularly when adverse conditions are forecast.

The following warning given in the Timber Deck Cargo Code should always be remembered.

Warning

The lashings are not designed to provide a means of securing against imprudent ship handling in heavy weather.

BEFORE LOADING BEGINS

Before the stevedores can begin loading pipes, calculations must be carried out to determine how many pipes are to be loaded on top of the hatch covers and in how many tiers. The size – length, breadth and height – of the stowage can then be determined. Also, and of great importance, the weight of the stowage can be calculated.

The weight of the stowage – both in terms of the total weight of the stowage on the hatch covers and the tonnage per square metre – must not exceed the maximum permissible loading of the hatch covers. Sufficient load-spreading timber dunnage should be used appropriately to ensure the weight of the cargo is satisfactorily spread (Fig. 3).

Calculations should therefore be carried out in advance to ensure that there will be no overloading of the hatch covers, and to ensure that sufficient timber dunnage will be available for the construction of the stowage. Also, calculations for the necessary securing arrangements must be done to ensure that sufficient lashing materials are available to secure the stowage.

Fig. 3. Timber dunnage should be used to spread the load on hatch covers

STOWAGE OF PIPES

Pipes should be stowed as follows.

Advice for stowing pipes on deck
• Pipes should be stowed in the fore-and-aft line of the vessel 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 pipe and wedges should be inserted against the inboard and outboard bilge of each pipe, and nailed to the base timbers, to prevent rolling (Fig. 4).
• 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.
• Suitable packing material (timber, rubber matting, etc.) should be fitted in way of all securing arrangements at points of contact to minimise abrasion damage.
• 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.

Fig. 4. Timber wedges nailed to base timbers are required along both sides of every pipe to prevent rolling

SECURING OF PIPES

A stowage of pipes is usually made up of a large number of pipes stowed in tiers. However, when considering what securing arrangements are necessary, the block as a whole can be taken to be a single, large, heavy unit to be secured. Reference can therefore be made to annex 13 of the CSS Code and its advanced calculation method for guidance on and assessment of securing arrangements.

The advanced method is a calculation in four parts, to determine if the securing arrangements are sufficient to act against the external forces and keep the cargo from shifting. The four steps are as follows.

Advanced calculation method for 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.

Appendix I provides more details of the advance calculation method and Appendix II provides three worked examples.

Three alternative securing methods

Three alternative arrangements are recommended in this guide for the securing of a pipe stowage on deck. All three are designed to include elements that prevent transverse sliding, elements to compact the stowage (hold it down bodily) and elements to prevent longitudinal sliding, as required under the advanced calculation method. Transverse tipping is not a problem with such a stowage.

Securing alternative one

- Transverse sliding is prevented by a sufficient number of pairs of vertical half-loop lashings of wire rope of appropriate size set tight by port and starboard turnbuckles. The half-loops, 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 (Fig. 5). Suitable packing materials are used in way of the lashings.
- Compacting of the stowage 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. Friction-increasing material fitted between the tiers of pipes, for example rubber matting, is used to prevent sliding of upper-tier pipes.

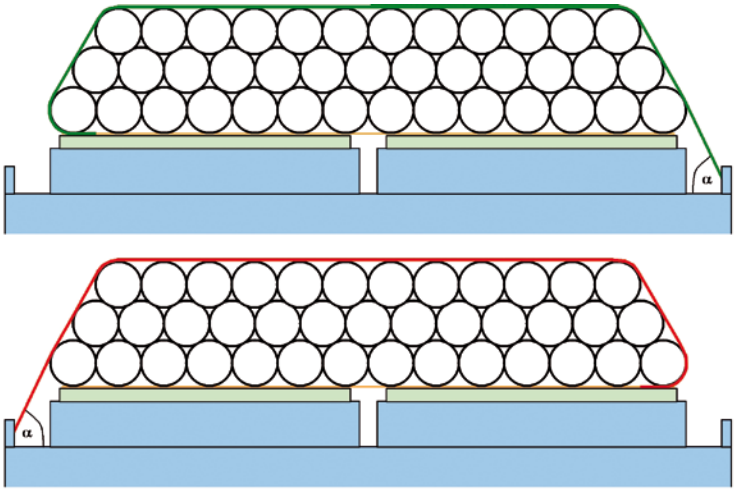


Fig. 5. Securing alternative one – pairs of vertical half-loops from both sides

Securing alternative two

- Transverse sliding is prevented by a sufficient number of pairs of horizontal half-loop lashings of wire rope of appropriate size set tight by port and starboard turnbuckles. The half-loops or 'spring lashings' are led longitudinally through individual pipes and down and inboard to securing points on the hatch top (Fig. 6). 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 in way of the lashings.
- Compacting of the stowage is achieved by an appropriate number of suitably spaced over-the-top or 'friction-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. Friction-increasing material fitted between the tiers of pipes, for example rubber matting, is used to prevent sliding of upper-tier pipes.

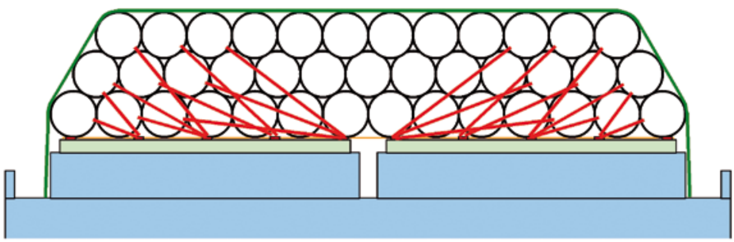


Fig. 6. Securing alternative two – horizontal half-loops on both sides (red) plus over-the-top compacting lashings (green)

Securing alternative three

- 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 (Fig. 7).
- Compacting of the stowage is achieved by an appropriate number of suitably spaced over-the-top or 'friction-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. Friction-increasing material fitted between the tiers of pipes, for example rubber matting, is used to prevent sliding of upper-tier pipes.

