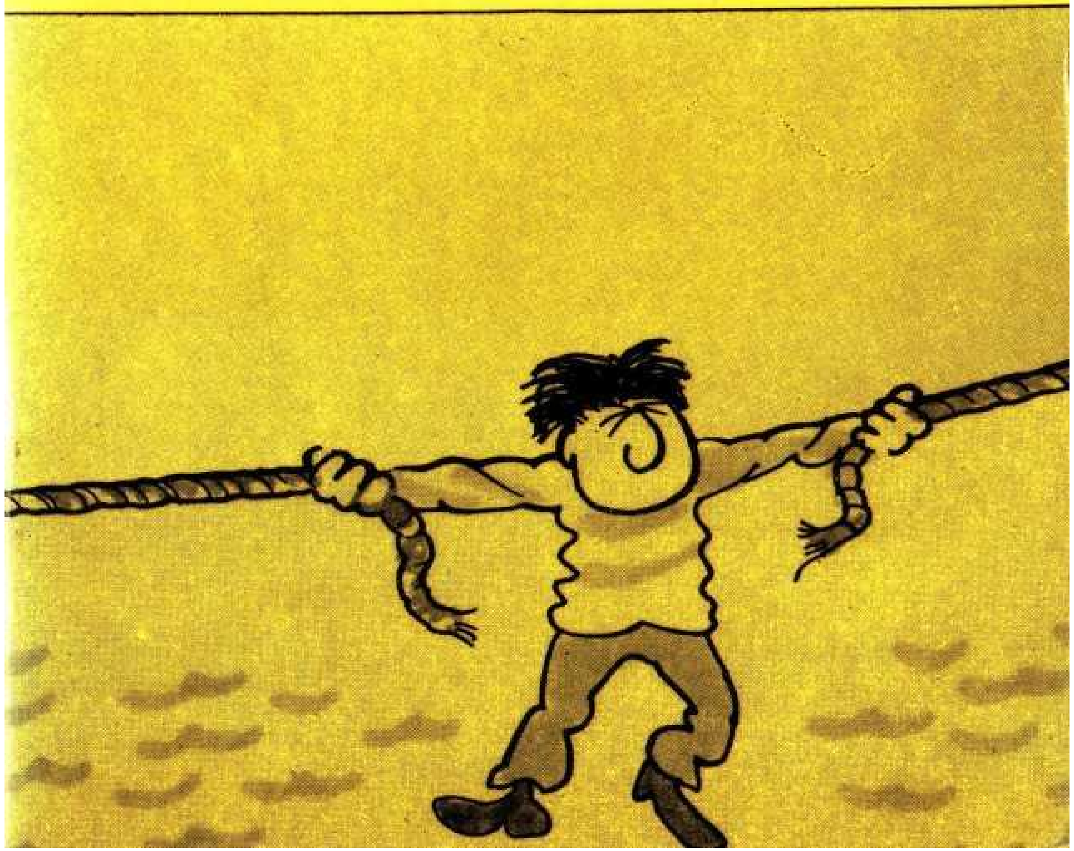
Oil Companies International Marine Forum

Effective Mooring



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Oil Companies International Marine Forum

Effective Mooring

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The Oil Companies International Marine Forum (OCIMF) is a voluntary association of oil companies having an interest in the shipment and terminalling of crude oil and oil products. OCIMF is organised to represent its membership before, and consult with, the International Maritime Organization (IMO) and other government bodies on matters relating to the shipment and terminalling of crude oil and oil products, including marine pollution and safety.

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FOREWORD

This booklet is derived from one entitled "Effective Mooring" which was originally published by Shell International Marine in 1976. The aim of the Shell booklet was to complement technical publications and rules and regulations with a publication that was deliberately written in such a style as to communicate effectively with seafarers at all levels. Experience over the past ten years has shown that "Effective Mooring" was successful in putting across its message and therefore the same general format is retained in this version of the booklet.

The emphasis in this booklet is on SAFETY. Its intention is that shipboard staff be made more aware of the hazards associated with mooring equipment and mooring operations by having a better understanding of the subject. A summary of the personal safety items mentioned in the text is given in Chapter 7.

This booklet is designed to be self-contained; however, readers who are interested in obtaining more detailed technical information should refer to other OCIMF documents dealing with mooring.

Although this booklet has been written primarily with oil and gas tankers in mind, most of its contents apply equally to other types of vessel.

EQUIVALENTS

Many quantities given in this booklet can be expressed in alternative units; the following approximate conversion factors will be found useful when evaluating equivalents.

To convert	to	multiply by
Metric Tons or Tonnes (35 tonnes =	Long Tons 34½ tons)	0.984
Long Tons (1000 tons =	Tonnes 1016 tonnes)	1.016
Millimetres (44 mm =	Inches 1¾ in)	0.039
Inches (¾ in =	Millimetres 19 mm)	25.4
Metres (27½ m = 1 shackle or 'shot' =	Feet 90 ft = 15 fathoms)	3.281
Feet (12 ft =	Metres 3½ m)	0.305
Millimetres diameter (48 mm diameter =	Inches circumference 6 in circumference)	0.125
Inches circumference (9 in circumference =	Millimetres diameter 72 mm diameter)	7.939
Kilogrammes/millimetres^2 (145 kg/mm^2 =	Tons/inches^2 92 ton/in^2)	0.635
Tons/inches^2 (115 ton/in^2 =	Kilogrammes/millimetres^2 180 kg/mm^2)	1.575

Chapter 1 Effective Mooring

Chapter 2 Mooring Winches

Chapter 3 Steel Wire Ropes

Chapter 1

EFFECTIVE MOORING

What Does a Mooring System Do?

A mooring system prevents the ship from drifting away from a berth and holds the ship in place in relation to the loading/discharging arms, which may only have limited freedom of movement. Mooring lines may also assist in heaving the ship alongside a berth and can be used to assist in unberthing.

The mooring system has to maintain the ship's position against forces that will be trying to move it, which may be caused by one or more of the following:

(a) Wind
(b) Current
(c) Surge due to passing ships
(d) Waves and Swell
(e) Change of freeboard

How Big Are These Forces?

At a well sited berth, the greatest forces arise from wind and current, but to design a mooring system capable of resisting the extreme conditions of wind and current would create problems in both size and cost of equipment. It is therefore normal practice to establish arbitrary wind and current criteria and then design the mooring system to meet these criteria.

Commonly used criteria are:

Wind 60 knots, plus a current on the beam of 0.75 knots, or

Wind 60 knots, plus a current from ahead or astern of 3 knots.

Both wind and current forces are proportional to the square of the wind or current speed, thus the force caused by a 60 knot wind is four times that caused by a 30 knot wind, and the force exerted by a 3 knot current is nine times that exerted by a 1 knot current.

Wind speed increases with height above sea level. For example, a wind of 60 knots at 10 metres will be more than 75 knots at 30 metres but only 30 knots at 2 metres (just above man-high). So that information from different sites can be compared, it is usual to correct all anemometer readings to an equivalent height of 10 metres.

Because of the speed/force and speed/height characteristics of wind behaviour, freeboard is a major and sometimes critical factor for safe mooring.

In the case of currents, forces become significant when the clearance under the keel is small in relation to the draft. In this situation, and when the current is from the beam, the ship begins to act as a major obstruction to a current which must either escape around bow and stern or accelerate under the keel. A similar but less pronounced effect occurs with currents aligned to the ship's fore and aft axis.

A well designed berth will be sited so that the current will be end on or nearly end on, but Fig. 1 shows how the current force due to a beam current increases as the "depth/draft ratio" is reduced.

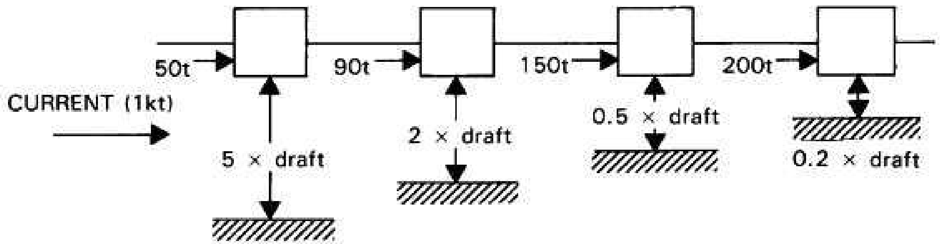


Fig. 1 Effect of Underkeel Clearance on Current Force

Ballasting the ship down will usually reduce the total forces acting on a ship as the wind gradient effect is greater than the underkeel clearance effect.

The table below gives some examples of the forces on various ship sizes due to wind (60 knots) and current (3 knots ahead or 0.75 knots abeam).

		TRANSVERSE FORCES tonnes		LONGITUDINAL FORCES tonnes	
SUMMER DWT		Wind	Current	Wind	Current
18,000	loaded	33	30	27	15
	ballast	102	7	48	5
70,000	loaded	72	62	37	35
	ballast	210	8	52	13
200,000	loaded	106	132	49	73
	ballast	378	15	76	23

A ship moves vertically up and down alongside a berth both with the tide and as a result of cargo operations. It is perhaps stating the obvious to see that as a ship rises, the tensions in the mooring lines will increase. Conversely, as the height above the jetty decreases, the lines will become slack and the ship is likely to move away from her proper position. ***The only reliable remedy for this is regular line tending whilst the ship is moored at a jetty.***

Forces caused by passing ships, waves or swell are complex and continually varying, although at most berths they will not create problems for a ship that is using her equipment properly. Where these forces are unusually large, jetty operators will have made some provision to supplement the ship's system. Attention to mooring restraint is especially important in the case of a deep draft loaded ship with minimum underkeel clearance berthed close to a shipping lane, when the force from passing ships could be large enough to part the lines or pull the ship off the dock if the lines are slack.

Mooring Layout

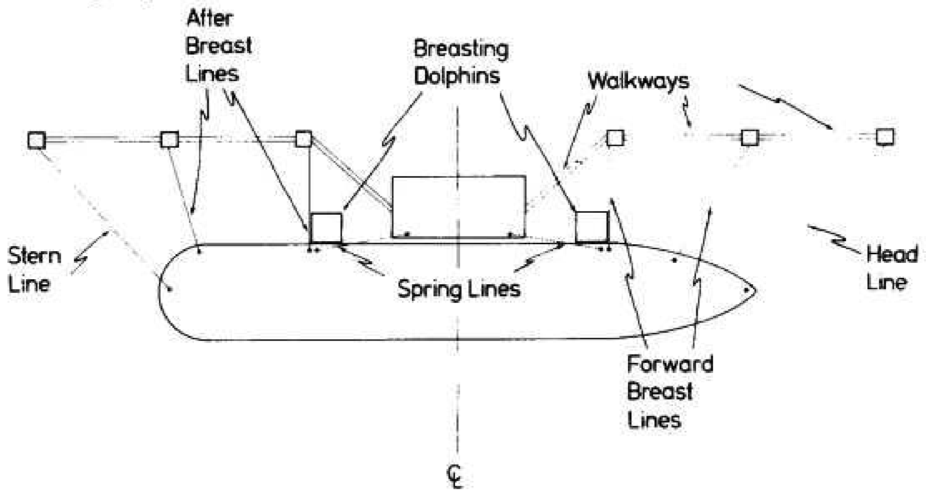


Fig. 2 Typical Mooring Arrangement

Whilst it is often difficult in practice to achieve an ideal mooring layout, Fig. 2 shows a typical mooring arrangement designed to resist environmental forces acting on the ship. These forces, particularly wind, can come from any direction, but when discussing mooring systems the forces are split into longitudinal and transverse components. A ship's equipment can always be employed to the best advantage if the following general principles are remembered:

(a) Breastlines provide the bulk of the transverse restraint against off-the-berth forces.

(b) Backsprings provide the largest proportion of the longitudinal restraint. It should be noted that spring lines provide restraint in two directions, forward and aft, but that only one set of springs will be stressed at any one time.

