NMC 68 – SAFE MOORING OPERATIONS

A. INTRODUCTION

Present handout is only a basic guideline that should be taken into account by Master and Deck Officers while performing mooring operations. The procedures explained here are only indicative, not exhaustive in nature, and one must always be guided by experience, knowledge and good seamanship practices.

This course has been developed in response to the prevailing incidents and accidents onboard ships related to mooring operations. To minimize the risks, Officers and Crew on board vessels must have good knowledge and understanding about mooring operations and equipment limitations.

B. OBJECTIVES

Those who successfully complete this course should be able to:

- Understand the basic principles of mooring operations;
- Be familiar with types of ropes and wires used in mooring operations;
- Understand the basic principles of anchoring maneuver;
- Be aware of the risk involved – Job hazard analysis and risk assessment;
- Relate and learn from the mooring accidents and incidents;
- Have basic knowledge about the mooring equipment;
- Be familiar with Company SMS – safe mooring practice and guidelines;
- Be able to understand and use proper communication – hand and whistle signals;
- Be familiar with Company standards regarding testing, inspection and maintenance of the mooring hawsers and mooring equipment, and
- Be able to conduct a practical simulation of mooring operations.

This training course will equip crew who are directly involved in mooring operations with the practical know-how and a prepared state of mind when engaging themselves in actual mooring on board.

FURTHERMORE, the Master shall ensure that mooring operations (including interaction with Tugs) are carried out in a safe manner and the following items are properly addressed:

• Suitable briefing, planning, training and supervision of all involved personnel.

• Proper communication.

• Competency of personnel and sufficient members in the mooring teams.

• Safety issues and risk assessment.

• Familiarity with own Vessel’s equipment and any specific shore requirements relating to moorings, passing traffic and tidal/weather conditions.

All mooring equipment and practices shall comply with Company’s SMS, with all applicable guidelines (for Tankers as per OCIMF) and with all applicable international / local regulations.

Any unsafe situations shall be identified, evaluated and recorded, corrective actions shall be implemented as necessary.

Master, deck Officers and Crew must be fully familiar with own Vessel’s mooring equipment:

- specifications
- number, location and general arrangement plan
- maintenance condition
- operating condition
- type, characteristics and technical parameters
- power and limitations
- illumination and markings
- safety issues, emergency procedures
- calibration and testing
- abnormalities, malfunctions and damage history.

- The objective of an effective mooring system is to ensure that the ship lies securely alongside, regardless of weather, waves, currents, cargo operations, tides, etc.

- Theory of Mooring examines the various forces acting upon a moored ship in the transverse, longitudinal and vertical directions. It explains the interaction between these forces and shows how they influence the choice of the most appropriate mooring scheme.
- The programme will include typical mooring schemes. Also discussed are load sharing between wire and synthetic fibre ropes, the effect on holding power of line length and orientation.

Chapter 1 – BASIC PRINCIPLES OF MOORING

1.1 THEORY OF MOORING

The term “MOORING” refers to the system for securing a ship to a berth / terminal or any other loading / discharging facilities.

A mooring system should be able to prevent the ship from drifting away from a berth, holding her in a stable position relative to the loading / discharging facilities against any forces that might move her away from the designated position. Therefore, operations associated with berthing a ship alongside a berth/terminal or jetty is basically referred to as mooring.

Mooring and unmooring operations are two of the most critical operations that are carried out onboard. The ability to carry out safe mooring operations is paramount since the whole vessel’s operations are depending on those; nevertheless, high risks of injury to personnel and damage of the vessel and environment are involved, therefore special attention and precaution must be exercised.

Good ship mooring management requires a knowledge of mooring principles, information about the mooring equipment installed on the ship, proper maintenance of this equipment, and good, seamanlike line tending.

Officers in charge of line tending and personnel assigned to tend lines should be aware of the capabilities of the equipment installed on their ship. Specifications should be available on the winch drum to show the design holding capacity and the torque required on the hand wheel or lever to achieve this. Specifications of the mooring lines should also be available. Recommendations concerning the proper direction of reeling of the wire on the drum should be followed and the drum should be marked accordingly to prevent any possibility of error.

Mooring is solely regarded as the ship’s responsibility and a properly moored ship is the most important requirement for safe terminal operations. Likewise it is the terminal’s responsibility to ensure that the berth made available for the ship can properly accommodate and secure the vessel alongside.

It requires also the shore mooring team to be adequately trained, experienced and supervised. They would need sufficient understanding of the requirements of the vessel. The vessel’s Master and/or Pilot have the responsibility for the safety of vessel’s mooring operation. The mooring team will also need to understand the hazards associated with the time, location, prevailing weather and tidal conditions at the berth.
Attention, in many Ports is considered an offense to use Vessel’s crew to cast-off or to make fast the lines on the shore bollards

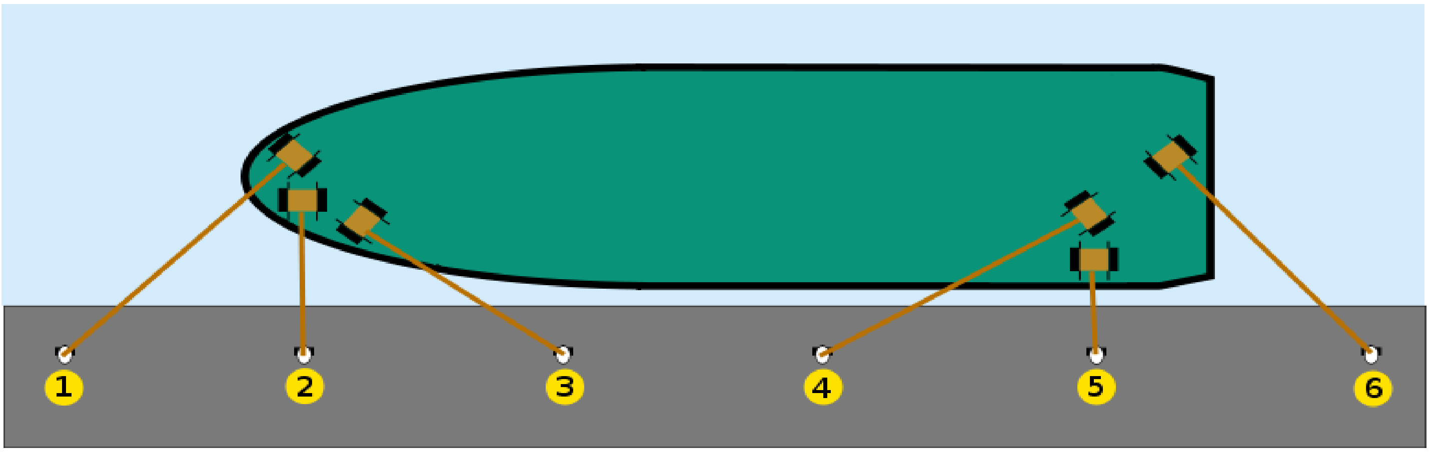
The lines and cables usually belong to the vessel and remain with the vessel when it is on passage. As the vessel approaches the berth, one end of each of the lines/cables is sent ashore by mooring boat or heaving line, so that it can be secured onto the bollard or hook on the berth. Once secured, the vessel might use own lines to come into position alongside, and/or a combination of tugs, engine movements and bow/stern thrusters. Most vessels use shore based mooring gangs to attach the lines to the bollards, with or without mooring boats.

1.2 STANDARD MOORING LAY-OUT OF SHIP AND GENERAL ARRANGEMENT

In order to understand the concept of mooring systems, each seafarer should first be familiar with the mooring lay-out and plans on board own ship. Each line on board has a corresponding term, function and effect on mooring. On the picture shown each mooring line from ship to shore is specifically labeled. Each line serves a specific purpose in keeping the ship alongside its berth, jetty, quay, etc.

- The term “mooring pattern” refers to the geometric arrangement of mooring lines between the ship and the berth.
- The generic mooring layout is mainly applicable to a multi-directional environment and to the design of ship’s equipment.
- Multi-directional is where no single direction dominates OR where any of the environmental forces become a dominant factor.

- The most efficient line “lead” for resisting any given environmental load is a line orientated in the same direction as the load.



1. Headline / Bowline – prevents the ship from moving astern and bow moving away from berth.
2. Forward Breast line – keeps the ship’s bow from moving away from berth.
3. Forward Spring line – prevents the ship from moving ahead and bow moving away from berth.
4. Aft Spring line – prevents the ship from moving astern and stern moving away from berth.
5. Aft Breast line – keeps the ship’s stern from moving away from berth.
6. Stern line – prevents the ship from moving ahead and stern moving away from berth.