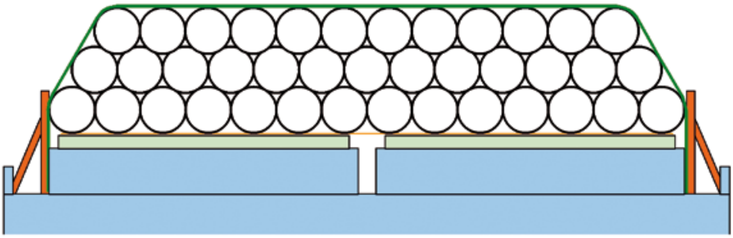


Fig. 7. Securing alternative three – solid stanchions each side plus over-the-top compacting lashings (green)

The elements of each alternative method provide a complete system for securing a stowage.

Warning

The elements of one method must not be mixed or combined with those of another because the result is likely to be an inefficient system which does not provide sufficient strength to act against the external forces encountered during the voyage.

One of the alternatives must be chosen and used in its entirety. In alternatives one and two, wire rope is used to prevent transverse sliding, whereas in alternative three, side stanchions with buttresses are employed. These systems must not be mixed because the flexibility and elasticity characteristics of wire rope lashings are completely different from those of stanchions, which are essentially rigid structures.

WORKED EXAMPLES

Application and assessment of the three securing alternatives can be demonstrated through worked examples involving a typical cargo of large pipes stowed on deck.

The cargo consists of 39 individual steel pipes in a stack of three tiers of 14, 13 and 12 pipes (as in Figs 5–7). Each pipe is of length 12 m, outside diameter 2 m and weight 10 t. The overall stowage is thus 12 m long, 28 m wide, 5.5 m high and 390 t in weight. The pipes are stowed on timber dunnage on the forward end of the number two hatch cover, and anti-slip rubber matting is used as packing between the pipes in upper tiers.

Three alternative securing arrangements are devised for the stowage, which can be summarised as follows.

Example securing arrangements

Securing alternative one

- ten vertical half-loop lashings each side, port and starboard, of 20 mm wire rope
- steel-bar stoppers welded next to bottom-tier pipe ends, forward and aft.

Securing alternative two

- ten horizontal half-loop lashings each side, port and starboard, of 18 mm wire rope
- four over-the-top lashings of 18 mm wire rope
- steel-bar stoppers welded next to bottom-tier pipe ends, forward and aft.

Securing alternative three

- four steel stanchions each side
- six over-the-top lashings, port and starboard, of 20 mm wire rope
- steel-bar stoppers welded next to bottom-tier pipe ends, forward and aft.

Appendix II shows how the advanced calculation method can be used to assess all three alternatives. In each case the chosen securing arrangements are demonstrated to have sufficient strength to exceed the likely external forces and thus prevent the cargo from shifting.

Additional factors

In deciding on which securing method to use, additional factors need to be considered.

Elongation of wire lashings

The stretching or elongation of wire rope lashings is always a problem – and more of a problem the longer the lashing. The wires used on pipe stowages can be particularly long so that noticeable elongation is inevitable. This can result in a serious shift of the stowage if left unattended.

For securing alternative one, each vertical half-loop lashing has a length of about $L = 42$m. The effective modulus of elasticity of the wire rope used in the example is about $E = 70$ kN/mm^2, related to its metallic cross-section. The 20 mm wire rope has a metallic cross-section area of $A = 157$ mm^2. All lashings are tightened to a pre-tension of $F = 30$ kN using the turnbuckles. The wire will stretch elastically as follows.

Lashing pre-tension stretch in securing alternative one

$$\Delta L = \frac{L \times F}{A \times E} = \frac{42 \times 30}{157 \times 70} = 0.115 \text{ m (115 mm)}$$

If the tension in the wires increases to about 60 kN as the vessel rolls heavily to port and to starboard, the wires will stretch by a further 115 mm and, if it were permitted to occur, would allow the whole block to shift sideways by about half that distance, that is 60 mm. However, without a slight shift of the block, the wires would not assume any load above the pre-tension. On the other hand, the total shift of the block of pipes to port and to starboard during heavy rolling would be proportional to the elongation of the wire lashing, assuming lashings are not tended during the voyage (which they must be).

For securing alternative two, the horizontal half-loop lashings have an average length of about L = 24 m. The effective modulus of elasticity is again about E = 70 kN/mm^2 and the 18 mm wire rope has a metallic cross-section of A = 127 mm^2. With the same pre-tension of F = 30 kN, the wires will stretch as follows.

Lashing pre-tension stretch in securing alternative two

$$\Delta L = \frac{L \times F}{A \times E} = \frac{24 \times 30}{127 \times 70} = 0.081 \text{ m } (81 \text{ mm})$$

If the tension in the wires again increases to about 60 kN as the vessel rolls, the wires will stretch by a further 81 mm, which would allow the whole block to shift sideways by about half that distance – around 40 mm – if the lashings are not tended during the voyage.

It is thus essential to ensure that the lashings are made up correctly and tightened at the beginning of the voyage and then at frequent, regular intervals as necessary throughout the voyage – particularly if they are new wires, which are prone to a permanent ‘construction stretch’ of up to 1% as well as elastic stretch.

Regular adjustments of the turnbuckles, or adjustment of the lashings themselves if the turnbuckle thread is insufficient, will ensure the tension remains adequate to prevent any significant movement of the stowage as the vessel rolls.

Fig. 8. This stowage incorrectly combines securing alternatives two and three, but the horizontal half-loop lashings are effectively redundant as the stanchions prevent them stretching sufficiently to carry any appreciable load

Damage to wires

With alternative two, problems might develop at the pipe ends where the wires turn through nearly 90º and as a result of the sawing effect of the wire stretching and contracting.