(c) Very short lengths of line should be avoided when possible, as such lines will take a greater proportion of the total load, when movement of the ship occurs. Short lines are also the ones most seriously affected by "dip" [see page 7].

Although headlines and sternlines, because of their direction, have the effect of providing *some* restraint against both longitudinal and transverse forces, they actually contribute less to the overall mooring strength than is commonly supposed. ***This is because the direction of the largest forces encountered is usually either nearly transverse or nearly longitudinal, ie along the lines of action of breast or spring lines respectively.***

Additionally, they are almost always much longer than the breastlines and so take a reduced share of the load. However, where the jetty layout prevents the use of the forward and aft lines as breast or spring lines only, the contribution of headlines and sternlines to the overall security should not be ignored.

The most extreme conditions, ie light ship and combined beam wind and current, will usualy produce a resultant force vector within about 25 degrees of the beam.

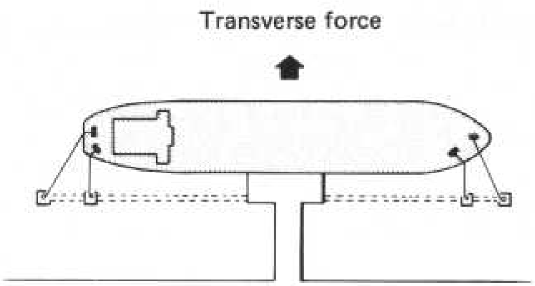


Fig. 3

In the example illustrated in Fig. 3, with the headlines leading at 45 degrees to the breastlines, the contribution of the headlines to the total transverse restraint is only about 26% of the whole. Even if the total resultant force aligns with a headline, the line takes only 41% of the load, with the breastline and springline sharing the remaining 59%.

Wires or Synthetic Fibre Ropes

The key factors for any wire or rope are strength, which is usually described by reference to minimum breaking load, and elasticity, which is a measure of its stretch under load.

Synthetic fibre ropes are adequately strong and of a reasonable size for mooring small to medium sized ships, but for large sized ships the ropes may become too large to handle unless fitted on self stowing winches. Further, the handling of a large number of such ropes would be difficult.

In addition, most synthetic fibre ropes stretch far more than wires. A typical figure for the extension of a nylon rope at maximum load is in excess of 30%, compared with 1½% for a wire. As the mooring ropes of a VLCC may reach 70 to 100 metres, it is clear that a normal synthetic fibre rope mooring system is unlikely to provide the accurate positioning demanded by the loading arms.

[Despite the above comments it should be noted that there is a group of synthetic mooring ropes (the "Aramides" or "Aramid fibre ropes") which have been developed fairly recently and which have an extension comparable with that of wire. However, their high cost generally limits them to specialist applications.]

Whilst smaller ships may be equipped with synthetic fibre lines, it is normal for larger ships to be equipped with wires fitted to self stowing winches. Even on smaller ships, wires, if fitted, are normally on self stowing winches for ease and safety of handling, and on new buildings it is common practice for the synthetic lines to be fitted to self stowing winches.

A synthetic fibre rope fitted to a self-stowing winch is sometimes provided at each end of the ship. Its purpose is to act as the "first line ashore" as its light weight and buoyancy make for easy handling in a mooring boat, on the jetty and on board, and it can thus be sent ashore easily when the ship is some distance from the berth (Fig. 4). It can then be used to assist in heaving the ship alongside the berth. However, because of its greater elasticity it should not be considered as part of the actual mooring system unless the other head and stern lines are of a similar material.

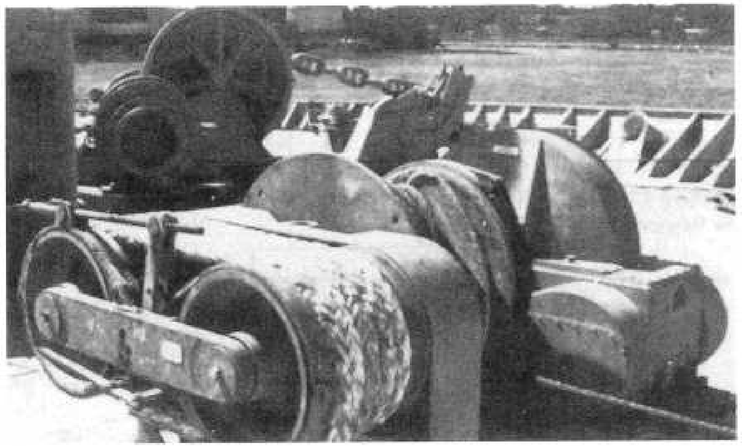


Fig. 4 First Line Ashore Equipment. Split drum assembly in background

Elasticity

The elasticity of mooring lines is important because it determines how the total load will be shared between a number of lines.

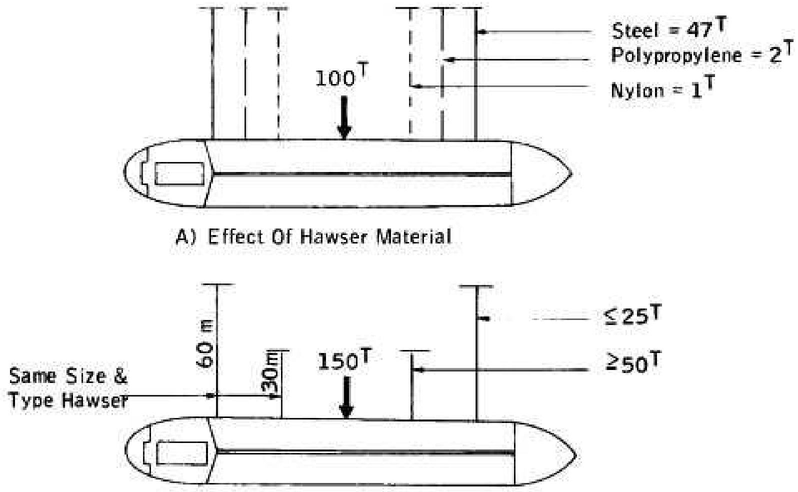
If two lines of the same size and material are run out in the same direction and pre-tensioned, but one is secured to a hook twice as far away as the other, the shorter line will take ⅔ of any additionally imposed load, the longer one only ⅓.

Therefore, two or more lines leading in the same direction should, as far as possible, be of the same length.

If two lines are of the same length, the same breaking strength, and have the same lead, but one is a wire of 1½% full load elongation and the other is a synthetic of 30% full load elongation, the wire will take 95% of the extra load, the synthetic only 5%.

Hence, two or more lines leading in the same direction should always be of the same material. Never mix wire and soft moorings if you can avoid it.

Fig. 5 demonstrates the significance of material and length of lines.



A) Effect Of Hawser Material

B) Effect Of Hawser Length

Fig. 5

Elasticity of a given type of line also varies with diameter, with a larger rope extending less than a smaller rope. Although this is unlikely to be an important factor, as mooring lines on a ship are usually of a uniform diameter, it should be borne in mind when ordering new mooring lines.

First Line Ashore

Although a synthetic fibre rope will not normally give much help in an all-wire mooring system owing to its higher elasticity, a "first line ashore" (if carried) is usually fitted onto a self-stowing winch of some kind. Hence this rope can be used to supplement the other moorings ***in an emergency*** by heaving at its full capacity. If the other head and stern lines are of similar material, then this line can be considered as part of the mooring system.

Vertical Angle (Dip)

Whenever a line is unable to act in exactly the same direction as the force it is trying to withstand, its holding power is reduced. Hence a short line to a mooring hook substantially lower than the ship's fairlead will be of limited value. The effectiveness is proportional to the cosine of the angle the line makes to the horizontal, ie for 30 degrees the line is 87% effective and, for 45 degrees, 71% effective (Fig. 6).

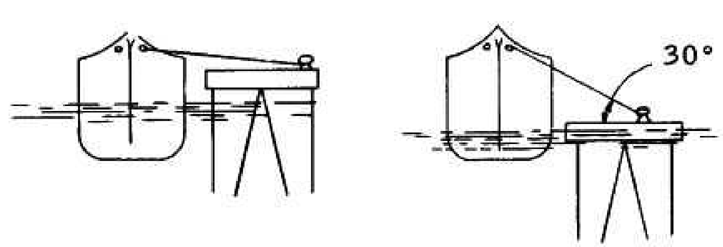


Fig. 6

Mixed Moorings

Not every ship is fortunate enough to possess an all-wire or all-synthetic mooring outfit and in such cases the best must be made of a mixture of wires and synthetic fibre ropes.

The earlier discussion indicated that the best procedure is to use, wherever possible, the wires for the spring and breast lines. The synthetic ropes are best reserved for headlines and stern lines, and for heaving alongside the berth.

Nylon Tails

Although wire moorings provide the most effective mooring system by reason of their low elasticity, that same low elasticity can also pose its own problem, particularly at berths where sea and swell, or perhaps passing ships, could impart shock (dynamic) loadings to the mooring system. In such cases there may be insufficient elasticity to prevent failure of the mooring wires.

This problem can be overcome by introducing a degree of elasticity by attaching nylon tails to the end of the wires and these are attached by means of a special joining shackle designed to minimise wear on the wire. The use of an ordinary "D" or "bow" shackle should be avoided as this will quickly damage both wire and tail.

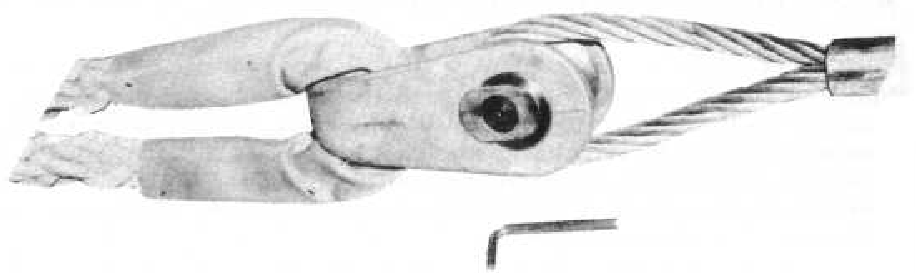
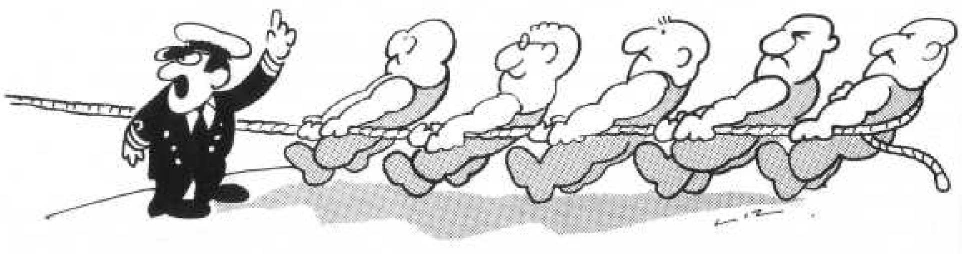


Fig. 7 Stainless Steel Shackles for Lines with Tails

In order to keep the additional elasticity to the minimum required to prevent wire failure, the length of the tail should not exceed 11m, and because nylon tails are likely to deteriorate more rapidly than wire, they should be at least 25% stronger than the wires to which they are attached and should be inspected frequently or replaced at regular intervals. The eyes of the tails should be covered in leather or plastic sheathing to protect them from chafing.

When tails are used, the shackle may cause increased wear on the eye of the wire, and this area should be inspected at regular intervals.

> Remember, the security of a ship alongside is not something which happens of its own accord. It needs good knowledge and use of the ship's equipment, an awareness of good mooring principles, and careful planning; THIS DOES NOT FINISH ONCE THE SHIP IS FINALLY MOORE BUT CONTINUES ALL THE TIME SHE IS ALONGSIDE.