Lines 1 and 4 work together in to keep the ship from moving astern while lines 3 and 6 prevent the ship from moving ahead. Lines 2 and 5 are most common on tankers and wide heavy vessels to keep them from moving away from their berth. Depending on their angles, lines 1, 3, 4 and 6 also prevent vessel from moving away from the berth.

All mooring lines control a ship’s motion and make the ship fast to a fixed position. Head lines and Stern lines are used to control surge, sway and yaw; Spring lines control the drift / parallel movement of the vessel along the berth. Moreover, since it is desirable that each line be extended as far as possible, attention to be paid during berthing to ensure maximum lengths, or additional lines to be considered.

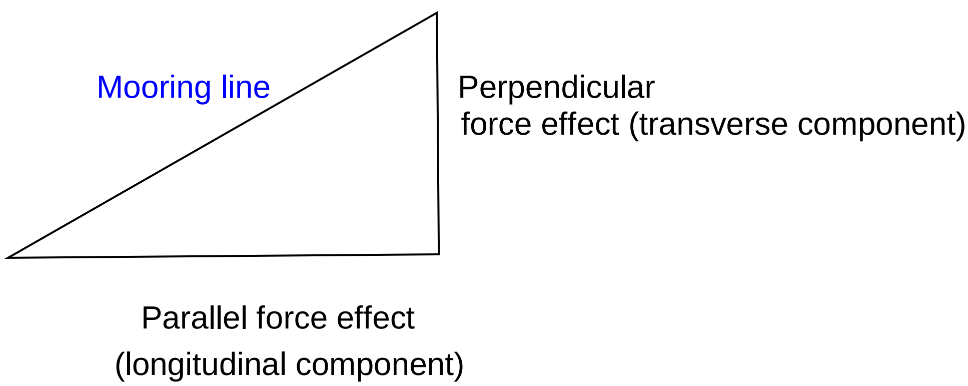
- For general applications, the mooring pattern must be able to cope with environmental forces from any direction.
- This is done by splitting these forces into transversal and longitudinal components, and then calculating how to most effectively resist them.
- Some mooring patterns incorporate head and stern lines which are oriented between a longitudinal and transverse direction. The longitudinal component of such a line acts like a spring line and the transverse component like a breast line.

- Head and stern lines are only partially effective in providing the transverse restraint.

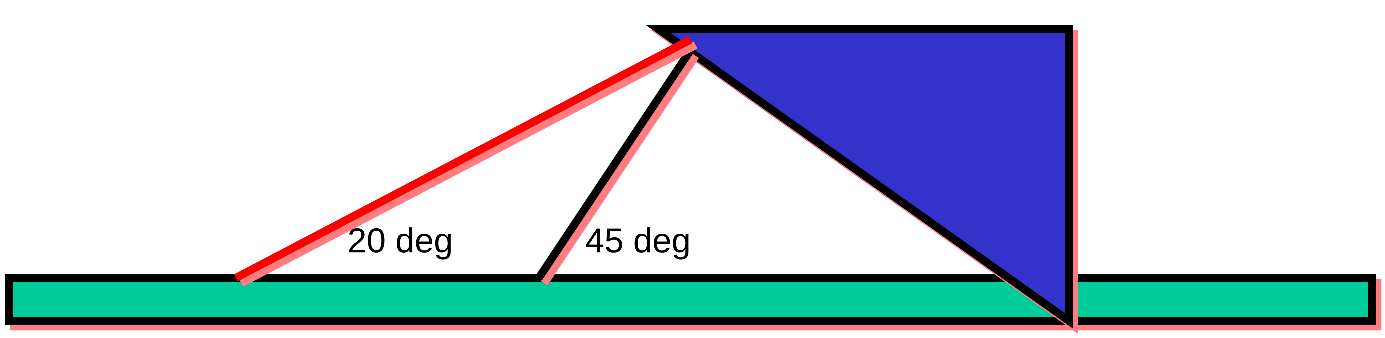
- The effectiveness of a mooring line is influenced by 2(two) angles: the vertical angle the line forms with the pier, and the horizontal angle the line forms with the parallel side of the ship.

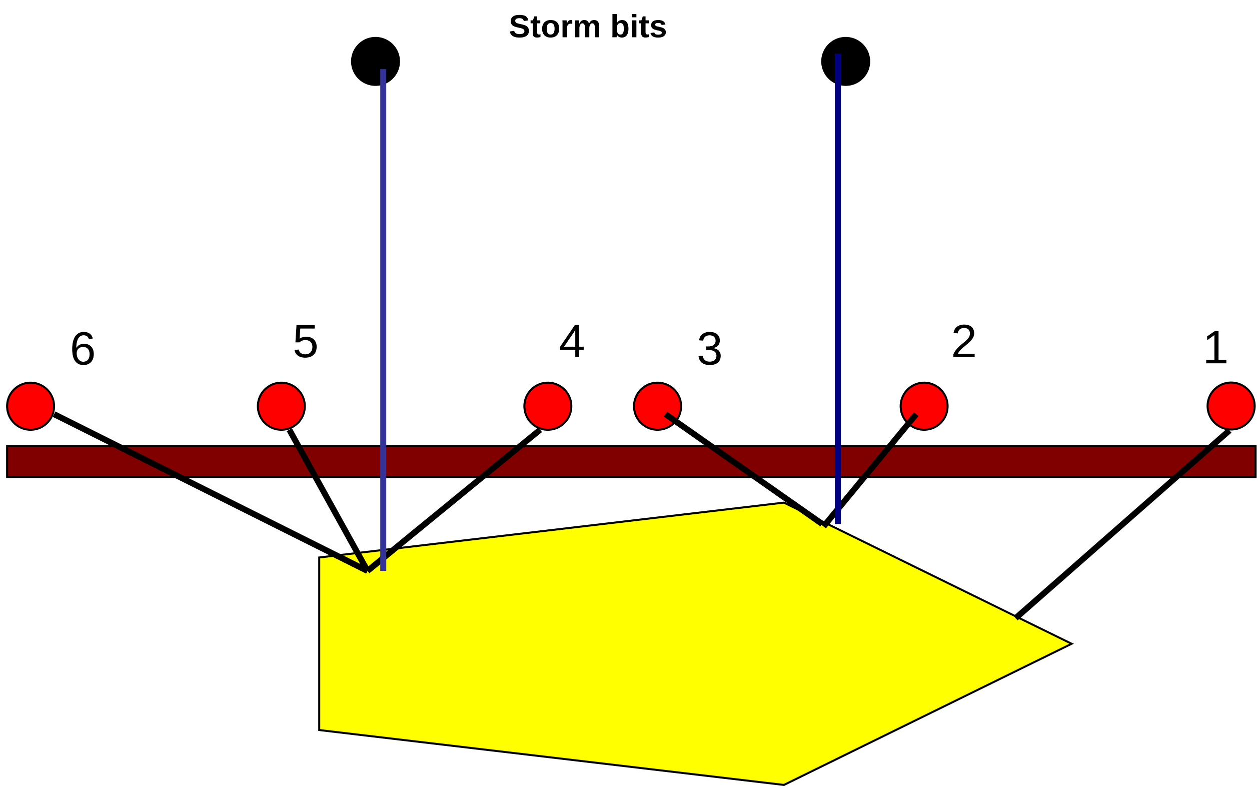
- The steeper the orientation of the line, the less effective is in resisting horizontal loads; similarly, the larger the horizontal angle (between parallel side of ship and the line), the less effective the line is in resisting a longitudinal force.

- For instance, a line oriented at a vertical angle of 45° is only 75% as effective in restraining the ship as a line oriented at a 20° vertical angle. Similarly, the larger the horizontal angle between the parallel side of the ship and the line, the less effective the line is in resisting a longitudinal force.



As an example, a line orientated at a vertical angle of 45deg is only 75% effective in restraining the ship, compared to a line orientated at a 20deg vertical angle.





- Obviously there is a basic *difference in the function of spring and breast lines* which must be well understood. Spring lines restrain the ship in two directions (forward and aft); breast lines restrain in only one direction (off the berth), restraint in the on-berth direction being provided by the fenders and breasting dolphins. Whereas all breast lines will be stressed under an off-berth environmental force, only the aft or the forward spring lines will generally be stressed.

- For this reason the method of line-tending differs between spring and breast lines. Some mooring patterns incorporate head and stern lines which are oriented between a longitudinal and transverse direction. The longitudinal component of such a line acts like a spring line and the transverse component like a breast line. Under tension, the longitudinal components of head and stern lines oppose and tend to cancel each other, and are therefore ineffective in the longitudinal restraint of the ship. Head and stern lines are only partially effective in providing the transverse restraint. Their effectiveness will be further reduced due to elasticity effects if they are arranged in combination with breast lines.