Both the pipe edge protectors and the wires should be examined for wear and should be replaced if significant wastage is found.

Strength of fittings

For alternative three, the transverse motion of the block of pipes is close to zero because the side stanchions are solid structures. The fitting of any additional half-loop lashings, as used in alternatives one and two, would therefore be useless because they would never stretch sufficiently to take any appreciable load (Fig. 8). Hence, it is of utmost importance that the stanchions, together with the share contributed by friction of the timber battens on the hatch top, are strong enough to keep the block in place.

The over-the-top friction loops cannot be included in the balance-of-forces calculations although they certainly contribute by increasing the friction at the base of the stowage, so long as they remain tensioned, and they will keep the top layers of pipes in place. They are therefore essential components.

SUMMARY

The three alternative securing methods give different ways of securing the block stowage of pipes in the athwartships and fore and aft line. All 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.

Wires of differing length will elongate by different amounts under the same loading and therefore are incompatible for lashing purposes. Stanchions are solid structures and must have sufficient strength to prevent movement of the block of pipes and act against the external accelerations without any transverse wire lashings being fitted.

Chapter 3

OTHER CONSIDERATIONS

The correct stowage of pipes requires extensive knowledge and experience, whereas the scope of this guide can cover only some general aspects. It is therefore recommended that expert advice is obtained.

Advanced planning of the stowage involving all interested parties – owner, master, crew, charterer, shipper and stevedores – is essential to achieve a successful outcome.

ENSURING A COMPACT BLOCK

The assumption that the stacked pipes may be treated as one compact block of cargo is only justified if all the pipes have good contact with each other. Pipes within the stack should have six lines of contact with adjacent pipes. Pipes in the bottom tier will have only five, and pipes at the top and the sides only four such lines of contact (Fig. 9). Pipes at the upper and lower corners of the stack, although having only three lines of contact, are held into the stack by the pressure of lashings.

However, there may be several factors that might prevent good contact between adjacent pipes, as follows.

- Pipes are not always 100% straight, but may have a slight curve. Thus, contact at the ends may produce space in the middle or vice versa.
- Pipes may be shipped with so-called 'spacers' made of synthetic fibre rope wrapped around the pipe at intervals of a few metres. The spacers may be compressed during rolling and may result in slackness in the stack of pipes.
- Wedges may be pre-fitted on the bottom dunnage by means of templates. This may lead to inaccuracies in the stowage of pipes as a result of small differences in the sizes of pipes.
- Rubber mats should be used between the pipes to increase friction and should be fitted at all lines of contact. However, if synthetic fibre rope spacers are attached to the pipes, the rubber mats may be ineffective if they are thinner than the ropes.

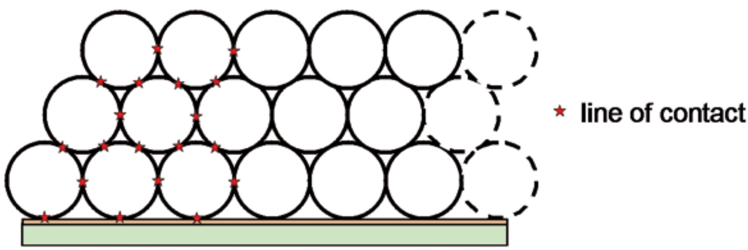


Fig. 9. Pipes can only be considered as a single stowage if they have complete lines of contact with each other

PROTECTION OF PIPES

Pipes are often shipped with bevel edge protectors (Fig. 10). These might be made of steel, aluminium or plastic material, and must not be damaged or removed.

If pipes are coated on their outside surfaces, dunnage in the form of so-called chicken-ladders must be used in all wire-contact areas. These chicken-ladders are made of short lengths softwood boards connected to each other by tacked-on lengths of fibre ropes or plastic tapes to produce a ladder of sufficient length.

If lashings are passed through pipes, as in securing alternative two, pipe-edge protectors must be used. These can be obtained ready-made, of steel or aluminium, with bulges for guiding the wire (Fig. 11). If the pipes are coated inside, such as with a special 'flow-coat' for use in the gas industry, direct contact of the wires to the pipes must be avoided by the use of slipped-on pieces of rubber hose.

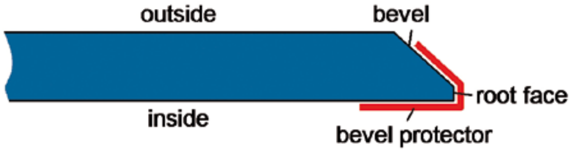


Fig. 10. Cross-section of bevel edge protector, which must not be damaged or removed

Fig. 11. Pipe edge protectors and rubber-hose sheaths should be used with horizontal half-loop lashings

Most pipes are welded with a longitudinal seam. Shippers usually require stowage with the seam in the 12 o'clock position in order to avoid chafing damage with other pipes. Sometimes pipes are shipped with a spiral seam. For those, only spacers can prevent contact and associated chaffage.

CONSTRUCTION OF STANCHIONS

There are a number of alternatives for the construction of suitable stanchions. The cost of stanchions is considerable but, if shipments of pipes are to be carried often, the cost of constructing re-usable fittings may be justified.

Two different concepts are presented.

Stanchion concept one

This is in some ways similar to that used on smaller vessels for timber deck cargoes. It consists of cantilevered stanchions made up from short lengths of steel I-beams, which are vertically inserted into two steel lugs on the hatch cover sides or coamings and chocked with timber (Fig. 12).

The cantilever arrangement requires the strength of the upper lug to be the desired MSL × h / (h – d), as indicated in Fig. 13.

The section modulus of the beam needs to resist a bending moment MSL × d with a bending stress of not more than about 200 N/mm^2.

Stanchion concept two

This arrangement may be applied if the hatch covers or coaming do not permit the welding of lugs.