'a heaving system of some kind'

Chapter 2

MOORING WINCHES

Mooring winches can be driven by steam, electric or hydraulic motors. Although steam is very common, many newer vessels are fitted with hydraulic equipment; electric winches are not common on board tankers.

Render and Heave

Whatever the power source, all mooring winches will be affected to a greater or lesser degree by a characteristic known as "Render/Heave Ratio". The term "Render" is defined as the force required to turn the winch in the opposite direction when set to heave with the driving force applied.

With hydraulic and electric driven winches, the render value is constant but with steam winches the render value varies. This is because the torque available is dependent upon the position of the pistons. Fig. 8 is typical of a two-cylinder machine.

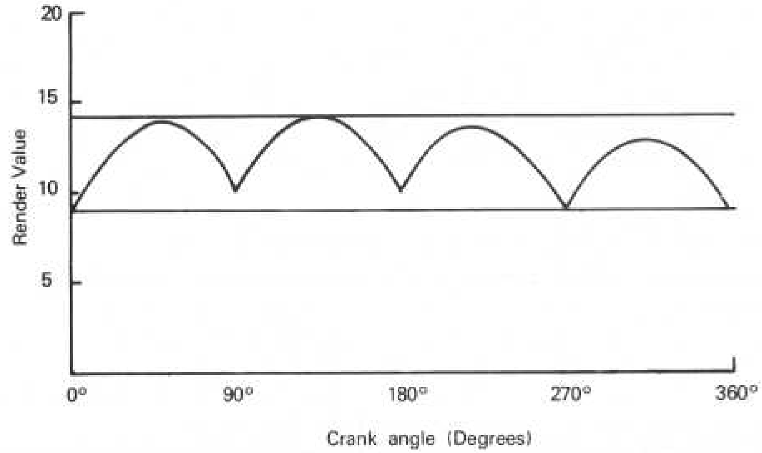


Fig. 8 Crank effort diagram for steam winch

Winch manufacturers have endeavoured to solve this problem in different ways, and for a given Render value the heaving power available varies as shown in the table.

WINCH TYPE	RENDER	HEAVING POWER
Maker A (Steam)	35 tonnes	15 – 22 tonnes
Maker B (Steam)	35 tonnes	30 tonnes
Maker C (Hydraulic)	35 tonnes	22 tonnes

As can be seen, the Render/Heave ratio can vary between 1.17 and 2.3 because of the differing mechanical advantages of different winches. ***It should be noted that the heaving power is always less than the render force and it is thus impossible to heave in after a winch has rendered unless there is a change in the forces acting on the moorings.***

Many ships are equipped with self-tensioning winches with the intention of eliminating the need for line tending. These are designed so that a specified line tension can be pre-set, and the winch will render (pay out) when tension in the line exceeds this value, and will recover (heave in) when it is less than this value.

However, experience has shown that the use of such winches whilst the ship is alongside is not a safe practice because the winch restraint is limited to its render load, which is small compared to what it can hold on the brake. It is possible for the winches at opposite ends of the ship to work against each other when an external force caused by either wind or current or both is applied to one end so that the ship could "walk" along the jetty. In the simple illustration given by Fig. 9 a ship is shown moored by one line at each end.

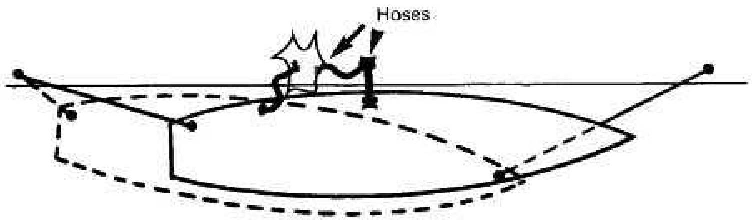


Fig. 9

Should the bow winch render a little for any reason (ie, a change in direction or force of wind or current) some wire will pay out, which cannot be heaved onto the drum again because the ***heaving force of a winch is always less than its render force*** and it is not possible to heave in until the external force which caused it to render is reduced. Consequently, the ship drifts astern a little and the after mooring begins to slack. The aft winch then heaves in that slack and re-tensions the line. If the disturbance is repeated or continuous the ship will move progressively astern.

Mooring winches should not therefore be left in automatic self-tensioning mode once the ship is secured alongside. On completion of mooring the winch should be left with the brake on and out of gear.

Winch brakes

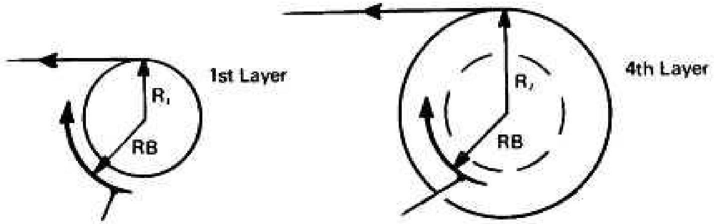
The holding power of winch brakes varies from ship to ship, but will always be designed to exceed the "render" value of the winch.

The above statement is dependent upon several factors which are discussed below.

Correct Layering

The number of layers of line on the drum effects the brake holding power.

The force at which the brake will slip will vary, dependent upon the number of layers of wire left on the drum, and the more layers of wire on the drum the greater will be the reduction of brake holding power. This is illustrated in Fig. 10.



Brake holding power
55 Tonnes
RB = Brake Radius

Brake holding power reduced to 40 Tonnes as radius R_1 increases to 4th layer

Fig.10

Non Split Drum Winches

The brake holding capacity for these winches (non split drum) will always be quoted for a specific number of layers. In order to minimise any reduction in brake holding power, the line should always be reeled on to the drum in a symmetrical pattern and not allowed to pile up on one side or in the centre. However, due to the length of line involved, it may not always be possible to achieve this in practice.

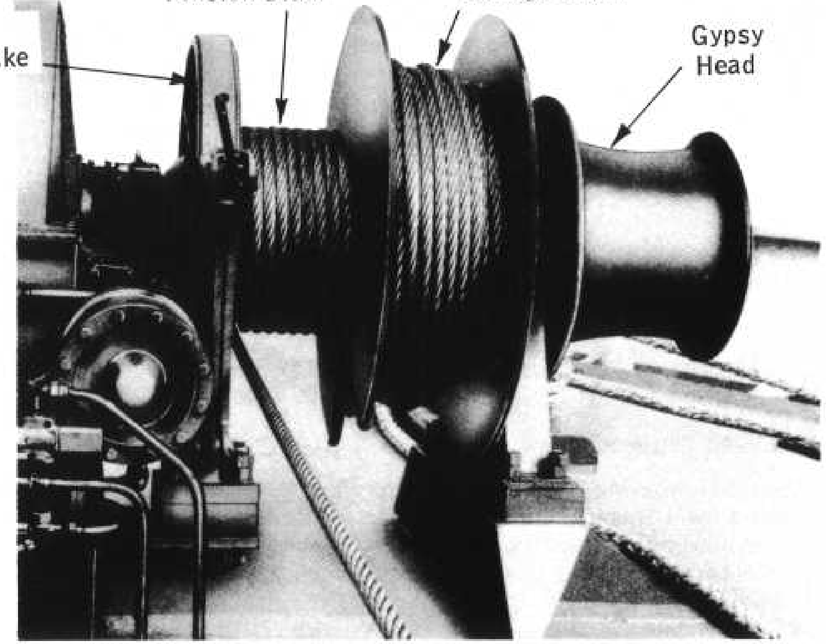
The following table shows a typical loss of brake holding capacity for each layer, based on 100% on the first layer:

NO. OF LAYER	BRAKE HOLDING CAPACITY	
1st Layer	100%	say 55 tonnes
2nd Layer	88%	48 tonnes
3rd Layer	80%	44 tonnes
4th Layer	73%	40 tonnes
5th Layer	67%	37 tonnes
6th Layer	61%	34 tonnes

Where possible, check for brake holding values by referring to manufacturer's literature or ship's plans. If the brake holding capacity is known, but the layer to which it is applied is not, for the sake of safety assume it applies to the 1st layer and make allowances accordingly.

Split Drum Winches

This design minimises crushing damage and is normally only used with wires. The brake holding capacity for these winches (Fig. 11) is always quoted for only a single layer of wire on the tension drum.



Courtesy of Pusnes

Fig. 11 Typical split-drum winch

When using this equipment, difficulty may be experienced when:

(a) Manhandling the wire from the storage drum to the tension drum.

(b) Judging the correct length of wire so that only one layer of wire is present on the tension drum all the time the ship is alongside.

Correct Reeling

The line must be reeled on to the winch drum in the right direction and manner.

Band brakes are designed for the line to pull directly against the fixed end of the brake band. Fig. 12 shows the correct method of reeling.

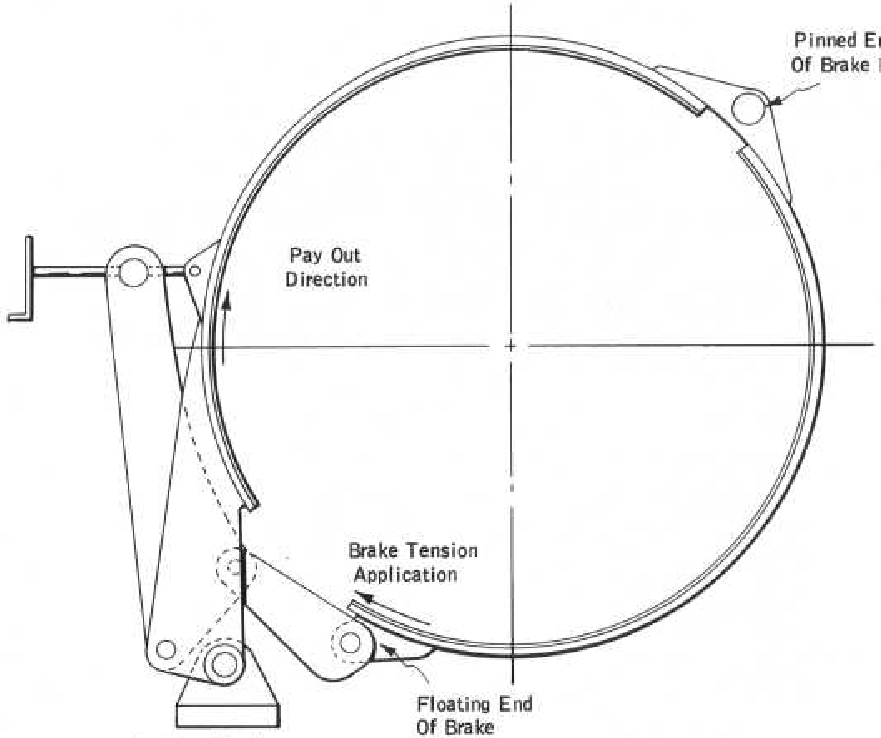


Fig.12 Reeling of Wire on Winch Drum

Reeling the line on to the drum in the wrong direction may reduce the brake holding power by up to 50%. Winch drums should be marked to indicate the correct reeling direction.

Winches fitted with disc brakes are not subject to this problem.

Brake Condition

The physical condition of the winch brakes effects the holding power.

Oil, moisture or heavy rust on the brake linings or drum can seriously reduce the brake holding power, in extreme cases by up to 75%.

Moisture can be removed by running the winch with the brake applied very lightly, although care must be taken not to cause excessive wear. Oil impregnation cannot be removed so linings should, if so affected, be replaced.

Whenever brakes are opened up for any reason, the brake drum should be examined for build-up of rust or worn brake material and should be descaled as necessary.

Brake linkages must be free and greased. If the linkages are not free there will be a loss of brake holding power and the winch operator could be under the impression that the brake is fully applied when in fact it may not be. Severe stresses could also be imposed on mechanical parts of the brake.

Before the end of a sea passage, when the brakes will have been exposed to the air and sea, it is essential to check them and ensure that all control and operating handles are oiled or greased and are free and easy to use, that all linkages are greased, and that the brake drums and linings are clean and (so far as possible) dry.