1.2.1 Basic Mooring Guidelines – assuming that the moored ship may be exposed to strong winds or current from any direction:

• Mooring lines should be arranged as symmetrically as possible about the midship point.
• Breast lines should be oriented as perpendicular as possible to the longitudinal centre line of the ship and as far aft and forward as possible.
• Spring lines should be oriented as parallel as possible to the longitudinal centre line of the ship. Head and stern lines are normally not very efficient in restraining a ship in its berth. Mooring facilities with good breast and spring lines allow a ship to be moored most efficiently, virtually within its own length. The use of head and stern lines requires two additional mooring dolphins / bollards and decreases the overall restraining efficiency of a mooring pattern when the number of available lines is limited. This is due to their long length and consequently higher elasticity and poor orientation.
• The vertical angle of the mooring lines should be kept to a minimum. The flatter the mooring angle is, the more efficient the line will be in resisting horizontally-applied loads on the ship.
• Mooring lines of the same size and type (material) should be used for all leads. If this is not possible due to the available equipment, all lines in the same service, i.e. breast lines, spring lines, head lines, etc. should be the same size and type. For example, all spring lines could be wire and all breast lines synthetic. First lines ashore can be synthetic lines, even though the main mooring lines are wire. This is acceptable as long as it is realized that the fibre lines will not add to the final restraining capacity of the system unless all lines in that group are of the same material.
• If tails are used on the wires, the same size and type of tail should be used on all lines run out in the same service. Synthetic tails are often used on the ends of wire lines to permit easier handling and to increase line elasticity.
• Mooring lines should be arranged so that all lines in the same service are about the same length between the ship's winch and the shore bollard. Line elasticity varies directly with line length and shorter lines will assume more load.

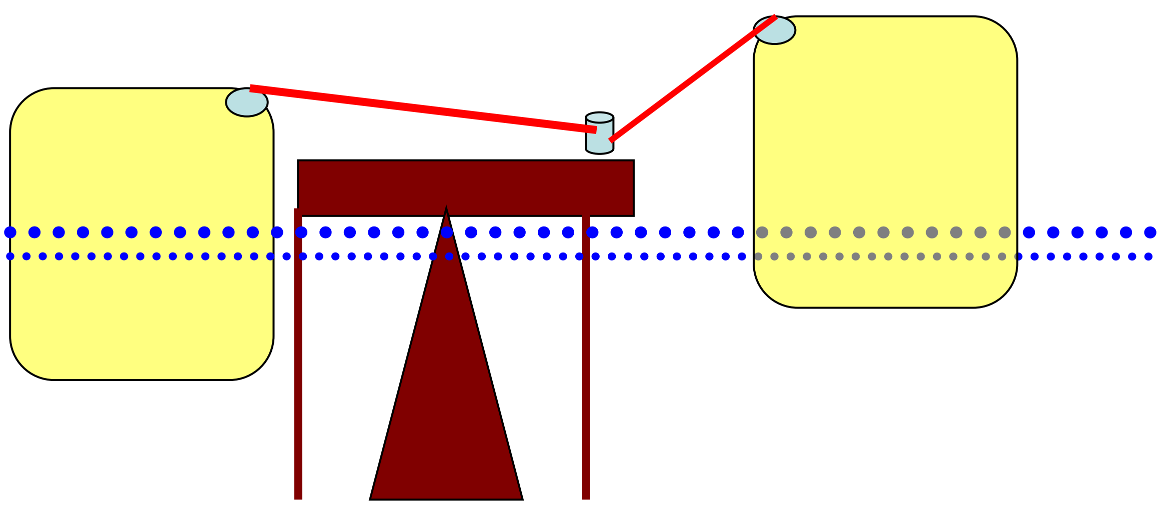
- The above mooring guidelines were developed to optimize load distribution to the moorings. In practice, final selection of the mooring pattern for a given berth must also take into account local operational and weather conditions, pier geometry and ship design. Some pilots, for example, desire head and stern lines to assist ships moving into, along, or out of a berth, while others may use spring lines for this purpose. Head and stern lines would be advantageous at berths where the mooring points are too close to the ship and good breast lines cannot be provided, or where the bollards are located so that the spring lines will have an excessive vertical angle in the light condition, although these excessive angles would result in considerably reduced restraint capability.

- High winds and currents from certain directions might make it desirable to have an asymmetrical mooring arrangement. This could mean placing more mooring lines at one end of the ship.

- The other factor to consider is the *optimum length* of mooring lines. It would be desirable to keep all lines at a vertical angle of less than 25°. For example, if the ship's chock location is 25m above the shore mooring point, the mooring point should be at least 50m horizontally from the chock. Long lines are advantageous both from standpoint of load efficiency and line-tending. But where fibre ropes are used, the increased extension can be a disadvantage by permitting the ship to move excessively, thereby endangering loading arms. Very short lines should be avoided if possible, as such lines will take a greater proportion of the total load in case of ship's movement; Short lines are also the ones most seriously affected by "**dip**".

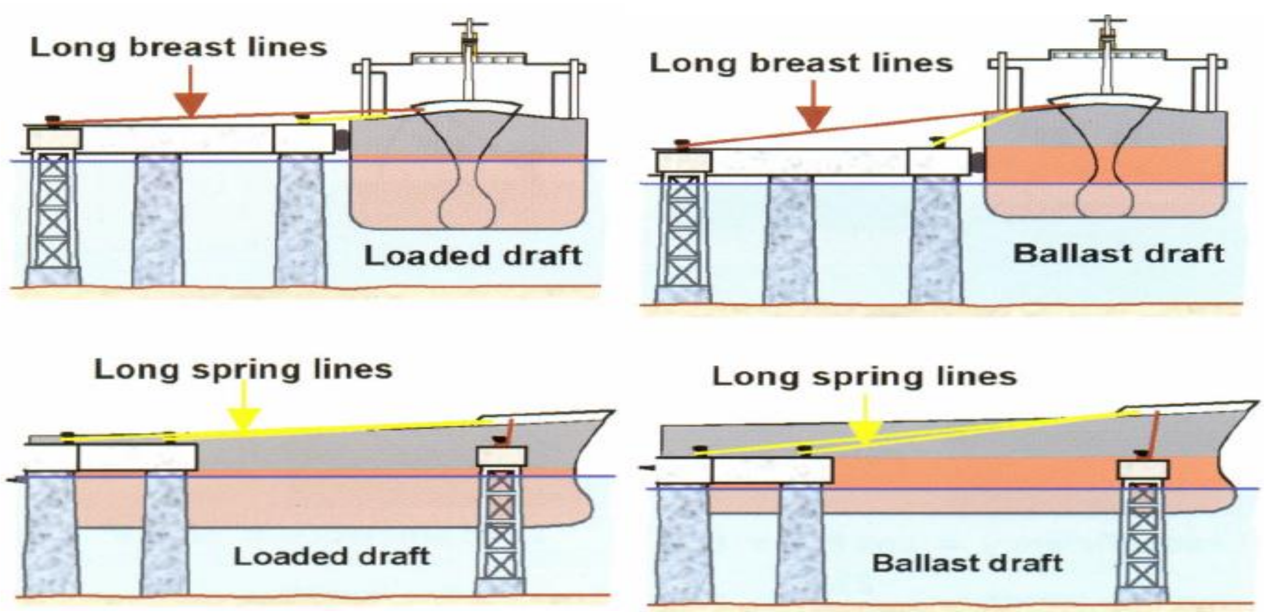
1.2.2 THE "DIP" EFFECT:

- If a mooring line has to be run around a corner, or be set at an angle along its length – such as when it passes through a fairlead and angles sharply down to a bollard below – then its restraining power on the vessel is reduced;
- The restraining power of an angled mooring line is proportional to its angle: the bigger the angle, the more the line's power is reduced.
- For example a mooring line angled at 30deg / 45deg has only 87% / 71% of its normal horizontal strength.