It consists of buttressed stanchions made up from short lengths of steel I-beams, of smaller section than concept one, with the bases of the stanchions and buttresses bolted to the deck.

The buttress must be attached to the upper part of the stanchion by way of a bolted connection sufficiently strong to support the transverse load.

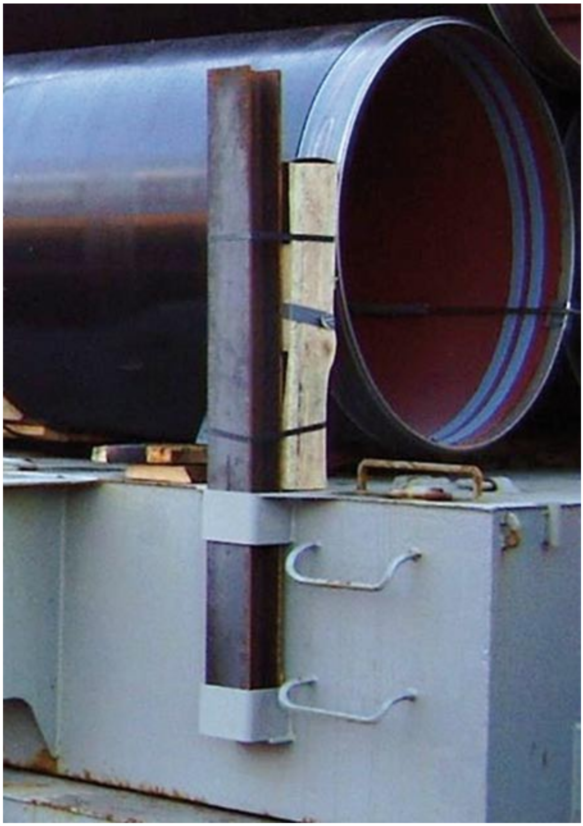


Fig. 12. Stanchion concept one – short lengths of steel I-beams are inserted into steel lugs welded to the hatch-cover sides or coamings

The dimensions of the stanchion and the buttress as well as the pedestals on deck must be able to withstand the tension and compression forces shown in Fig. 14. There is no significant bending moment in this concept, but the buttress must resist buckling.

CARE OF THE SECURING ARRANGEMENTS

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 as discussed above. Bearing these factors in mind, it is recommended that the lashings be set up and tended as follows.

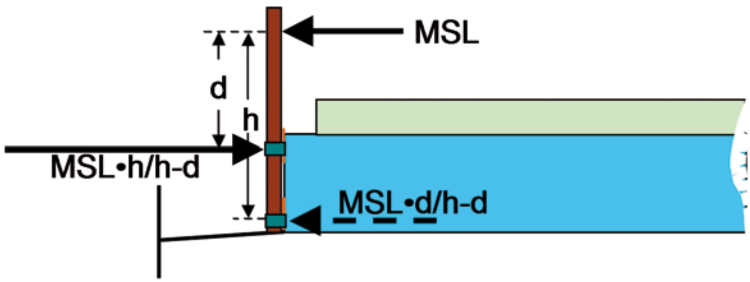


Fig. 13. Layout and force calculations for stanchion concept one

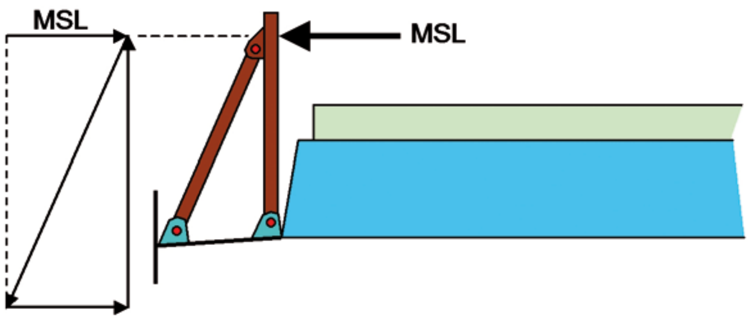


Fig. 14. Layout and force diagram for stanchion concept two

Advice for set up and tending of 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 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.

Appendix I

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 from annex 13 of the CSS Code 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 method is a calculation in four parts to determine if the securing arrangements are sufficient to act against the external forces and keep the cargo from shifting. The four steps are as follows.

Advanced calculation method

- *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.

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

Calculation of external forces (step two)

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

Where

- F = longitudinal ($_x$), transverse ($_y$), and vertical ($_z$), force as appropriate
- m = mass of cargo unit in t
- a = longitudinal ($_x$), transverse ($_y$), and vertical ($_z$), accelerations (from CSS Code 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.

Steps three and four may be combined by using the balance calculations, as follows.

Balance calculations (steps three and four)	
Transverse sliding:	$F_y \leq \mu \cdot m \cdot g + CS_1 \cdot f_1 + CS_2 \cdot f_2 + \ldots + CS_n \cdot f_n$
Transverse tipping:	$F_y \cdot a \leq b \cdot m \cdot g + CS_1 \cdot c_1 + CS_2 \cdot c_2 + \ldots + CS_n \cdot c_n$
Longitudinal sliding:	$F_x \leq \mu \cdot (m \cdot g - F_z) + CS_1 \cdot f_1 + CS_2 \cdot f_2 + \ldots + CS_n \cdot f_n$

A worked example of an advanced calculation method is described in North of England's loss prevention guide *Cargo Stowage and Securing – A Guide to Good Practice*.

Worked examples for the three securing alternatives for a deck-stowed cargo of pipes appear in the Appendix II of this guide.