Testing Brakes

Deterioration of the brake holding capacity will be caused by normal wear down of the brake linings. Brake holding capacity should therefore be tested annually or after excessive loading has been experienced. Brake linings should be renewed if there is any significant deterioration of holding power.

Application of Brake

When there is a load on the line, the fact that the brake is not fully applied will be all too obvious. However, it is sometimes difficult to tighten manually applied brakes to their maximum possible extent when there is little load on the line. Different people are of different builds and can apply different forces to the brake applicator.

Therefore, when the freeboard is increasing during cargo discharge or with a rising tide, brakes should be tightened at frequent intervals even if there is no sign of slipping. As the load in the line increases, redistribution of stresses in the brake band will often relax the load on the applicator, allowing the brake to be tightened further.

Ships with hydraulic brakes will probably have a torque indicator which shows the actual torque applied to the brake, and this should always be maintained at the level designated by the winch manufacturer.

Incorrect Use of Brake

The brake is a static device for holding a line tight and it is ***not*** intended as a means for controlling a line. If a line has to be slacked down, the winch should be put into gear, the brake opened and the line walked back under power. It should never be slacked down by releasing the brake as this causes increased and uneven wear on the brake band, it is uncontrolled and thus unsafe, and if two lines in the same direction have equal loads then the entire load will be suddenly transferred to the other line, which may then part.

Brake Holding Capacity

The value of the brake holding capacity in relation to the size of line is important; there would be little point in a mooring system where the line parts at a load less than the brake holding acpacity. ***Brakes should have a holding capacity of about 60% of the breaking load of the wire, which will permit slippage before the wire breaks.***

This factor should be considered when renewing lines and reference should be made to the ship's specification or appropriate drawings.

It should be remembered that the brake holding power is always greater than the heaving power, and that once the brake starts to slip (render) it is impossible to heave in unless the forces causing the slippage are reduced.

Exceptional Circumstances

Occasionally, unanticipated changes of load, perhaps caused by extreme winds, waves, swell or tide, may cause the brakes to slip and the ship to be at risk of moving off the berth. Should this occur, do NOT release the brakes and attempt to heave the ship alongside, as this is impossible (see above), and any attempt to do this will only worsen the situation. Tug assistance should be requested, the engine should be made ready for manoeuvring, and hoses should be disconnected.

If the problem is caused by high winds, consideration should be given to reducing the freeboard by the addition of extra ballast if this is possible.

Winch In Gear

The brake holding capacity can be increased by leaving the winch in gear with the power on and set to "heave". However, this should only be considered in an emergency situation and should not be carried out in normal operations as it is possible to:

(a) exceed the breaking strain of the line and the safe working load of leads and rollers,

(b) damage the winch by distorting the shaft.

As an example, if the render value is 35 tonnes and the brake holding power is 65 tonnes, the total holding power is 100 tonnes. If a line with a new braking load of 108 tonnes is used, and allowing a 20% reduction for wear and tear, then the breaking load is only 86 tonnes, and the line will probably part.

It is also ineffective where one winch drives two or more drums as it is not normally possible to engage all the drum shafts whilst at the same time maintaining equal tension on the lines.

Thus, this practice should only be considered in an emergency situation.

Freezing Weather

During periods of freezing weather, it may be necessary to run the steam winches continuously to prevent serious damage to the cylinders, steam pipes, etc. Alternatively, some winches are provided with a steam-to-exhaust by-pass valve which can be adjusted to allow sufficient steam to pass through the system to prevent the pipes freezing up.

On certain winches, when the brake is applied and the drum is out of gear, the winch motor still drives the drum shaft. If the wire is under load, this load is transferred to the drum bearings and the rotating shaft, resulting in eventual wear of the bearings. Where this is the case, it is preferable to utilise the steam and exhaust by-pass valves to prevent damage in cold weather.

Joining A New Ship

It should be obvious that people using the ship's mooring equipment must be familiar with its operation and capabilities.

Always check the following when joining a new ship:

(a) Mooring line size, length and type.

(b) Type of winch
Self-tensioning, split-drum, steam, electric or hydraulic.

(c) Heaving power and render value of the mooring winches.

(d) Type of brake mechanism.

(e) Brake holding capacity of the mooring winches, and to which layer it is applied.

(f) Whether the combined render value and the brake holding power of each winch is more than "MBL-less 20%" for the line attached to it.

(g) General condition of mooring lines (splices, age, etc.).

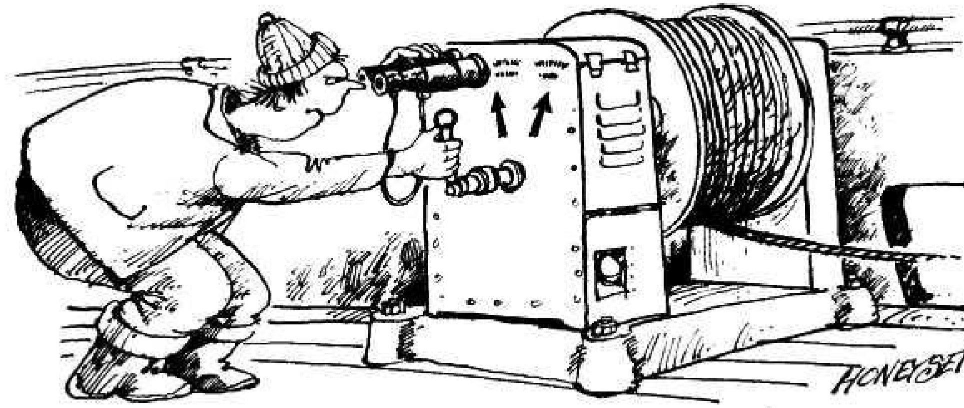
SAFETY REMINDERS

Ensure that the "heave-in" and "slack-out" directions are clearly marked on the winch handles and controls.

Steam pipes in vicinity of an operator or rope handler must be lagged or adequately guarded against accidental contact.

Do not allow oil leaks from hydraulic winches to go unnoticed, it could be YOU that slips on that pool.

Do not try to assess the tension in a line by kicking or standing on it; this is dangerous as well as being futile.



'... ensure controls are clearly marked'.

Chapter 3

STEEL WIRE ROPES

Construction of Wire Ropes

When a high Minimum Breaking Load (MBL) together with reasonable ease of handling is required, it is usual to select wire ropes.

A wire rope consists of a number of strands layed up around a central core of fibre or wire. Each strand in turn consists of a number of wires layed up to form the strand.

It is normal to describe the rope in terms of the number of strands and number of wires per strand, eg. 6 × 36, 6 × 41 (Fig. 13).

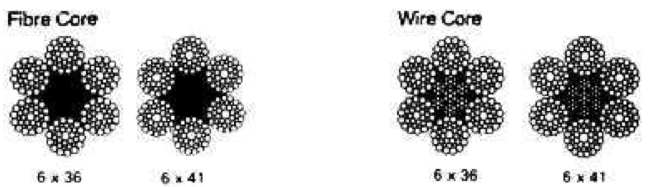


Fig. 13

The first number is the number of strands in the rope and six round strands around a central wire or fibre core are the normal construction for marine use. (Ropes of eight strands, or multiple strand design, or triangular strand design are also available but are normally restricted to specialist applications.) The second number is the wires in each strand; ropes with more wires have greater flexibility and fatigue resistance but have less resistance to abrasion, whilst those with fewer wires have less flexibility and fatigue resistance but more resistance to abrasion. A standard mooring wire is of 6 × 36 or 6 × 41 construction.

Several constructions are available and the following definitions and illustrations will be of assistance in identifying the different wire types:

Definitions

Lay — the twisting of strands to form a rope, or wires to form a strand, during its manufacture.

Righthand or Lefthand Lay — the angle or direction of the strands relative to the centre of a rope.

Cross Lay (Fig. 14) and **Equal Lay** (Fig. 15) — terms describing the lay of the wires used to make up the strands.

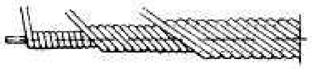


Fig. 14 Cross Lay

Fig. 15 Equal Lay

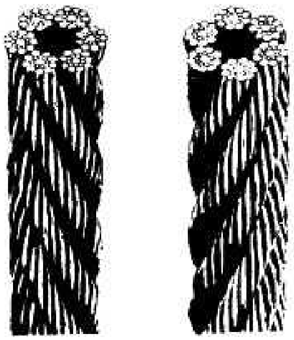


Fig. 16 Ordinary Lay

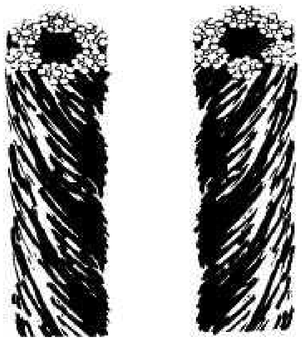


Fig. 17 Lang's Lay

Ordinary Lay (Fig. 16) — a method of making a rope where the lay of the wires in the strand is opposite to the lay of the strands in the rope.

Lang's Lay (Fig. 17) — a method of making a rope where the lay of the wires in the strand is the same as the lay of the strands in the rope. Although this construction has better wearing properties than ordinary lay, because it tends to untwist it has only limited use. It is not used for mooring lines.

Aggregate Breaking Load — the sum of the breaking loads of all the individual wires used to form a wire rope.

Minimum Breaking Load (MBL) — the smallest load at which a wire rope breaks when tested to destruction. This value is usually the manufacturer's guaranteed breaking load and is the figure that should be quoted when ordering wires.

Spinning Loss — due to deformation of individual wire strands during manufacture, the actual breaking load of a wire rope is always less than the aggregate breaking load. The difference is referred to as Spinning Loss.

Yield Point — the point at which the ratio of strain/stress increases sharply. This is the point at which a wire may become permanently distorted.

Equal Lay construction gives superior performance over a Cross Lay rope of the same diameter because:

(a) It possesses up to 14% higher MBL due to lower spinning loss. This is because all the layers of wire have the same pitch or length of lay, and each wire in each layer lies either in the trough between the wires of the underlayer or alternatively along the crown of the underlying wire.

(b) No wire crosses over the crown of the underlying wires as in Cross Lay construction, thus reducing internal wear by the elimination of cross cutting.

A standard 6-strand Equal Lay/Ordinary Lay construction is usually adopted for mooring wires, and wires of diameter 22 – 40 mm are usually 6 × 36 construction, and larger wires 6 × 41. Mooring wires are usually Righthand Lay unless otherwise specified.

Wire ropes can be supplied in different grades of steel, usually 145 kg/mm^2 or 180 kg/mm^2. The latter is recommended because, for a given diameter of wire rope, an increased MBL and general better performance is obtained.

Wire ropes can be supplied in Righthand Lay or Lefthand Lay. Unless otherwise specified, a Righthand Lay will normally be supplied.

Wire ropes can be supplied with fibre cores or steel wire cores. Fibre cores will give easier handling and are ideal for use with smaller wire sizes and where a wire is to be handled manually and say "turned up" on bitts or bollards.

Where the wire ropes are used on storage drum type winches with little manual handling, it is advantageous to use a steel wire core. Wires constructed using a steel wire core offer a greater resistance to the crushing forces experienced on these winches, suffer a smaller loss of MBL when bent, are about 7 – 8% stronger and extend slightly less (¼ – ½% as opposed to ½ – ¾%) than a fibre core wire rope of the same diameter (Fig. 18 refers).

Mooring wires are usually galvanised in order to provide better resistance to corrosion.