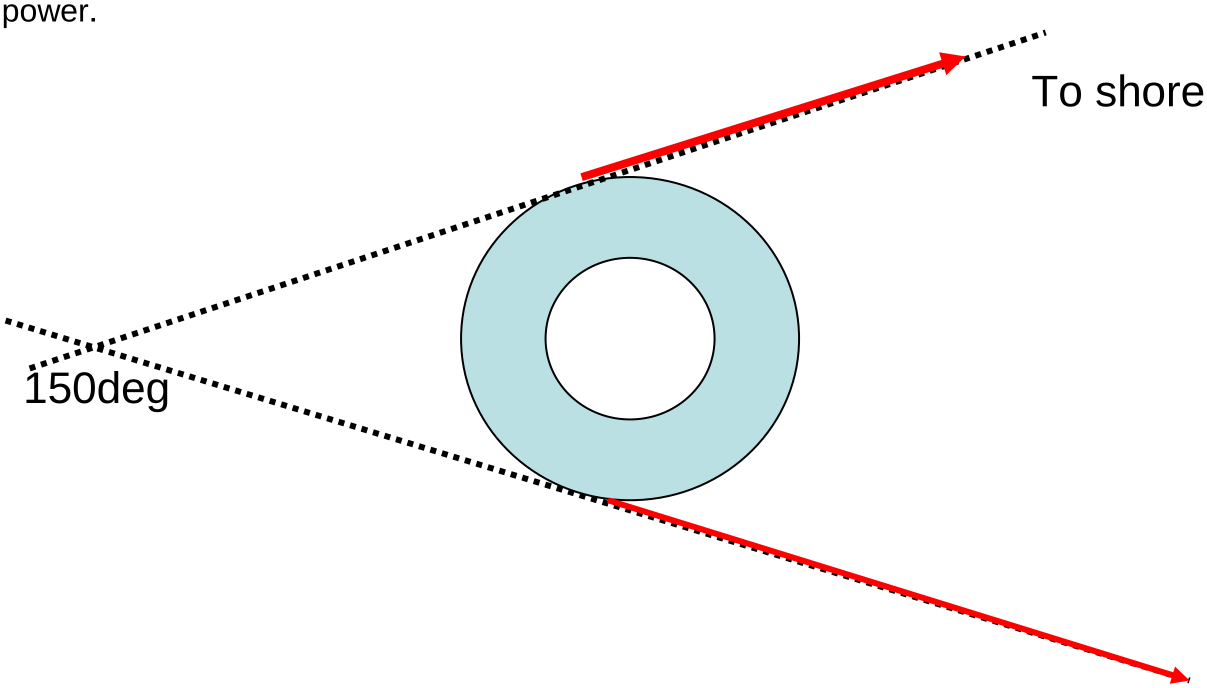


A short mooring line from a ship to a bollard close to and below its fairlead can mean the line loses much of its holding power.

- Example: a Tanker alongside a jetty with the spring lines made fast to the loading platform amidships and the breast lines secured to bollards set into dolphins. The tanker's breast and spring lines remain closer to the horizontal and so are less affected by the draft change if the length of the lines is increased.



1.2.3 THE "BEND" EFFECT - Taking a wire line round a sharp edge or corner might not only cause it damage, it can also lead to loss of load-holding power. If a wire line is looped horizontally at too big angle around a fairlead on deck, this also can cause it to lose load holding power.



A mooring line running at an angle from a quayside bollard to a deck winch can have its

MBL reduced – the amount of MBL loss depending on the degree of angle in the line.

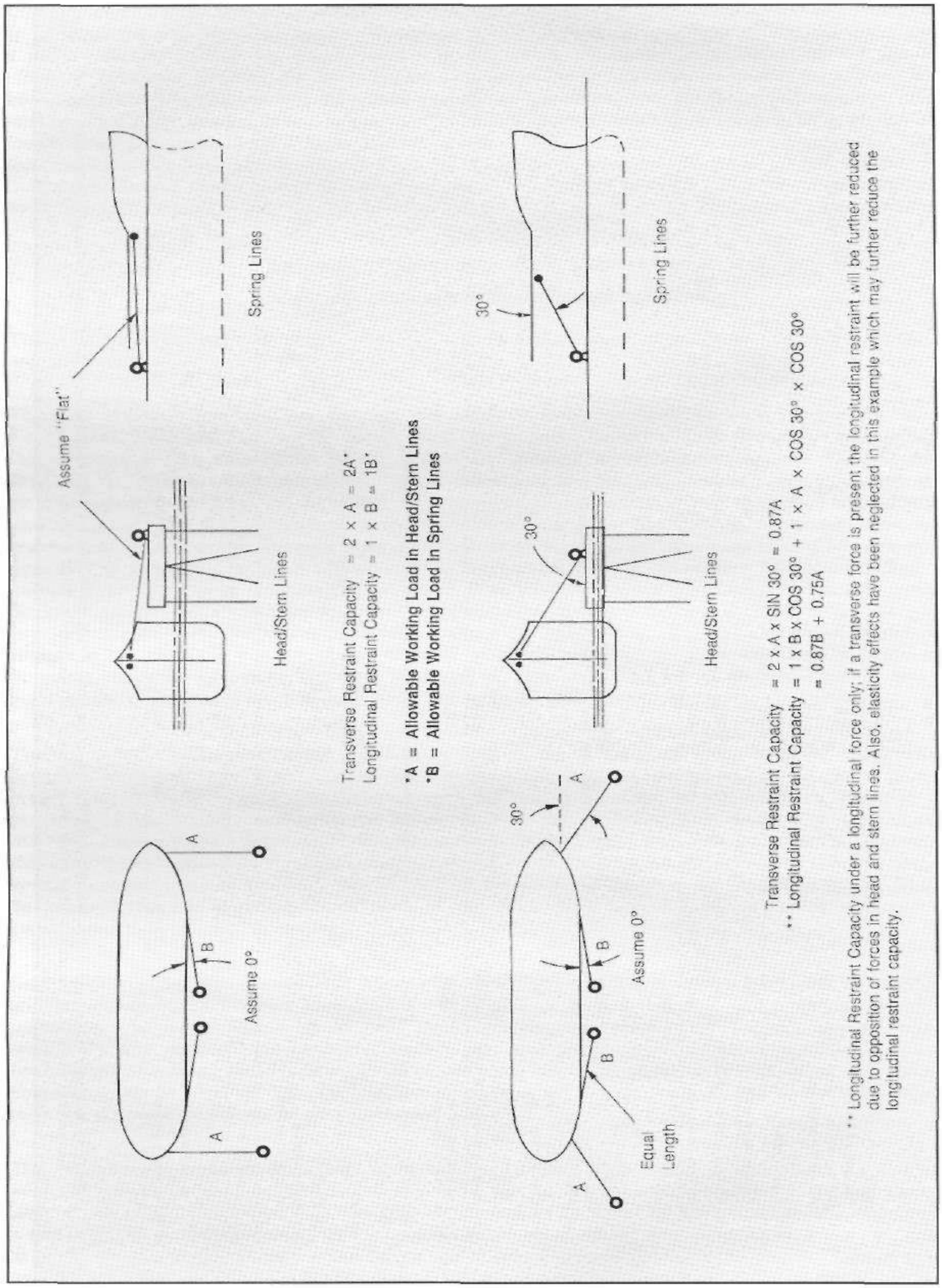
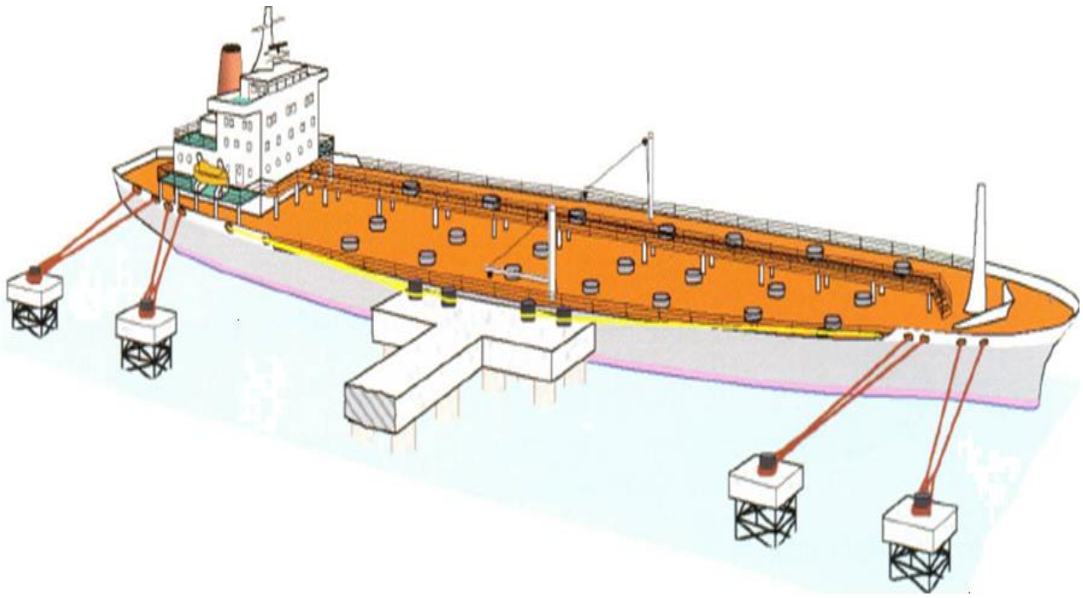
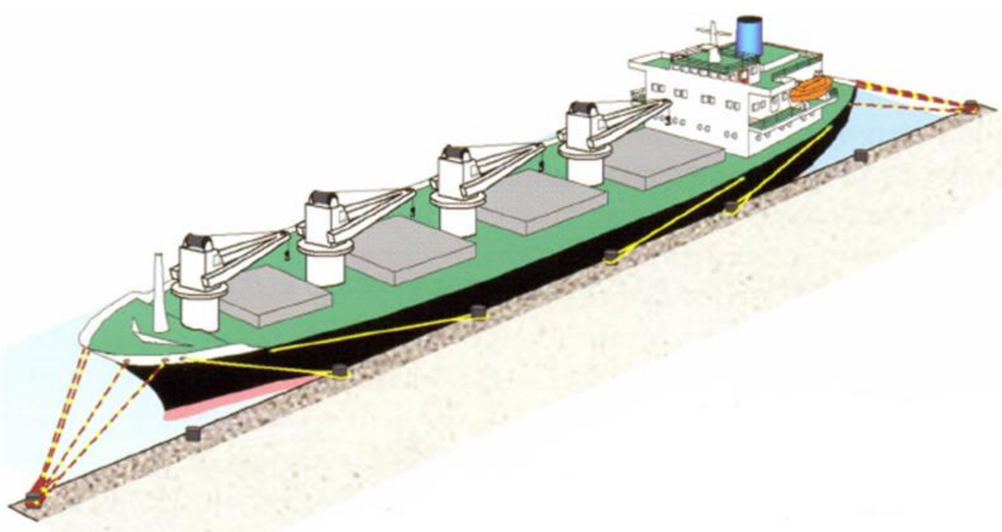