Appendix II

VERIFICATION OF SECURING ALTERNATIVES FOR DECK-STOWED PIPES – WORKED EXAMPLES

A deck-stowed cargo of pipes consists of 39 individual steel pipes in a stack of three tiers of 14, 13 and 12 pipes (Fig. 5). Each pipe is of length 12 m, outside diameter 2 m and weight 10 t. Thus the overall stowage is of length 12 m, width 28 m, measured height 5.5 m and total weight 390 t.

The pipes are stowed on timber dunnage, such that the coefficient of friction at the base is 0.3. Packing material between the pipes in upper tiers is anti-slip rubber matting and gives a coefficient of friction of 0.6. The stowage is on the forward end of number two hatch covers and therefore the longitudinal position is 80% of the ship's length.

Three different securing arrangements are devised in accordance with the recommended methods set out in Chapter 2. These then need to be assessed according to the advance calculation method set out in annex 13 of the CSS Code.

The first two steps of the advanced calculation are common to all three arrangements, as follows.

STEP ONE – Inputs and primary calculations			
SHIP		**CARGO**	
Length (m)	180	Width (m)	28
Breadth, *B* (m)	32.2	Length (m)	12
GM (m)	3.2	Height (m)	5.5
Speed (knots)	15	Mass, *m* (t)	390
B / GM	10	Longitudinal position (m)	0.8
Table 3 correction: T3	0.68	Vertical position (m)	4
Table 4 correction: T4	1.19	Friction, μ	0.3 / 0.6
Longitudinal acceleration – Table 2, $\boldsymbol{a}_x$ (m/s^2)	3.8	Lever arm of tipping, *a* (m)	-
Transverse acceleration – Table 2, $\boldsymbol{a}_y$ (m/s^2)	7.1	Lever arm of stableness, *b* port (m)	-
Vertical acceleration – Table 2 $\boldsymbol{a}_z$ (m/s^2)	7.6	Lever arm of stableness, *b* starboard (m)	-
		Wind load longitudinal $\boldsymbol{F}_{w(x)}$ (kN)	0
Longitudinal acceleration corrected $\boldsymbol{a}_x$ (m/s^2)	2.58	Wind load transverse $\boldsymbol{F}_{w(y)}$ (kN)	66
Transverse acceleration corrected $\boldsymbol{a}_y$ (m/s^2)	5.75	Sea slosh longitudinal $\boldsymbol{F}_{s(x)}$ (kN)	0
Vertical acceleration corrected $\boldsymbol{a}_z$ (m/s^2)	5.17	Sea slosh transverse $\boldsymbol{F}_{s(y)}$ (kN)	24

STEP TWO – External forces and moments				
Longitudinal sliding (kN)	$\boldsymbol{F}_x = m \cdot \boldsymbol{a}_x + \boldsymbol{F}_{w(x)} + \boldsymbol{F}_{s(x)}$	390 × 2.58 + 0 + 0	=	1006
Transverse sliding (kN)	$\boldsymbol{F}_y = m \cdot \boldsymbol{a}_y + \boldsymbol{F}_{w(y)} + \boldsymbol{F}_{s(y)}$	390 × 5.75 + 66 + 24	=	2333
Transverse tipping (kN m)	$\boldsymbol{F}_y \cdot a$	N/A		
Vertical (kN)	$\boldsymbol{F}_z = m \cdot \boldsymbol{a}_z$	390 × 5.17	=	2016

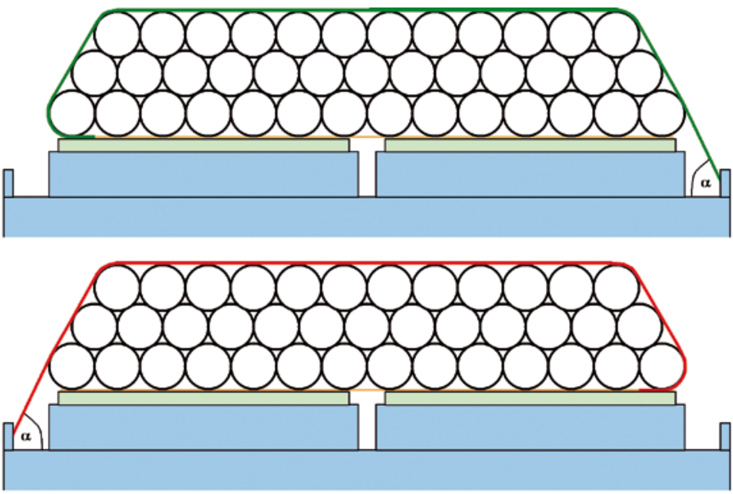
SECURING ALTERNATIVE ONE

A total of 10 wire-rope vertical half-loop lashings are rigged to port and 10 to starboard at appropriate separations. Each 20 mm diameter lashing is secured to a hatch cover D-ring via a shackle, and to a deck D-ring via a turnbuckle and shackle, and has bulldog grip eyes. Sections of steel bar are also welded close forward and aft of each pipe in the bottom tier to prevent longitudinal sliding. These stoppers, at each end, have a total welded seam length of about 2 m, each seam being a single 4 mm thick weld run and having a MSL of 400 kN/m, giving the stoppers a total MSL of 800 kN/m or 80 t. Each stopper is provided with timber packing to chock the pipe end.

Securing devices and strengths (alternative one)		
Component	*Breaking strength*	*Maximum securing load (MSL)*
Wire 20 mm diameter 6 x 19 + 1FC (vertical half-loops)	18 t	80% = 14.4 t
Wire bulldog grip eyes	18 t	70% = 12.6 t
Shackles – large D-type	28 t	50% = 14 t
Turnbuckles	30 t	50% = 15 t
D-rings	30 t	50% = 15 t
Welded stoppers with welded seams of 2 m		80 t

The governing (weakest) components in the securing arrangement are the eyes in the vertical half-loops formed with bulldog grips (see table above) and thus each lashing may be considered to have a MSL of 12.6 t, or 126 kN for the purpose of the calculation. A safety factor is then applied to the MSL to give the 'calculated strength', given by $CS = \text{MSL} / 1.5$ (this is achieved in the calculation by multiplying by a factor of 0.67).