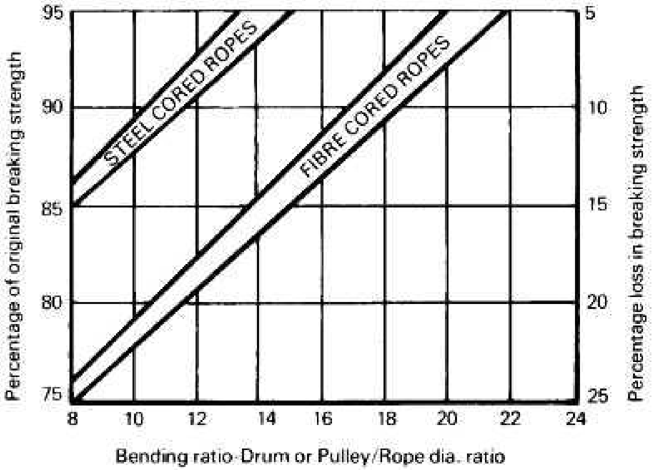


Fig. 18 Graph showing the loss in breaking load when a wire is bent over small diameters

To summarise, the wires most frequently found on self-storing winches will be of the following constructions:

(a) Equal Lay

(b) Ordinary Lay

(c) Righthand Lay

(d) Steel wire Core

(e) Usually of engineering grade steel, ie 180 kg/mm^2

(f) 6 × 36 or 6 × 41

Wire rope is used in preference to synthetic fibre ropes because it possesses:

(a) Low elasticity, ie. limited stretch. When a wire is first used under load there is a slight permanent extension known as "constructional" stretch which results from a slight rearrangement of the wires. After this the wire experiences an elastic stretch which is recoverable and linear up to about 65% MBL; above this the stretch increases non-linearly until the line breaks.

(b) A strength/diameter ratio superior to most synthetic fibre ropes (apart from Aramid fibres and other specialist ropes).

(c) A smaller diameter making it suitable for use on storage reels that can be directly linked to the winch. (The maximum diameter found in normal service is usually 44mm.)

The table below shows some typical breaking loads (in tonnes) for round strand equal lay wire ropes:

Diameter	180 kg Wire	
	Fibre Core	Wire Core
28mm (6 × 36)	46.6	50.3
32mm "	60.8	65.7
36mm "	77.0	83.2
38mm "	85.7	92.6
40mm "	95.0	103.0
44mm (6 × 41)	115.0	124.0

When delivered, all mooring wires should be accompanied by a certificate from the manufacturer indicating the minimum breaking load. These certificates should always be consulted if it is necessary to ascertain the specification of a particular wire.

Maintenance of Steel Wire Moorings

It is essential to grease or oil steel wire mooring ropes at frequent intervals as rusting will reduce the strength of the wire in a very short time.

It is important that periodically the whole wire is physically removed from the drum for inspection and greasing.

Investigations have shown that deterioration of the wires can occur undetected on the bottom layers, especially when a wire has seen some service and has been turned "end for end".

Regular ***visual*** inspection is vital, particularly around eyes which are shackled to nylon tails, as the shackle tends to increase wear on the wire at this point (see p 8).

If "dry" or darkened patches are observed, the depth and degree of corrosion should be checked. An effective way to do this is to place the wire on a solid surface and strike it with a hammer. This will cause the rust to fall away and will part the weakened strands, exposing the severity of the corrosion.

Snags in a wire also indicate a reduction in the strength.

Wires must be replaced if the number of broken strands (snags) exceed 10% of the visible strands in any length of wire equal to 8 diameters.

Selection of Anchor Point for 1st layer of Wire on a Drum

When fitting a new wire to a mooring winch, or replacing an old wire after inspection and greasing, it is important that the wires are replaced as shown in Fig. 19.

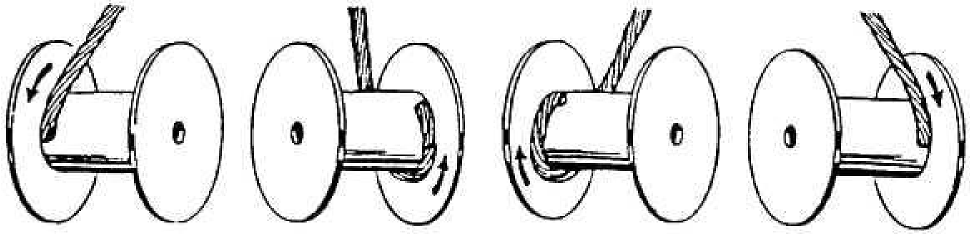


Fig. 19

Stoppers for use with Steel Wires

There are two methods of stoppering a steel wire prior to turning it up on the bitts.

One method is to use a specially designed stopper such as the Carpenter stopper (Fig. 20). The second and only other recognised method of stoppering wires is to use a length of chain.

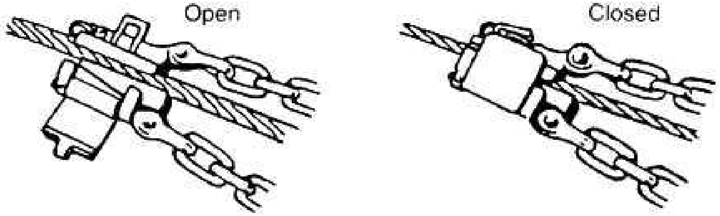


Fig. 20 Carpenter stopper

Rope must never be used as a stopper on wires because it does not grip the wire well enough.

Where a carpenter type stopper is used, it is recommended that the stopper be of equal breaking load to the wire size for which it is designed. An important safety feature of this type of stopper is that when in position, it is self-tightening and can be left unattended. Further, it will not damage the wire when under load, provided it is of correct size and design for the circumference and lay of wire rope on which it is to be used.

Where carpenter type stoppers are not available, it is important to note the following:

When securing a chain stopper to a wire, use only a "Cow Hitch" (also known as a "Lanyard" hitch) (Fig. 21), **never** a "Clove Hitch".

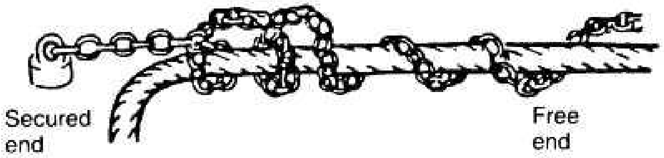


Fig. 21 Cow Hitch

Stoppers exceeding 20 mm diameter are virtually unmanageable and hence this is the largest size likely to be encountered. All chain stoppers should be tested and annealed at each vessel refit.

Warning: In most cases, the stopper will break at a lower load than the wire.

When ordering chain stopper, it is important to specify the following:

Size — Diameter of link.

Type of chain — close link, higher tensile steel, ie. tensile strength in the order of 63 kg/mm^2, equivalent to BS1663 Grade 40. (Superior grades and higher breaking loads are available if required.)

The following table shows typical breaking loads for Grade 40 steel chain. (Note: The diameter is the diameter of the steel forming the link of the chain.):

12 mm diameter	7.2 tonnes
16 mm diameter	12.7 tonnes
20 mm diameter	19.9 tonnes

Length of chain — usually 3.5–4.5 m.

CARE OF WIRE

AVOID — LEADING WIRES AROUND SHARPEDGES.
It damages the wire, and seriously reduces the wire's strength. If a wire is run through a lead which is not aligned with the winch drum, the wire will be damaged where it rubs on the edge of the spool, and this practice should be avoided.

AVOID — CROSSING THE WIRE ON THE DRUM.
Crushing or flattening also seriously reduces the wire's strength.

AVOID — KINKING THE WIRE.
This opens the lay and leaves the wire permanently weakened.

AVOID — LEADING WIRES THROUGH EXCESSIVE ANGLES.
because the wind or current loads or both could exceed the wire's MBL on the outboard section of wire (T_2 in Fig. 22) and break the wire before the winch brake renders. Should both the winch brake and steam holding power be combined, the risk of wire breakage is increased.

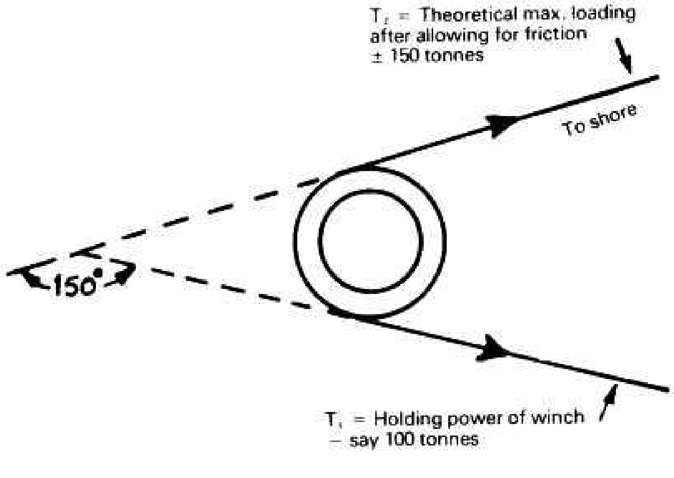


Fig. 22

Always check a wire for snags before use.
The practice of sighting any wire before use could also prevent an injury or accident.

Do not open a new coil of wire without using a turntable or similar apparatus, in order to avoid kinking the wire.

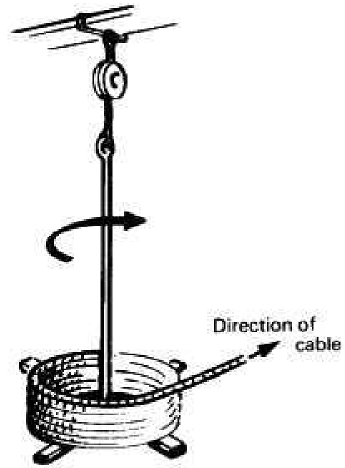


Fig. 23

Splicing Wire

Modern practice is for mooring wires to be supplied with eyes formed by means of a ferrule applied mechanically by the manufacturer. If the eye is damaged, it can be cut off and a new eye spliced in the wire. If this is done there should be a minimum of 5 full tucks and 2 half tucks. However, a manual splice will effectively reduce the MBL of the wire by 10 – 15%, and it is preferable to have the eye re-made by a mechanically applied ferrule. It will be found that it is extremely difficult to put an effective manual splice in a large mooring wire.

Short splices should not be used on wires fitted to self stowing winches as the splice could further deform or damage the wire on the reel.

SAFETY REMINDERS

ALWAYS stand well clear of a wire under load.

NEVER stand in the bight of a wire.

ALWAYS wear gloves when handling wires.

Chapter 4

SYNTHETIC FIBRE ROPES

Use of Synthetic Fibre Ropes

Synthetic fibre ropes have now almost completely superseded natural fibre ropes for mooring purposes. As with steel wire ropes, there exist many relatively new terms and rope types, a few of which are described below.

Mooring ropes are normally made of nylon, polyester, polypropylene, or a polyester/polypropylene mixture. Although hawser laid ropes (Fig. 24) may still be found in use, they are not favoured because of their tendency to kink and their relative stiffness in handling. More common these days are 8-strand plaited ropes (sometimes called square braid); the balance between left and right hand strands make them virtually unkinkable and very flexible. Fig. 25 shows an 8-strand plaited rope and Fig. 26 shows a sheathed and plaited construction known as double braid or braid on braid often used for specialised purposes (ie. first line ashore equipment), which consists of a plaited inner rope covered by a tightly plaited sheath which may be of a different or similar material to the inner rope.

Fig. 24

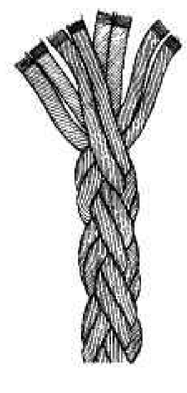


Fig. 25

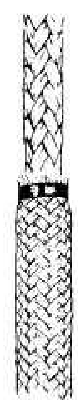


Fig. 26

As mentioned in Chapter 1, mooring ropes are available manufactured from Aramid fibres. These have very low extension under load (approaching that of wire) and a higher breaking load than other synthetic fibres of the same size. They are however very expensive and their use is generally limited to special applications or specific situations.

Types of material used

NYLON — this is the strongest of the man-made rope fibres, except for Aramid, and has exceptional resistance to sustained loading. It is highly resistant to chemical attack from alkalis, oils and organic solvents, but will be damaged by acids. However, its high elasticity makes it unsuitable for tanker moorings, where the ship's movement has to be restricted to avoid damaging loading arms. It does not float.