FIGURE 1.5: EFFECT OF HAWSER ORIENTATION ON RESTRAINT CAPACITY

1.2.4 Typical Mooring Arrangements:

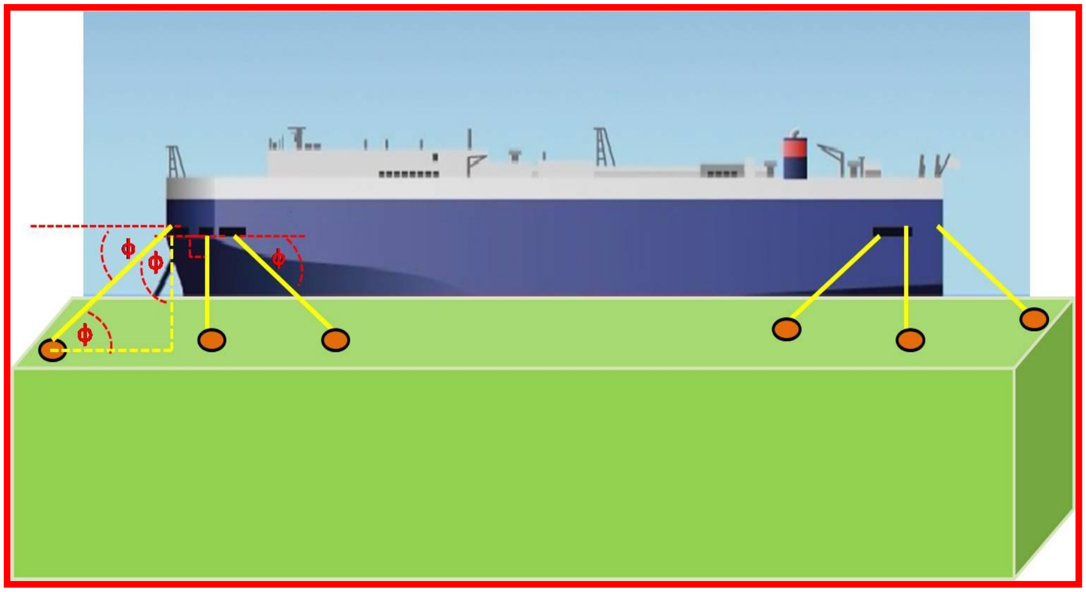


Typical mooring layout for a Tanker vessel alongside



Typical mooring layout for a Cargo vessel alongside

Typical Mooring Set-up Forward



- With the headlines leading at 45° degrees to the breast lines, 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 breast line and spring line sharing the remaining 59%.

- Space on the foredeck is limited so only the spring and offshore headlines are flaked out along the deck ready for being sent ashore. The remaining lines can be flaked out after these lines have been made fast.

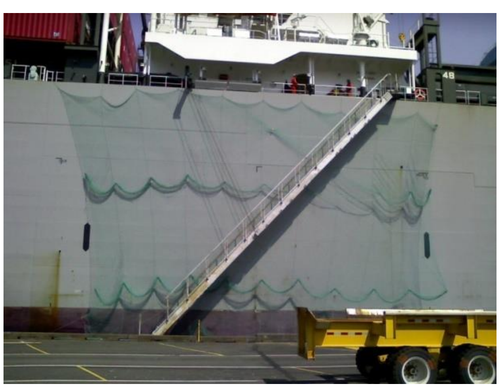
<u>1.3 DEFINITIONS OF MOORING TERMS</u>:

- “<u>LET GO</u>” - At this order remove the turns and slack down the hawser. When the eye of the hawser is removed from the shore bollard, heave it in, but if it is the last hawser to a buoy, do not remove the turns suddenly, as the hawser will have a lot of strain on it; slack away gradually at first until the hawser stops slackening itself.
- “<u>MAKE FAST</u>”- At this order, make fast the hawser on the bitt. If the hawser is on the drum and it has to be transferred to the bitts, pass a stopper on the hawser and when ready, slack a little hawser from the drum or walk the winch back a little so as to shift the strain gently onto the stopper. When the stopper has taken the strain, quickly remove the hawser from the drum and make it fast on the bitt, taking in all the slack.
- “<u>SINGLE UP</u>” - It means that all lines should be cast off except those as advised by the master. When the ship is to leave berth, stations are called and the crew take in all extra hawsers, so that when the order “let go” is given, there are only one or two ropes to contend with. generally this order is qualified by stating what lines are to be kept, e.g., “single up to a line and backspring, or single up to a slip wire”.

- “<u>SLACK AWAY</u>” – it means the hawser should be paid out.
- “<u>CHECK THE ROPE</u>” - This order is heard when the hawser is being slacked away. On hearing this order, take one more turn on the bitt or drum and pull on the inner part of the hawser. Let the hawser become tight but feed a little slack as soon as the hawser gets too tight.
- “<u>HOLD ON</u>**”** - It means that the hawser should not be slackened any more and should be stopped wherever it is. Carry out this order by taking one more turn on the bitt or drum. Of course do not break the hawser and always avoid over-load.
- “<u>RAT GUARDS</u>” – Circular plates used to prevent ship’s rats going ashore and shore rats coming on board; all ropes leading ashore must have rat guards fixed on them.
- <u>STOPPERS</u> – Are used to hold tight mooring ropes or wire ropes while it is being transferred from the warping drum to the bitts and vice versa. Rope stoppers are used on manila and nylon hawsers, and chain stoppers are used for wire ropes.
- <u>HEAVING LINE</u> – Is a light thin rope, about 15 fathoms long. It may be either a 6 mm or 8 mm (dia.) vegetable fibre rope or a nylon rope. One end of it is weighted by making a monkey fist or a heaving line knot on it and the other end is just whipped.
- <u>MESSENGER LINE</u> – It is a 16 or 20 mm (diameter) rope used for bringing on board a heavy hawser when a heaving line is not strong enough; usually used for picking up tug’s lines.
- “<u>HEBEYST</u>” **-** means “<u>HEAVE AWAY</u>”. Take three turns of the hawser round the warping drum and pull on the inner part of the hawser just behind the turns. If due to heavy strain the turns slip, take another turn on the drum.
- “<u>OFF TURNS</u>” - it means “remove all turns from bitt or drum”.
- <u>Windward</u> – The general direction from which the wind blows; opposite of leeward.
- <u>Leeward</u> – On or towards the sheltered side of a ship.
- Newton (N) – A unit of force. A Newton is the amount of force required to accelerate a body from rest with a mass of one kilogram at a rate of one meter per second squared. One Newton is equal to 0.10197 kilogram-force (kgf).

<u>1.4 BASIC KNOWLEDGE OF SHIP’S STRUCTURE:</u>

- <u>Accommodation ladder (gangway)</u> can be parallel or rectangular to the ship's board.