At one side of the stowage, where it is secured to the deck, each lashing has an angle (α) of 65° to the horizontal whereas at the other, where it is secured to the hatch top, each has an angle (α) of 0°. For the purposes of the calculation, the lashings can be considered to comprise two lashings of 1260 kN (10 × 126), one at 65° and one at 0°. From CSS Code Table 6, the *f* values are 0.69 and 1 respectively.



STEP THREE – Friction and lashings (alternative one)												
Port side	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**		
MSL (kN)	1260	1260										
Lashing angle, α (°)	65	0										
f value – Table 6	0.69	1										
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)	582	844									Σ(sum)	1426
CS·*c* (MSL × safety factor × *f*) (kN)	-	-									Σ(sum)	-
Starboard side	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**		
MSL (kN)	1260	1260										
Lashing angle, α (°)	65	0										
f value – Table 6	0.69	1										
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)	582	844									Σ(sum)	1426
CS·*c* (MSL × safety factor × *f*) (kN)	-	-									Σ(sum)	-
Longitudinal forward	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**		
MSL (kN)	800											
Lashing angle, α (°)	0											
f value – Table 6	1											
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	1											
Corrected ***CS***·*f* (MSL × safety factor × *f* × longitudinal component proportion) (kN)	536										Σ(sum)	536
Longitudinal aft	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**		
MSL (kN)	800											
Lashing angle, α (°)	0											
f value – Table 6	1											
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	1											
Corrected ***CS***·*f* (MSL × safety factor × *f* × longitudinal component proportion) (kN)	536										Σ(sum)	536

STEP FOUR – Anti-movement forces and moments, and balance assessment (alternative one)											External forces and moments	Balanced (Yes/No)?
Transverse sliding port (kN)	$\mu \cdot m \cdot \mathbf{g} + \Sigma \mathbf{CS} \cdot f$	0.3	×	390	×	9.81	+	1426	=	2574	2333	Yes
Transverse sliding starboard (kN)	$\mu \cdot m \cdot \mathbf{g} + \Sigma \mathbf{CS} \cdot f$	0.3	×	390	×	9.81	+	1426	=	2574	2333	Yes
Transverse tipping port (kN m)	$b \cdot m \cdot \mathbf{g} + \Sigma \mathbf{CS} \cdot c$											N/A
Transverse tipping starboard (kN m)	$b \cdot m \cdot \mathbf{g} + \Sigma \mathbf{CS} \cdot c$											N/A
Longitudinal sliding forward (kN)	$\mu \cdot (m \cdot \mathbf{g} - \mathbf{F}_z) + \Sigma \mathbf{CS} \cdot f$	0.3	(390	×	9.81	–	2016)	+ 536	=	1079	1006	Yes
Longitudinal sliding aft (kN)	$\mu \cdot (m \cdot \mathbf{g} - \mathbf{F}_z) + \Sigma \mathbf{CS} \cdot f$	0.3	(390	×	9.81	–	2016)	+ 536	=	1079	1006	Yes

The final step is to consider longitudinal sliding of the upper tiers (see page 28).

SECURING ALTERNATIVE TWO

A total of 10 wire-rope horizontal half-loops are rigged to port and 10 to starboard in the fore and aft line through individual pipes. Each 18 mm diameter lashing is led down and inboard and attached via turnbuckles and shackles to D-rings welded to the hatch top, and has bulldog-grip eyes.

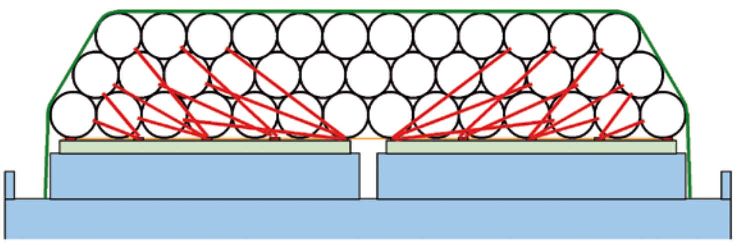
Four over-the-top wire lashings are fitted to compact the stowage but they do not contribute to the security of the stowage and are not included in the calculations.

Sections of steel bar are also welded close forward and aft of each pipe in the bottom tier to prevent longitudinal sliding. These stoppers, at each end, have a total welded seam length of about 2 m, each seam being a single 4 mm thick weld run having a MSL of 400 kN/m, giving the stoppers a total MSL of 80 t. Each stopper is provided with timber packing to chock the pipe end.

Securing devices and strengths (alternative two)		
Component	*Breaking strength*	*Maximum securing load (MSL)*
Wire 18 mm diameter 6 x 19 + 1FC (horizontal half-loops)	14 t	80% = 11.2t
Wire bulldog grip eyes	14 t	70% = 9.8t
Shackles – large D-type	28 t	50% = 14 t
Turnbuckles	30 t	50% = 15 t
D-rings	30 t	50% = 15 t
Welded stoppers with welded seams of 2 m		80 t

The governing (weakest) components in the securing arrangement are the eyes in the horizontal half-loops formed with bulldog grips (see table above) and thus each lashing may be considered to have an MSL of 9.8 t, or 98 kN for the purpose of the calculation. A safety factor is then applied to the MSL to give the 'calculated strength', given by by CS = MSL / 1.5 (this is achieved in the calculation by multiplying by a factor of 0.67).

Four horizontal half-loop lashings at each side of the stowage make an angle (α) of 45° while the other six make an angle (α) of about 20° to the horizontal. Because wires are rigged in horizontal loops, each wire has the effect of two lashings for calculation purposes. For the purposes of the calculations the lashings can be considered to comprise two lashings, one of 784 kN (4 x 2 x 98) at 45° and one of 1176 kN (6 × 2 × 98) at 20°. From CSS Code Table 6, the *f* values are 0.92 and 1.04 respectively.