Specific Gravity 1.14. Melting Point 250 Deg. Centigrade.

POLYESTER — this is the heaviest of the man-made fibres. It is not as strong as nylon but it possesses the lowest extension under load of all man-made rope fibres, except the Aramids, and has an exceptional abrasion resistance. It also has high resistance to acids, oils and organic solvents, but will be damaged by alkalis. It does not float.

Specific Gravity 1.38. Melting Point 230 Deg.-260 Deg. Centigrade.

POLYPROPYLENE — this is the lightest of man-made fibres and is manufactured in various qualities. It is of equal strength wet or dry and will float indefinitely. It is resistant to chemical attack by acids, alkalis and oils, but can be affected by bleaching agents and some industrial solvents.

Specific Gravity 0.91. Melting Point 170 Deg. Centigrade.

POLYESTER/POLYPROPYLENE — this is considerably lighter than polyester although heavier than polypropylene, and has a strength about 50% between the two. It is resistant to chemical attacks by acids, alkalis and oil. It does not float.

Specific Gravity 1.14. Melting Point 170 Deg. Centigrade (polypropylene material).

ARAMID — the strongest of the man-made fibres, and with the lowest extension under load. It is heavier than all the man-made fibres except polyester. It has good resistance to chemical attacks. It has low resistance to abrasion. It is difficult to splice. It does not float.

Specific Gravity 1.4. Melting Point 260 Deg. Centigrade.

Some manufacturers now make ropes of similar construction to wire with 6 strands of nylon laid up around a solid nylon core. They have a higher breaking load and a lower elasticity than conventional synthetic ropes of the same size.

Many manufacturers now produce ropes of unconventional construction in an effort to achieve a reduction in weight and/or elasticity, and an increase in strength. When such ropes are used, the manufacturers' literature should always be consulted in order to ascertain the properties and MBL of the rope.

The table below gives the weight, breaking load and elasticity for a 64mm diameter 8-strand plaited rope of different materials, and a 6-strand nylon rope.

ROPE TYPE	WEIGHT (kg/100m)	BREAKING LOAD (tonnes)	EXTENSION (@ 50% Breaking Load)
Nylon	265	72	12%
Polyester	328	67	10%
Polypropylene	185	47	9%
Polyester/Polypropylene	242	58	14%
Aramid	293	160	2½%
6-strand Nylon	245	81	16%

The elasticity figures are those quoted by one manufacturer for used, worked ropes. The extension is likely to be considerably greater for new ropes.

The following table gives comparative minimum breaking loads (in tonnes) for a number of different 8-strand plaited ropes, and a six-strand nylon rope.

Dia. (mm)	Nylon	Polyester	Polypropylene	Polyester/ Polypropylene	Aramid	6-Strand Nylon
40	30	27	19	24	73	31
44	36	33	23	28	88	42
48	42	38	27	33	105	50
52	49	45	31	39	123	54
56	56	51	36	45	145	66
60	64	57	41	50	163	74
64	72	67	47	58	185	81
72	90	83	58	72	232	114
80	110	103	72	88	290	135

When delivered, all mooring ropes should be accompanied by a certificate from the manufacturer which will indicate the minimum breaking load. These certificates should always be consulted if it is necessary to ascertain the specification of a particular rope.

NB: When wet, nylon has only 80% of its dry strength. It is the dry MBL which is quoted and due allowance should be made when comparing with other fibres, or when ordering nylon lines.

Synthetic fibre ropes ***give little or no warning when about to break***, and possess low resistance to chafing when under load.

When making synthetic fibre ropes fast to bitts, ***do not*** use a "figure of 8" alone to turn them up. Use two round turns (***but not more***) around the leading post of the bitts before figure of eighting for large size bitts, or around both posts before figure of eighting for bitts with smaller circumference posts. This method allows better control of the rope, is easy to use and is safer.

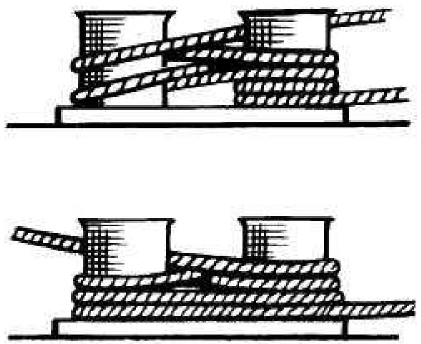


Fig. 27

Rope Care

(a) ***Ropes must be kept clear of chemicals, chemical vapours or other harmful substances.*** They should not be stored near paint or where they may be exposed to paint or thinner vapours.

(b) Ropes should not be exposed to the sun longer than is necessary, as ultra-violet light can cause fibres to deteriorate.

(c) Ropes must be ***visually*** inspected at ***regular*** intervals, and these inspections should include, so far as possible, inspection of the inner strands.

[Excessive wear in ***synthetic*** fibre ropes is indicated by powdering between the strands and results in permanent elongation. This indicates a reduced breaking load, and consideration must be given to replacing the rope. If damage is localised, the worn or damaged part can be cut out and the rope spliced.]

The inspection should include checking for the security of strands in splices.

(d) Ropes must be stowed in a well ventilated compartment on wood gratings to allow maximum air circulation and to encourage drainage.

(e) Do not store ropes in the vicinity of boilers or heaters; do not store them against bulkheads or on decks which may reach high temperatures.

(f) Ensure that fairleads and warping drums are in good condition and free from rust and paint. Roller heads should be lubricated and freely moving to avoid friction damage to the rope.

(g) Do not surge ropes around drum end or bitts, as the friction temperature generated may be high enough to melt the fibres.

(h) Do not drag ropes along the deck; if this is unavoidable, ensure that they pass clear of sharp edges or rough surfaces.

(i) When using winch stored ropes, do not run them through leads which are not on a direct line from the drum, as they are liable to chafe on the edge of the spool.

Rope Stoppers

With the increased numbers and types of man-made fibre rope now available, and the great strength of such ropes, it is essential that when "stopping off" a mooring line the right rope stopper is used. Experience has shown that the ideal rope for stoppers should satisfy the following requirements:

(a) The stopper should be of synthetic fibre rope.

(b) The stopper should be used "on the double".

(c) The stopper should be very flexible and the size should be as small as is possible.

(d) The stopper rope should be of low stretch material.

(e) The man-made fibre ropes used for the stopper should be made from high melting point material, ie. polyester or polyamide.

(f) The double rope used for the stopper should where possible have a combined strength equal to 50% of the breaking load of the mooring rope on which it is to be used.

Fig. 28 shows the correct method of stoppering off a synthetic mooring rope.

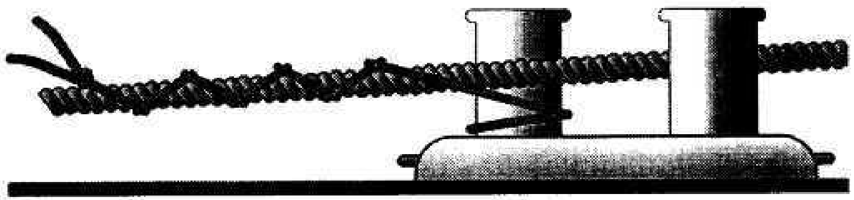


Fig. 28

Splicing

All splices must have a minimum of 5 tucks using ALL the rope strands and it is important to whip all the strands before starting the splice. In the case of plaited ropes, manufacturers normally issue detailed instructions as to how they can be spliced.

When a rope is spliced, its breaking load is reduced by about 10%. However, this figure does not increase if more than one splice is made in a rope.

Snapback

The most serious danger from synthetic ropes is "snapback" which is the sudden release of the energy stored in the stretched synthetic line when it breaks. The primary rule is to treat every synthetic line under load with extreme caution; ***stand clear of the potential path of snapback whenever possible! Synthetic lines normally break suddenly and without warning.*** Unlike wires, they do not give audible signs of pending failure and they may not exhibit any broken elements before completely parting.

When a line is loaded, it stretches. Energy is stored in the line in proportion to the load and the stretch. When the line breaks, this energy is suddenly released. The ends of the line snap back striking anything in their path with tremendous force.

This snapback is common to all lines. Even long wire lines under tension can stretch sufficiently to snap back with considerable energy. Synthetic lines are much more elastic, and thus the danger of snapback is more severe.

Stand well clear of the potential path of snapback (see Fig. 29). The potential path of snapback extends to the sides of and far beyond the ends of the tensioned line.

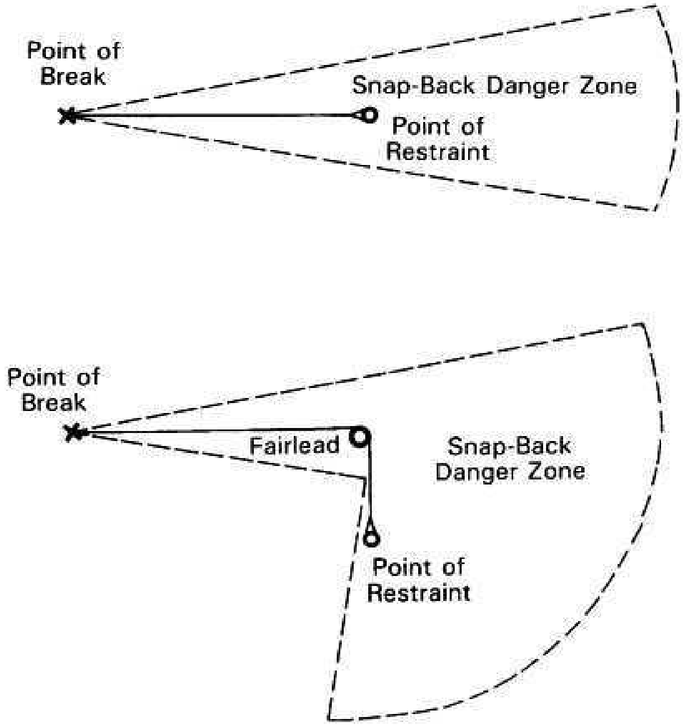


Fig. 29

A broken line will snap back beyond the point at which it is secured, possibly to a distance almost as far as its own length. If the line passes around a fairlead, then its snapback path may not follow the original path of the line. When it breaks behind the fairlead, the end of the line will fly around and beyond the fairlead.

It is not possible to predict all the potential danger zones from snapback. When in doubt, stand aside and well away from any line under tension.

When it is necessary to pass near a line under tension, do so as quickly as possible. If it is a mooring hawser and the ship is moving about, time your passage for the period during which the line is under little or no tension. If possible, do not stand or pass near the line while the line is being tensioned or while the ship is being moved along the pier. If you must work near a line under tension, do so quickly and get out of the danger zone as soon as possible and plan your activity before you approach the line.

SAFETY REMINDERS

DO NOT surge synthetic fibre ropes on the drum end; in addition to damaging the rope, as it melts it may stick to the drum or bitt and jump, with a risk of injury to people nearby. ALWAYS walk a winch back to ease the weight off the rope.

DO NOT stand too close to a winch drum or bitt when holding and tensioning a line; if the line surges you could be drawn into the drum or bitt before you can safely take another hold or let go. Stand back and grasp the line about one metre from the drum or bitt.

DO NOT apply too many turns; generally 4 turns should be taken with synthetic lines — if too many are applied then the line cannot be released in a controlled manner.