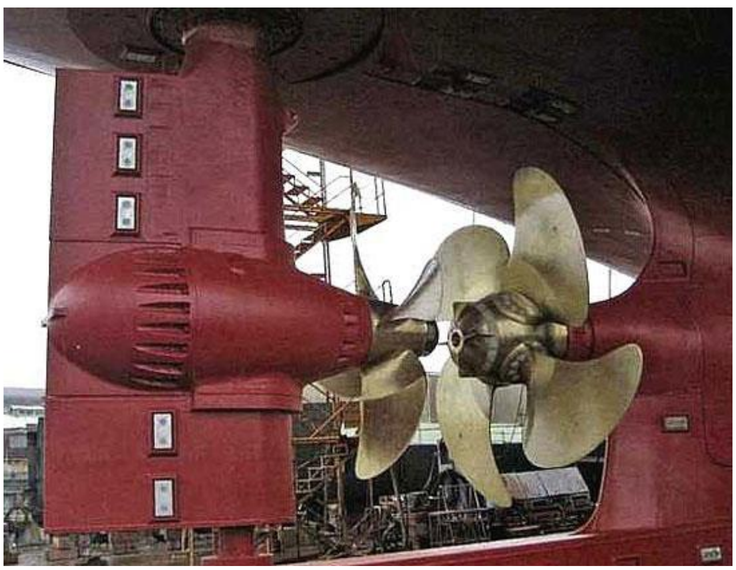
The ladder has handrails on both sides for safety. The construction of an accommodation ladder ensures that the steps are horizontal in each angle of inclination of the ladder. The lower platform is based on a roll to compensate the motion of the ship relation to the quay.

<u>Accommodation - Bridge</u> – ship's superstructure which houses the crew quarters, living spaces and offices. The top deck contains the navigational Bridge with maximum visibility

<u>Forecastle</u> – the section of the upper deck of the ship located in the bow. This section contains the mooring equipment for anchoring and berthing. Common to most ships the deck store or "Bosun's Store" is located below this deck for storage of spares and equipment.

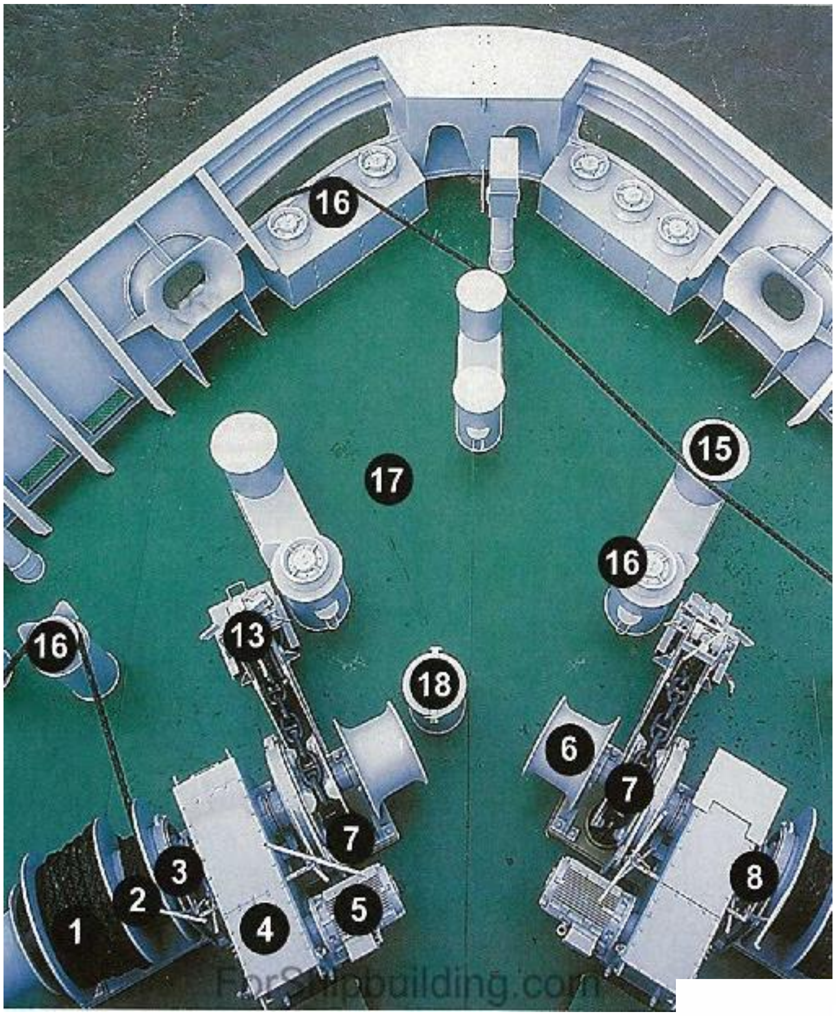
<u>Poop Deck</u> – the section of the main deck of the ship located in the stern.

A propeller is the propulsion of the ships, made up of sections of helicoidally shaped surfaces which act together 'screwing' through the water. Three, four, or five blades are most common in marine propellers. The blades are attached to a boss (hub), which should be as small as the needs of strength allow - with fixed pitch propellers the blades and boss are usually a single casting. An alternative design is the controllable pitch propeller (CPP, or CRP for controllable-reversible pitch), where the blades are rotated normal to the drive shaft by additional machinery - usually hydraulics - at the hub and control linkages running down the shaft.

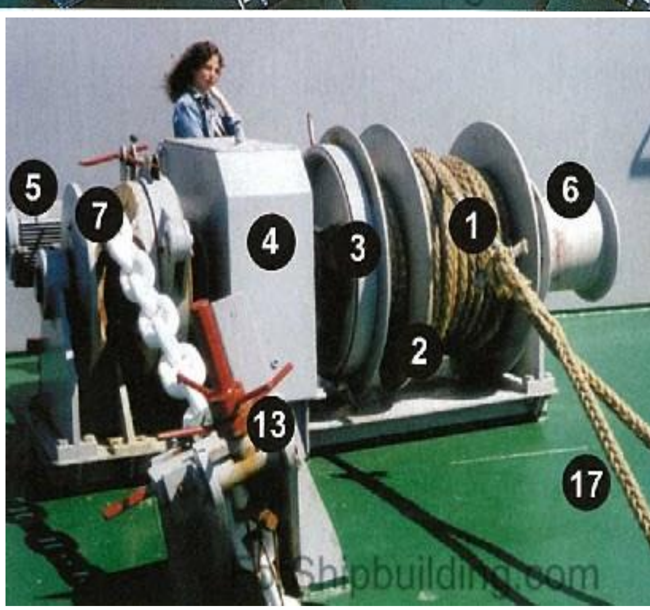


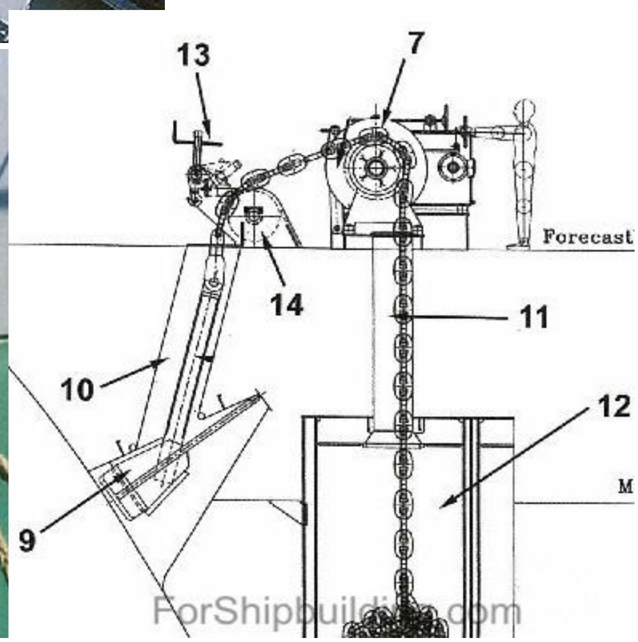
This allows the drive machinery to operate at a constant speed while the propeller loading is changed to match operating conditions. It also eliminates the need for a reversing gear and allows for more rapid change to thrust, as the revolutions are constant.

Special attention to be carried out during mooring and unmooring – avoid ropes to be caught by the propeller(s) !!