STEP THREE – Friction and lashings (alternative two)												
Port side	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**		
MSL (kN)	784	1176										
Lashing angle, α (°)	45	20										
f value – Table 6	0.92	1.04										
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)	483	819									Σ(sum)	1302
CS·*c* (MSL × safety factor × *f*) (kN)	-	-									Σ(sum)	-
Starboard side	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**		
MSL (kN)	784	1176										
Lashing angle, α (°)	45	20										
f value – Table 6	0.92	1.04										
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)	483	819									Σ(sum)	1302
CS·*c* (MSL × safety factor × *f*) (kN)	-	-									Σ(sum)	-
Longitudinal forward	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**		
MSL (kN)	800											
Lashing angle, α (°)	0											
f value – Table 6	1											
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	1											
Corrected ***CS***·*f* (MSL x safety factor x *f* x longitudinal component proportion) (kN)	536										Σ(sum)	536
Longitudinal aft	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**		
MSL (kN)	800											
Lashing angle, α (°)	0											
f value – Table 6	1											
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	1											
Corrected ***CS***·*f* (MSL × safety factor × *f* × longitudinal component proportion) (kN)	536										Σ(sum)	536

STEP FOUR – Anti-movement forces and moments, and balance assessment (alternative two)											External forces and moments	Balanced (Yes/No)?
Transverse sliding port (kN)	$\mu \cdot m \cdot \boldsymbol{g} + \Sigma \boldsymbol{CS} \cdot f$	0.3	×	390	×	9.81	+	1302	=	2450	2333	Yes
Transverse sliding starboard (kN)	$\mu \cdot m \cdot \boldsymbol{g} + \Sigma \boldsymbol{CS} \cdot f$	0.3	×	390	×	9.81	+	1302	=	2450	2333	Yes
Transverse tipping port (kN m)	$b \cdot m \cdot \boldsymbol{g} + \Sigma \boldsymbol{CS} \cdot c$											N/A
Transverse tipping starboard (kN m)	$b \cdot m \cdot \boldsymbol{g} + \Sigma \boldsymbol{CS} \cdot c$											N/A
Longitudinal sliding forward (kN)	$\mu \cdot (m \cdot \boldsymbol{g} - \boldsymbol{F}_z) + \Sigma \boldsymbol{CS} \cdot f$	0.3	(390	×	9.81	–	2016)	+ 536	=	1079	1006	Yes
Longitudinal sliding aft (kN)	$\mu \cdot (m \cdot \boldsymbol{g} - \boldsymbol{F}_z) + \Sigma \boldsymbol{CS} \cdot f$	0.3	(390	×	9.81	–	2016)	+ 536	=	1079	1006	Yes

The final step is to consider longitudinal sliding of the upper tiers (see page 28).

SECURING ALTERNATIVE THREE

Four steel stanchions of solid construction are bolted or welded to the deck and supported by strong steel buttresses, and fitted with equal separation to both sides, port and starboard, of the hatchway. Each stanchion has an MSL of 50 t or 500 kN for the purpose of the calculations.

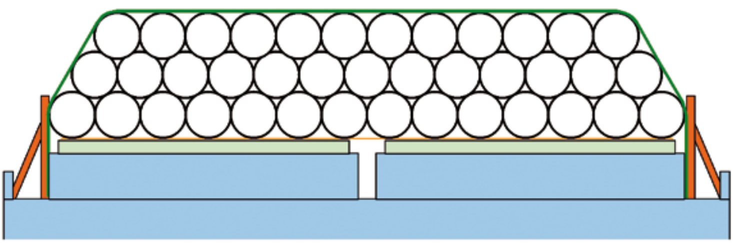
The contact areas between the stanchions and the outer bottom-tier pipes are lined with timber to reduce local pressure and minimise abrasion.

Six over-the-top wire lashings are fitted to compact the stowage but they do not contribute to the security of the stowage and are not included in the calculation.

Sections of steel bar are also welded close forward and aft of each pipe in the bottom tier to prevent longitudinal sliding. These stoppers, at each end, have a total welded seam length of about 2 m, each seam being a single 4 mm thick weld run and having a MSL of 400 kN/m, giving the stoppers a total MSL of 80 t. Each stopper is provided with timber packing to chock the pipe end.

Securing devices and strengths (alternative three)	
Component	*Maximum securing load (MSL)*
Steel construction stanchions	50 t
Welded stoppers with welded seams of 2 m	80 t

The governing (weakest) components in the securing arrangement are the stanchions (see table above). A safety factor is then applied to the stanchion MSL to give the 'calculated strength', given by CS = MSL / 1.5 (this is achieved in the calculation by multiplying by 0.67).



STEP THREE – Friction and lashings (alternative three)												
Port side	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**		
MSL (kN)	500	500	500	500								
Lashing angle, α (°)	0	0	0	0								
f value – Table 6	1	1	1	1								
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)	335	335	335	335							Σ(sum)	1340
CS·*c* (MSL x safety factor × *f*) (kN)	-	-									Σ(sum)	-
Starboard side	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**		
MSL (kN)	500	500	500	500								
Lashing angle, α (°)	0	0	0	0								
f value – Table 6	1	1	1	1								
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)	335	335	335	335							Σ(sum)	1340
CS·*c* (MSL × safety factor × *f*) (kN)	-	-									Σ(sum)	-
Longitudinal forward	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**		
MSL (kN)	800											
Lashing angle, α (°)	0											
f value – Table 6	1											
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	1											
Corrected ***CS***·*f* (MSL × safety factor × *f* × longitudinal component proportion) (kN)	536										Σ(sum)	536
Longitudinal aft	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**		
MSL (kN)	800											
Lashing angle, α (°)	0											
f value – Table 6	1											
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	1											
Corrected ***CS***·*f* (MSL × safety factor × *f* × longitudinal component proportion) (kN)	536										Σ(sum)	536