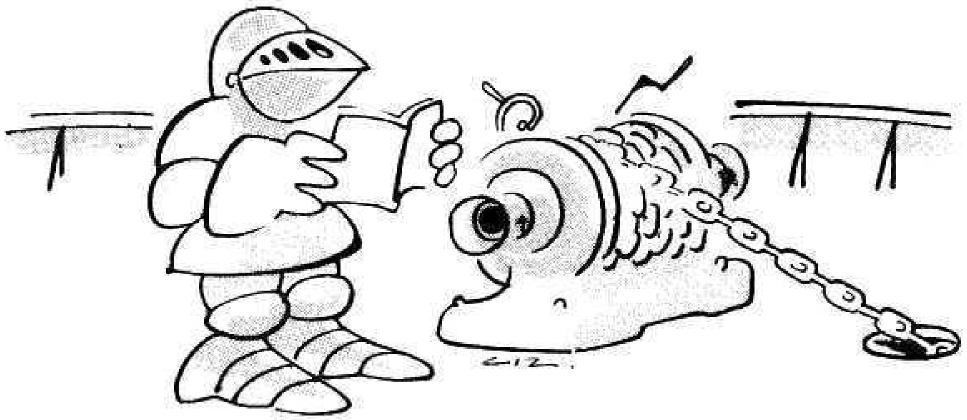
DO NOT bend the rope excessively.

DO NOT stand in the bight of a rope.

DO NOT stand close to a rope under load; it may part without warning.

DO NOT leave loose objects in the line handling area; if a line breaks it may throw such objects around as it snaps back.

DO NOT have more people than necessary in the vicinity of a line.



READ ANY GOVERNMENT NOTICES, COMPANY INSTRUCTIONS OR "CODES OF PRACTICE" ON BOARD YOUR SHIP.

Chapter 5

MOORING AT BUOYS

Conventional or Multibuoy Moorings (CBM or MBM)

Although there are many variations, the basic layout of such a berth is shown in Fig. 30, with the ship moored in position using both anchors forward and with the stern secured to buoys located around the stern.

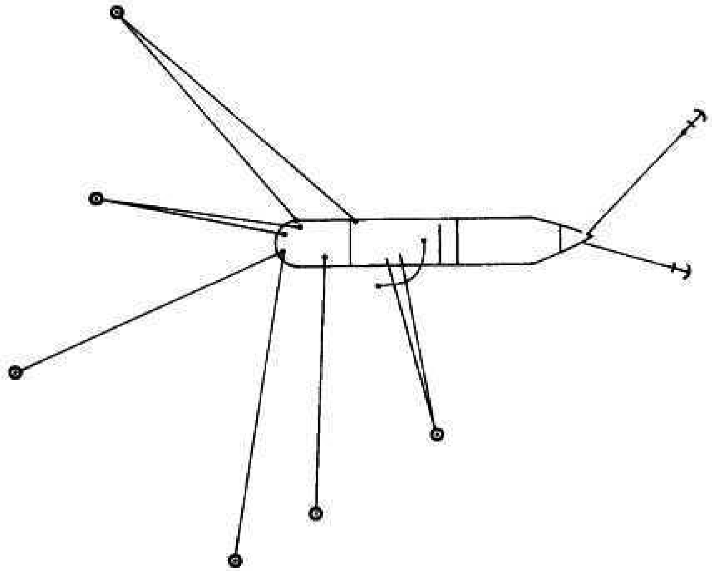


Fig. 30

The mooring operation, which is often carried out without tugs, is difficult and requires the full and efficient use of all the ship's mooring equipment.

The operation starts with the ship carrying out a "running moor" and, while it is most common for the manoeuvre to be started with the stern buoys on the port side of the ship to take advantage of the propeller thrust when the engine is going astern, there are some berths where for a particular reason the manoeuvre has to be started with the buoys to starboard. Fig. 31 shows the different stages of the operation.

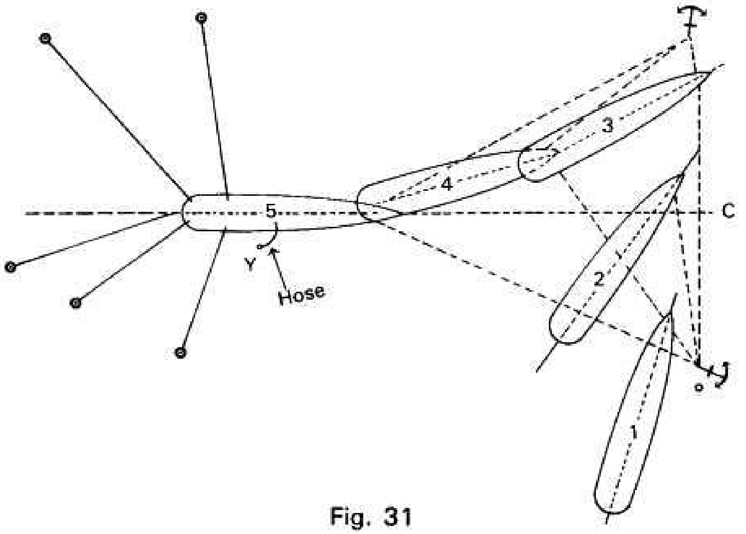


Fig. 31

The tanker steams slowly towards the forward end of the berth in a line almost perpendicular to her final position. At the correct moment, the starboard anchor is let go and the cable is run out as the ship moves ahead, whilst the engine is operated astern; when the ship is stopped in the water the port anchor is let go. By careful manoeuvring of the engines and helm, and by paying out on the port cable whilst heaving in on the starboard cable, the stern of the ship is swing round so that it passes clear of the nearest buoy at the same time as the ship is backing into the sector between the buoys. Mooring lines have to be run to the buoys as quickly as possible in order to assist controlling the swing and to assist in heaving the ship backwards into the berth.

Considerably higher loads than those experienced during a normal berthing operation are imposed on the lines, and it is recommended that only lines on drums be used during such an operation. Because of these higher than normal loads, all the equipment should be thoroughly checked beforehand, and only good quality lines should be used. The number of personnel required should be kept to the essential minimum and should be restricted to experienced seamen. The mooring team should be briefed beforehand and should be under the direct supervision of an experienced officer.

At many CBM's, the ships' moorings are often supplemented by shore wires run from the buoys or from sub-sea platforms. The handling of these heavy wires around the warping drum of a winch and thence to bitts, should be done carefully by experienced seamen. When stopping off the wires prior to securing to bitts, correctly sized carpenters stoppers should be used.

There are often lengthy periods when mooring boats are around the stern, or mooring lines are in the water, and good comunications between poop and bridge are essential to avoid boats or lines from being caught up in the propeller.

Because the whole operation initially depends on dropping the first anchor in the correct place, the approach line and dropping point are usually marked by leading lines or ranges. If the anchor is let go too far away it is virtually impossible to heave the ship into the berth using the lines alone; the best option is to heave up and start again.

Because of the difficulties involved, some terminals provide their own experienced mooring gangs for the berthing operation.

When unberthing, shore wires should be stoppered off with the carpenters stopper, transferred to the winch drum and walked back, using slip wires as necessary. Full length wires should never be let go "on the run", due to the dangerous whipping action of the wire.

The ship's lines are then heaved in as the anchors are both weighed, and the ship moves forward clear of the buoys. The windward mooring line is usually the last one to be let go, in order to prevent the stern dropping on to the lee buoys.

Single Buoy Mooring (SBM)

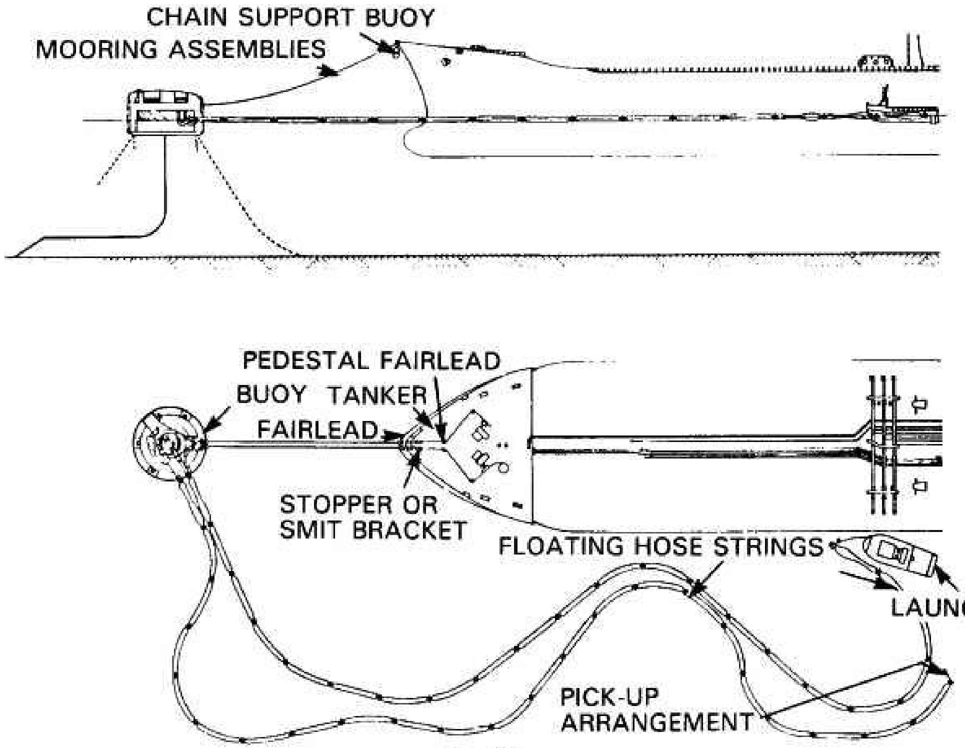


Fig. 32

At an SBM the tanker bow is secured to the buoy using specially supplied moorings which are attached to a swivel on the buoy, thus permitting the tanker to swing around the buoy in response to wind and tides.

Because the ship is only moored at one point, all the load is borne by the one or two mooring lines used. In addition to the normal static loads, considerable dynamic (shock) loads are experienced as the ship moves to wind, tide and sea. It is thus impracticable for the ship's normal mooring lines to be used, and the terminal always supplies special mooring lines. There are normally two lines each of 120–190mm diameter made from nylon or polyester, giving very high minimum breaking loads.

Minimum Breaking Loads		
	Nylon	Polyester
120mm	305 tonnes	219 tonnes
168mm	570 tonnes	430 tonnes
192mm	760 tonnes	550 tonnes

Obviously with the ship moving significantly, the hawsers would quickly chafe on the fairlead. To overcome this, chafe chains are attached to the end of each hawser and it is these chains which pass through the fairleads and are connected on board to specially designed chain stoppers or brackets (see Fig. 33) located on the focsle for this purpose. The chains are 76mm diameter links with safe working loads of 250 tonnes (54mm SWL 100 tonnes for ships below 100,000 DWT).

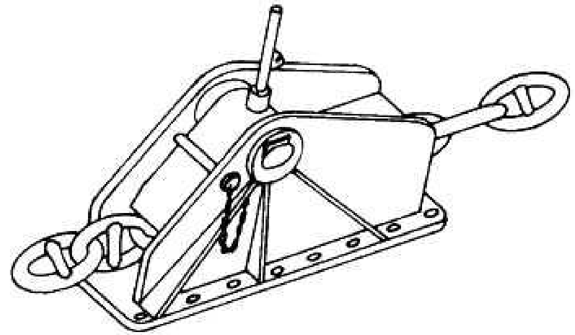


Fig. 33 Tongue Type Chain Stopper

The chains and hawsers are supported by a buoy and attached to the end of the chain is a floating polypropylene pick up rope 80mm diameter 150m long.

Before the ship commences her approach to the buoy, a messenger line should be ready on the focsle running through one of the bow fairleads. This messenger should be 75mm circumference and approximately 90 metres long and should pass through the chain stopper before going to a winch. If possible, the messenger should be secured around a winch drum so that the whole operation can be carried out on a "hands off" basis.

The mooring operation is normally supervised by a pilot stationed on the bow. He should be accompanied by a responsible officer who is in radio contact with the bridge to pass on the pilot's instructions.

In order to avoid damage to submarine pipelines and SBM anchor chains, the ship's anchor should not be dropped except in an extreme emergency.