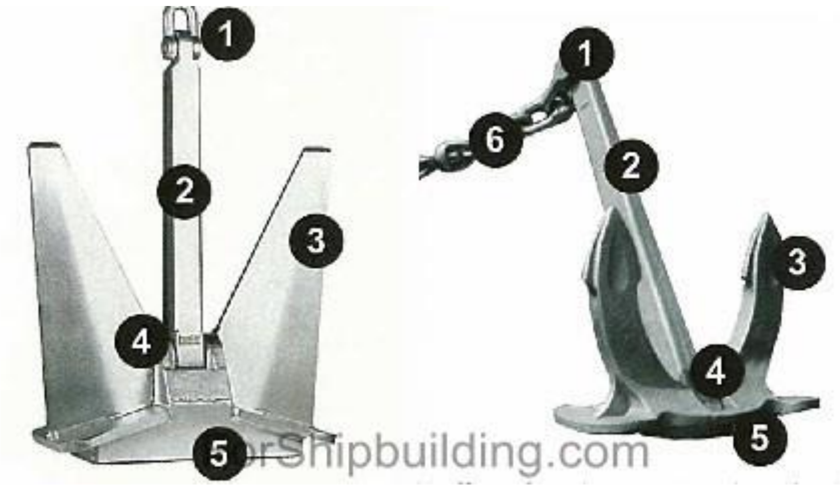


1. Storage part of the mooring drum
2. Pulling section of the drum (working part)
3. Brake band
4. Gear box
5. Electro-hydraulic motor
6. Warping end
7. Gypsy wheel
8. Dog clutch
9. Anchor
10. Hawse pipe
11. Spurling pipe
12. Chain locker
13. Chain stopper with security device
14. Guide roller
15. Bollard
16. Guide roller
17. Deck
18. Hatch to chain locker

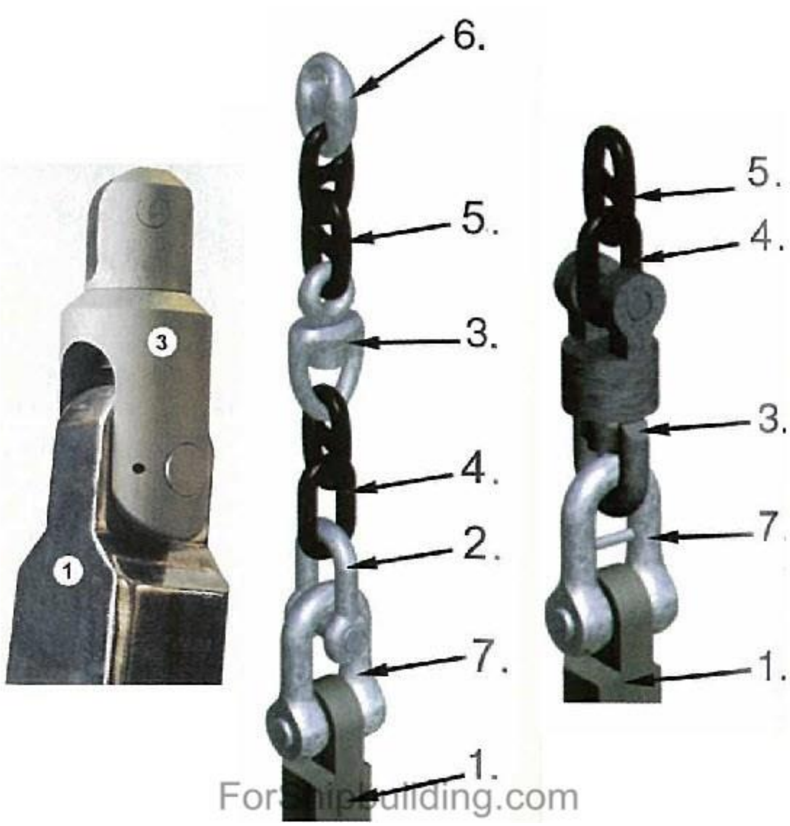




Anchor Equipment

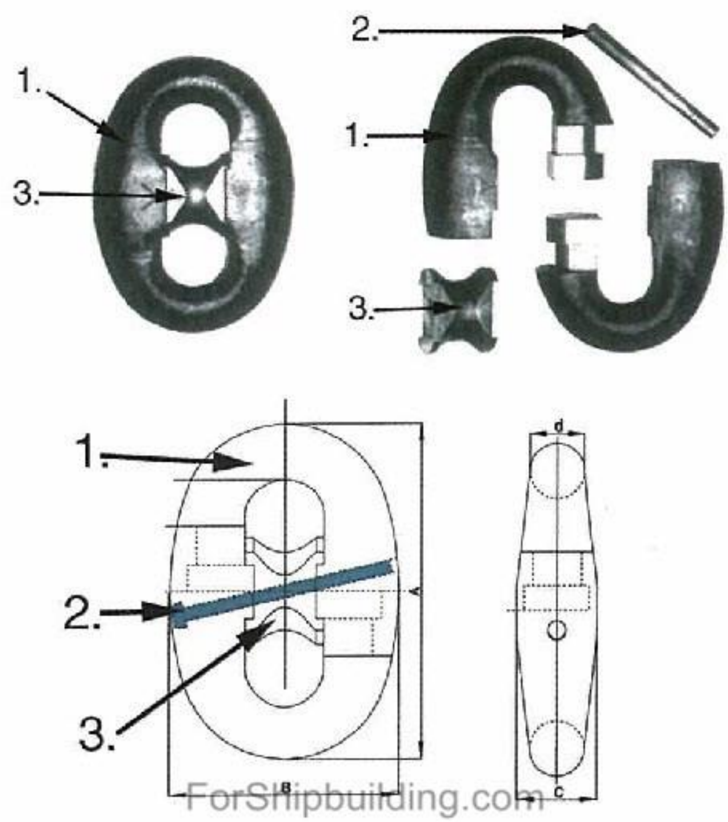


1. crown/ shackle
2. shank
3. flukes
4. crown pin
5. crown plate
6. anchor chain with swivel



1. Anchor shank
2. Anchor/ link
3. Swivel
4. Open link
5. Enlarged link
6. Kenter shackle
7. Crown shackle

Kenter shackle



1. Half link
2. Locking pin
3. Stud

1.5 LOADS ON THE ROPES AND FITTINGS:

- MBL = Minimum Breaking Load
- SWL = Safe Working Load
- DBL = Design Basis Load
- SMYS = Specified Minimum Yield Stress
- SF = Safety Factor (SF = MBL / SWL)

- The SWL marked on the fitting is normally equal with MBL – at the SWL of a fitting, the line is at its MBL. As defined, the SWL is approx. twice the maximum force in the line in normal service. In normal service conditions, the line tension is less than 20% of MBL.

- The SWL is defined by the MBL of the line and not by the force exerted on the fitting by the line; further, it is the SWL of the fitting rather than a SWL for the line.

- The DBL calculation takes account of the location and geometry of the line in contact with the fittings and is based on a force in line equal to MBL.

- The most important and common factor all ropes share is known as the *Minimum Breaking Load (MBL).*

- For any individual rope, this value is found by testing to destruction a sample of that line.

- MBL is defined as the minimum load that a new rope will sustain before breaking when tested to destruction.

- MBL is a critical factor used by ship designers when selecting mooring equipment, mooring layout and winch brake loads and settings.

- The MBL of all ropes supplied is stated on the rope's certificate and should be made known to all personnel involved in mooring activities.

- Therefore, the DBL of the fitting is given by the product of the MBL and the geometric factor.

- The dimensions of the fitting should be chosen so that the stresses caused by the DBL acting on the fittings are less than 85% of the SMYS of the material.

- Thus, the safety margin against yield is the reciprocal of 0.85, i.e. 1.18

- The fitting or piece of equipment should be able to withstand, without permanent deformation, the DBL given by multiplying the mooring line MBL by the geometrical factor.

Comparison between OCIMF and IMO requirements	Rope MBL (tons)	Fitting SWL (tons)	DBL at Geometric Factor of 1.0 (tons)	Maximum Fitting Stress at SWL (% of yield)	Maximum Supporting Hull Structure Stress at SWL (% of yield)
OCIMF	100	100	100	85 %	80% of SMYS
IMO MSC CIRC 1175	100	100	125	References Industry Standards	80% (i.e. 100% at design load)

1.6 FORCES ACTING ON VESSEL AND ROPES:

FORCES ACTING ON A MOORED VESSEL:

- Wind
- Current
- Tides
- Surges from passing ships
- Waves / Swell / Seiche
- Changes in draft / trim / list
- Ice
- Other forces

(Seiche = surface movement on water: a movement on the surface of an enclosed body of water, usually caused by storm activity).

- The greatest forces are caused by the *wind and current*, but to design a mooring system capable of resisting in any extreme conditions of wind and current would create problems in both size and cost of equipment.
- It is therefore a normal practice to establish wind and current criteria and then to design the mooring system to meet these criteria:

Wind 60 knts, plus a current abeam of 0.75 knts, or Wind 60 knts, plus a current from ahead / astern of 3 knts**,** OR as stated below:

- 60 knots wind (defined Below) from any direction simultaneously with:
  - 3 knots current 0° or 180°
  - Or
  - 2 knots current at 10° or 170°
  - Or
- 0.75 knots current from the direction of maximum beam current loading

- 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.