STEP FOUR – Anti-movement forces and moments, and balance assessment (alternative three)											**External forces and moments**	**Balanced (Yes/No)?**
Transverse sliding port (kN)	$\mu \cdot m \cdot \boldsymbol{g} + \Sigma \boldsymbol{CS} \cdot f$	0.3	×	390	×	9.81	+	1340	=	2488	2333	Yes
Transverse sliding starboard (kN)	$\mu \cdot m \cdot \boldsymbol{g} + \Sigma \boldsymbol{CS} \cdot f$	0.3	×	390	×	9.81	+	1340	=	2488	2333	Yes
Transverse tipping port (kN m)	$b \cdot m \cdot \boldsymbol{g} + \Sigma \boldsymbol{CS} \cdot c$											N/A
Transverse tipping starboard (kN m)	$b \cdot m \cdot \boldsymbol{g} + \Sigma \boldsymbol{CS} \cdot c$											N/A
Longitudinal sliding forward (kN)	$\mu \cdot (m \cdot \boldsymbol{g} - \boldsymbol{F}_z) + \Sigma \boldsymbol{CS} \cdot f$	0.3	(390	×	9.81	–	2016)	+ 536	=	1079	1006	Yes
Longitudinal sliding aft (kN)	$\mu \cdot (m \cdot \boldsymbol{g} - \boldsymbol{F}_z) + \Sigma \boldsymbol{CS} \cdot f$	0.3	(390	×	9.81	–	2016)	+ 536	=	1079	1006	Yes

The final step is to consider longitudinal sliding of the upper tiers (see page 28).

LONGITUDINAL SLIDING OF UPPER TWO TIERS

The final check for all three alternative securing arrangements is to check the longitudinal sliding of the upper two tiers of 12 and 13 pipes, which weigh a total of 250 t (10 × (12 + 13)).

With friction-increasing rubber matting between the pipes in each tier and with the compressive nature of the lashings used in all three alternative arrangements, it is assumed the friction coefficient is 0.6.

STEP TWO – External forces and moments (top two tiers)				
Longitudinal sliding (kN)	$\boldsymbol{F}_x = m \cdot \boldsymbol{a}_x + \boldsymbol{F}_{w(x)} + \boldsymbol{F}_{s(x)}$	250 × 2.58 + 0 + 0	=	645
Vertical (kN)	$\boldsymbol{F}_z = m \cdot \boldsymbol{a}_z$	250 × 5.17	=	1293

STEP FOUR – Anti-movement force, and balance assessment (top two tiers)											External force	Balanced (Yes/No)?
Longitudinal sliding forward and aft (kN)	$\mu \cdot (m \cdot \boldsymbol{g} - \boldsymbol{F}_z)$	0.6	(250	×	9.81	–	1293)	+ 0.0	=	696	645	Yes

CONCLUSION

All three alternative securing arrangements, including the friction-increasing matting used for the upper two tiers, provide an effective combination of friction and lashings that exceed the likely external transverse and longitudinal sliding forces.

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DECK STOWAGE AND SECURING OF PIPES

by CHARLES BLIAULT, HERMANN KAPS
and North of England P&I Association

Large-diameter pipes for today's sophisticated energy and water industries are now expensive, precision-engineered pieces of cargo that need to be handled with utmost care. Given their often substantial size and relatively low weight they tend to be carried on the decks of cargo ships rather than in the holds, which exposes shipowners to considerably higher risk from damage and loss claims. The main causes of such claims are inadequate or inappropriate stowage and securing, which this guide sets out to address. It describes how best to stow pipes on deck, provides details of three recommended securing methods, explains why these methods must not be combined and stresses the importance of regularly tending to securing arrangements during the voyage. It also provides worked examples showing how all three securing methods can be properly verified using the advanced calculation method from the IMO Code of Safe Practice for Cargo Stowage and Securing. The guide is intended to be used in conjunction with Cargo Stowage and Securing – A Guide to Good Practice, also by Charles Bliault.

Charles Bliault (left) is an extra master who was at sea with Cunard for 13 years. He progressed from cadet to chief officer, serving on a wide range ships – including general and refrigerated cargo liners, bulk carriers and container vessels – carrying all types of dry cargo. He joined Brookes Bell in 1983 and became a partner of the firm in 1994. His work as a surveyor and consultant includes the carriage of all types of steel and concrete pipes as well as most other types of cargoes. general cargoes, steel products, forest products, containers and ro-ro items. Having witnessed the extensive damage and injuries that can result from poor or inappropriate stowage and securing, he has a keen interest in promoting safe practice in all aspects of cargo handling and carriage.

Hermann Kaps (right) is an internationally recognised authority on all aspects of project cargo and tanker shipping. He spent 13 years at sea with Hansa-Line in Bremen, Germany, progressing to chief officer. In 1970 he joined the former Hochschule für Nautik in Bremen, where he lectured in cargo technology, ship stability and emergency management until 2004, and was also visiting professor at the World Maritime University in Malmö, Sweden. From 1985 to 2002 he advised the German delegation to the International Maritime Organization in London, during which time he also chaired the working group for the Code of Safe Practice for Cargo Stowage and Securing Code. Annex 13 to the code, which covers assessment of non-standard securing arrangements, is based on his initiative.

North of England P&I Association, with offices in the UK, Hong Kong, Greece and Singapore, is one of the leading international mutual marine liability insurers with over 90 million GT of entered tonnage. The Association has developed a world-wide reputation for the quality and diversity of its loss-prevention initiatives, which include this series of loss prevention guides co-authored with leading industry experts.

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