When the ship is close to the SBM, the messenger is lowered to a mooring boat where it will be connected to the pick up rope and when the boat is clear this should be heaved on board. The pick up rope should be heaved in until the chafe chain passes through the fairlead and reaches the required position. Care should be taken when winching in the pick up rope and chain to ensure that there is always some slack in the mooring assembly. It can be very dangerous to the mooring crew if the assembly becomes tight before connection is completed, and the ship should be carefully manoeuvred to ensure that this does not occur. ***The pick up rope must never be used to heave the ship into position or to maintain its position.*** Once the chafe chain is in position it should be secured to the stopper as quickly as possible.

If the chain is to be attached to a special bracket (Smit bracket), the ship will supply a mooring chain which should be connected to the bracket prior to arrival. The chafe chain is heaved on board so that it passes close to the mooring chain and is stoppered off using special chains and stoppers supplied by the terminal. The chafe chain and mooring chain are then joined using a specially designed shackle provided by the terminal.

Regardless of whether a stopper or bracket is used, once the chain is connected the pick up rope should be walked back until the weight is transferred to stopper or bracket.

Although tending of moorings is not required, an experienced crew member should be posted forward at all times to observe the moorings and the SBM and to advise if the tanker starts to ride up to the buoy or starts to yaw excessively.

When unmooring, the chains should be walked back into the water and the pick up rope slowly paid out through the fairlead.

When mooring to either a CBM or an SBM, always have a few items of essential equipment such as a large axe, sledgehammer, and crow bar readily available to the crew.

Chapter 6

WINDLASSES AND ANCHORING

It is essential that you read your company's rules and regulations concerning anchoring. They will give clear directions for anchoring procedures. Nevertheless, anchor losses sometimes occur on all classes of vessel and have mainly been attributed to:

(a) Too great a speed ***over the ground***.

(b) Too little cable being paid out during the initial lowering of the anchor prior to letting go.

The risk of anchor and cable losses, particularly on large ships such as VLCCs, can be minimised by:

(a) Ensuring minimum or nil speed over the ground by using doppler log (where fitted) or other navigational aids. As a final check, the anchor can be lowered to just touch the bottom to confirm the Master's judgement that the ship has ceased to make way over the ground.

(b) The fitting of a speed limiter to the windlass.

(c) In all cases, the anchor should be "walked" (ie. lowered with the windlass in gear) out of the hawse pipe until just clear of the seabed, thus reducing the amount of "freefall" of the anchor and cable.

(d) Anchoring with the windlass in gear. This gives good control over the anchor and cable throughout the operation. It also helps to maintain brake efficiency by reducing wear of the brake lining.

In all cases, care must be taken to avoid over speeding of the windlass engines to avoid damage.

Brakes

These will be most effective if tightened up at the moment that the maximum weight comes on to the anchor cable. Further adjustment should then be unnecessary, as the changes in load due to changing tides and wind will be borne by the cable stopper.

Cable Stoppers

Cable stoppers form an integral part of the anchor cable restraining equipment and are designed to take the anchoring loads. Cable stoppers must be used when the vessel is anchored, and must be applied only after the brake has been set to ensure that the brake augments the action of the stopper for additional security. Fig. 34 shows the correct way to fit a stopper.

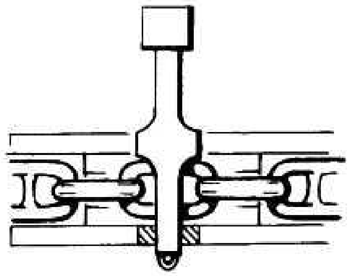


Fig. 34

Consideration may also be given to tying down the cable stopper whenever it is in use, in order to prevent it jumping when under a heavy load.

Cable stoppers must also be in position, together with the securing chains, when the anchor is "home" in the pipe.

Anchor Cables

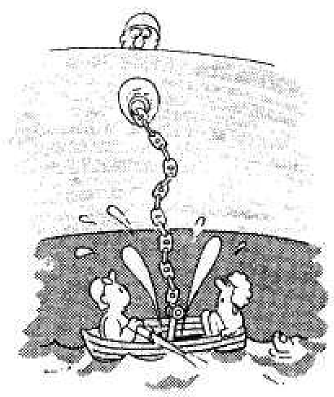
It is very important that anchor cable lengths are clearly marked with white paint and if possible, stainless steel bands, even when cable counters are fitted.

It is also advisable to paint the second shackle from the bitter end red. This will serve as a visual warning of the approach of the end of the anchor cable.

Communication

If you are charged with the duty of controlling the anchor during an anchoring operation, ***be sure that the bridge is aware of precisely what is happening or could happen***, as the Master is, to a large degree, dependent upon your information.

Before lowering the anchor, or indeed, heaving in, check over side for small boats, tugs, etc.



Maintenance of Windlass Brakes

Windlass brakes require careful attention with regard to greasing and adjustment.

Where linkages form part of the braking mechanism, it is important that the linkages are ***free***.

Malfunction can cause the operator to believe that the brake is fully applied when, in fact, ***it is not***.

It is also most important to inspect the tightness of bearing keep nuts and cotter pins, especially after a refit, where it is known that work has been carried out on the assembly.

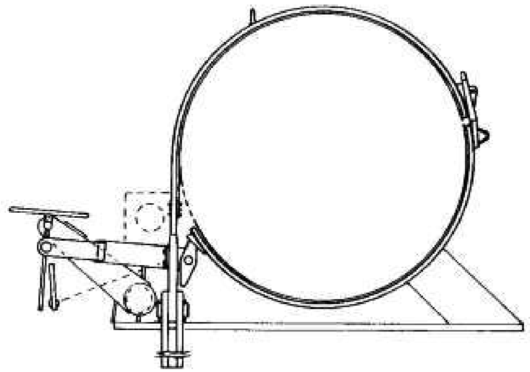


Fig. 35 Typical brake arrangement

Adjustments

Provision is sometimes made to compensate for brake lining wear. Consult the Maker's instructions and make sure you are familiar with this facility.

If in doubt about the brake holding efficiency — REPORT IT!

Prolonged Periods of Non-Use

After a long sea passage and a port call not requiring the use of either anchor, consideration should be given to a controlled walking out (ie. windlass in gear) of the anchors and cable to ensure that the system is still fully operational.

Greasing of bearings, brake linkages, etc, should be carried out during this operation.

SAFETY REMINDERS

DO NOT stand in line with the cable when it is under load or being "run out" or hove in.

The Windless operator *MUST* wear:

(1) Safety goggles; the windlass operator should remember that the wearing of safety goggles may reduce his field of vision, but nevertheless, they must be worn.

(2) Safety helmet.

(3) Safety shoes.

(4) A good pair of overalls with long sleeves.

Flying fragments can injure the operator. Minor injuries could distract him and set the scene for a more serious accident.

Chapter 7

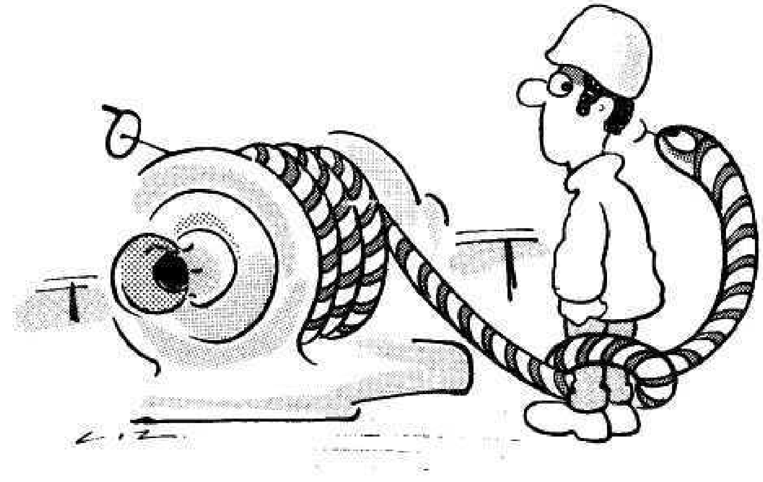
PERSONAL SAFETY

Handling of Moorings

REMEMBER, you stand a greater risk of injuring yourself or your shipmate, during mooring and unmooring operations than at any other time.

STAND CLEAR of all wires and ropes under heavy loads even when not directly involved in their handling.

When paying out wires or ropes, watch that both your own and shipmate's feet are not in the coil or loop. BEWARE THE BIGHT!



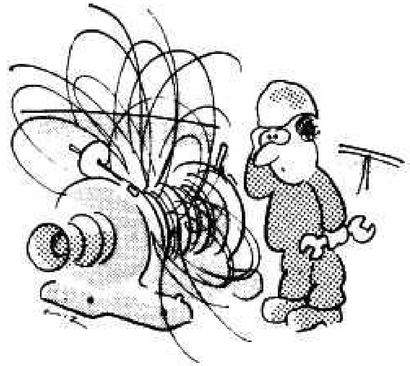
Beware the Bight!!

Always endeavour to remain in control of the line.

Anticipate and prevent situations arising that may cause a line to run unchecked. **If the line does take charge, DO NOT attempt to stop it with your feet or hands as this can result in serious injury.**

Ensure that the "tail end" of the line is secured on board to prevent complete loss.

WHEN OPERATING A WINCH OR WINDLASS, ensure that the man (or yourself) understands the controls and **CAN SEE** the officer or person in charge for instructions.



DO NOT leave winches and windlasses running unattended.

DO NOT stand on the machinery itself to get a better view.

DO NOT use a wire direct from a stowage reel that has been designed only for stowing, but ***do make sure*** you have enough wire off the reel ***before*** you put it into use.

When using a Double Barrel Winch, ***ensure that the drum not in use is clear.***

Safe Handling of Tug Lines

When tugs are used to assist manoeuvring the ship, additional care is required by the ship's crew.

The condition of the tug's lines is unknown, and the crew on mooring stations will not normally be aware of when the tug is actually heaving or what load is being applied to the line. ***It is therefore important to stay well clear of the tow line at all times.***

When the tug is being secured or let go, the person in charge of the mooring should monitor the operation closely to ensure that no load comes on to the line before it is properly secured, or whilst it is being let go.

Never let a tug go until instructed to do so from the bridge; do not respond to directions from the tug's crew.

If the tow line has an eye on it, heave this past the bitts so that there is sufficient slack line to work with, stopper off the line, then put the eye on the bitts. Do not try to manhandle a line on to the bitt if there is insufficient slack line. If the line has no eye and is to be turned up on the bitts then it should ***always*** be stoppered off before handling it.

Do not try to hold a line in position by standing on it just because it is slack — ***if the tug moves away so will you!***

When letting go do not simply throw the line off the bitts and let it run out; always slack it back to the fairlead in a controlled manner, using a messenger line if necessary to avoid whiplash.

Gloves

Gloves protect the hands against abrasion and also give insulation against very hot or cold conditions, both of which could affect a person's handling of equipment.

Wire should not be handled without leather or similar heavy protective gloves. These can prevent wounds caused by "snags" (broken wire strands). Such wounds may become infected and may bring about medical complications.

Loose fitting gloves are more liable to become trapped between wires and other equipment such as drum ends or bollards and do not give the necessary degree of protection.

In any event, it must always be remembered that gloves cannot be relied upon to give complete protection against snags in the wire. Also, that such snags may catch in the material and endanger life and limb through trapping.

Such an event can be prevented by attention to the good practices described in this book.

SAFETY REMINDERS

DO NOT attempt to handle a wire or rope on a drum end, UNLESS a second person is available to remove or feed the slack rope to you.

DO NOT work too close to the drum when handling wires and ropes. The wire or rope could "jump" and trap your hand.

ALWAYS wear safety helmets with chinstraps properly tightened during mooring operations.

Gear wheels and other moving parts must be protectively covered. If any guards are missing:

★ REPORT IT!

★ Have them replaced as soon as possible.

KEEP YOUR DISTANCE.