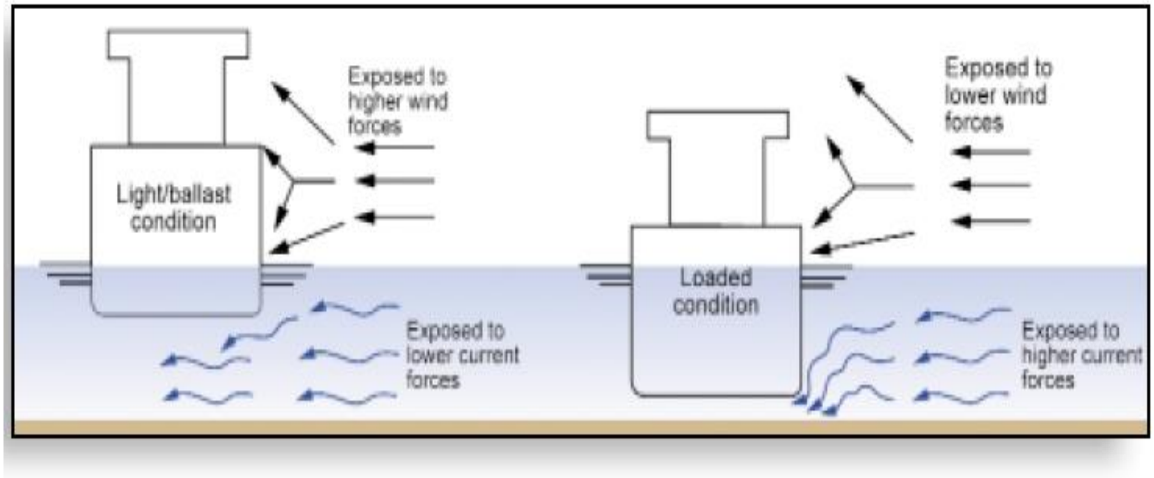
1.6.1 WIND FORCE:

Attention: Wind speed increases with height above sea level! For example, a wind of 60 knots at 10 mtrs will be more than 75 knots at 30 mtrs but only 30 knots at 2 mtrs (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 10mtrs.

Mean Draft in meters	Astern Tons	Ahead Tons	Abeam Tons
6	47.8	68	303
7	47.2	66.7	283
8	46.7	65.3	263
9	46.1	63.9	244

- The table above shows maximum longitudinal and transversal Wind forces on a 250,000 Dwt Tanker, 5 meters trim, 50 Knts wind speed.

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

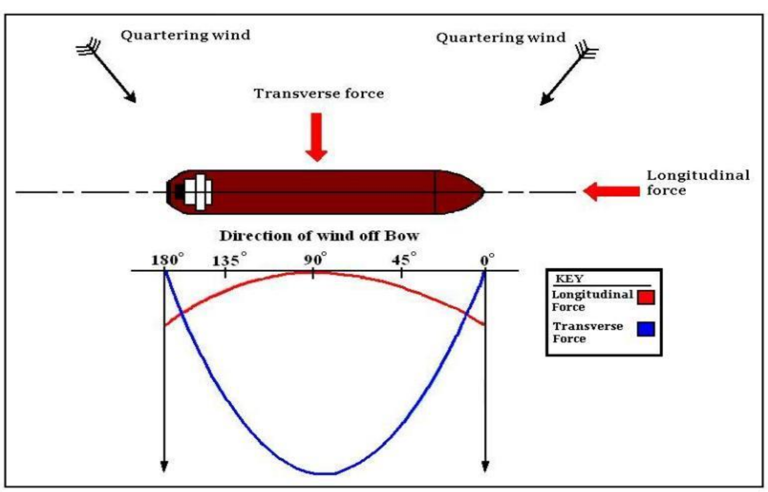


Effect of Wind/current Forces on a Ship in Light/loaded Condition

The force effect of wind is greater on a large ship than on a small ship in a similarly loaded condition as it has more exposed area. Wind forces on a large vessel can be broken down into two components: the longitudinal force acting parallel with the longitudinal axis, and the transverse force acting perpendicular to the longitudinal axis.

The magnitude of wind force effect on the ship correlates to the square of the velocity. If the wind velocity doubles, the force due to wind will be four times greater.

Other factors that contribute to the magnitude of the wind force include the shape of the area on which the wind is acting and the angle at which the wind strikes the surface.



Wind and Current Forces

1.6.2 CURRENT FORCES:

- Current forces must be added to the wind forces when evaluating a mooring arrangement.
- Furthermore, the current forces are significantly higher with lower clearance under keel.

Example: for a 250,000 Dwt Tanker with UKC = 2m, abeam current of 1 Knot will create a force of 230 Tonnes, while 2 Knots abeam current will create a force of 990 Tonnes

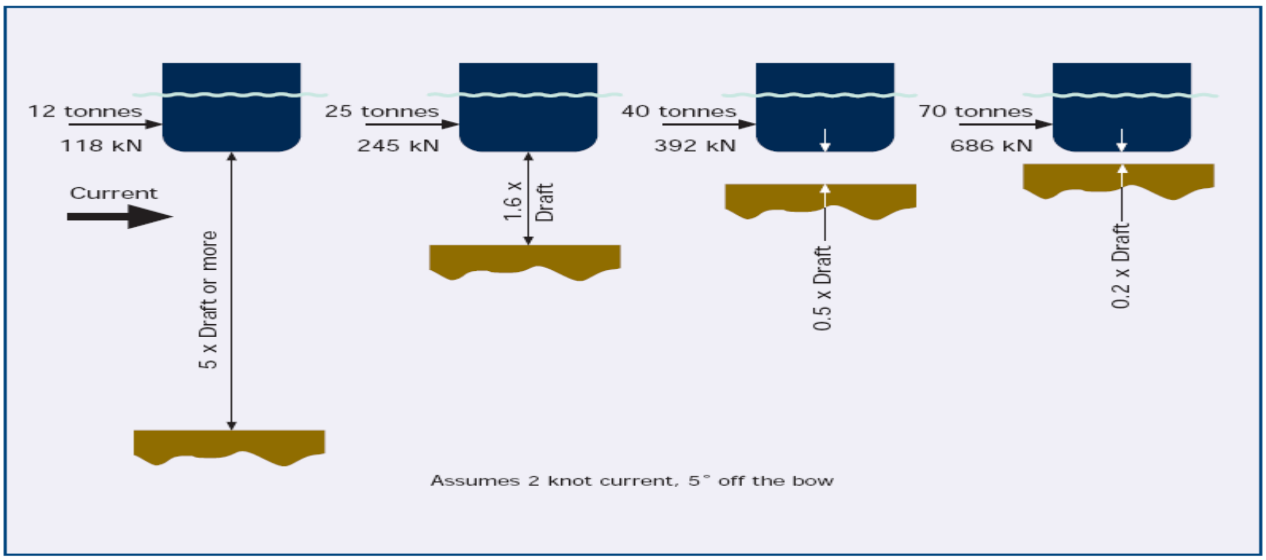
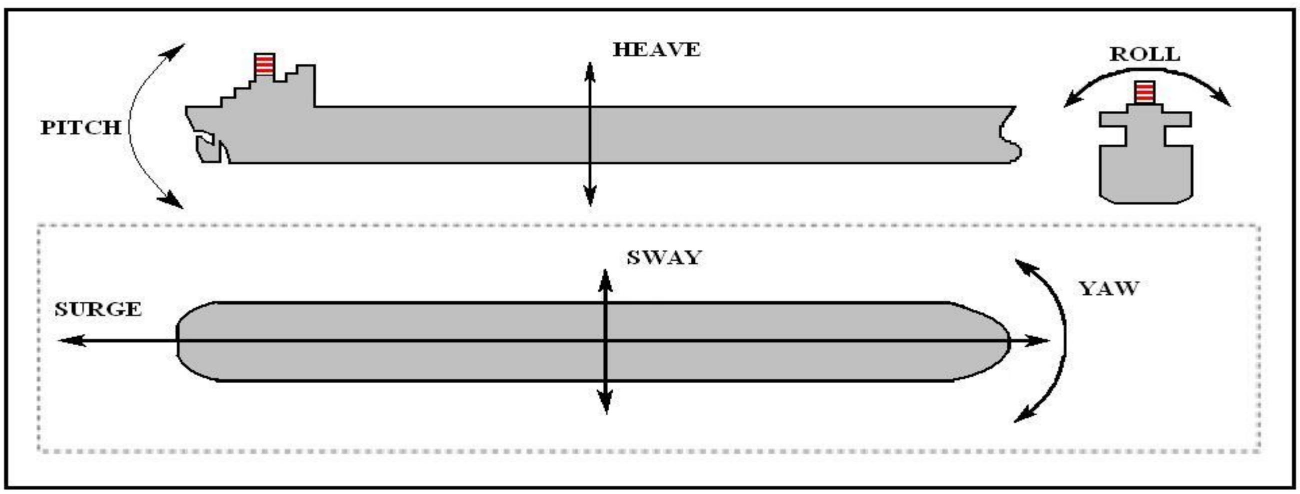


Figure 1.3: Effect of Underkeel Clearance on Current Force

The magnitude of current forces on a ship depends on the velocity of the current, the hull area exposed to the current and the under keel clearance of the vessel. As with wind, current forces are directly related to the area of the ship exposed to them. The maximum force of the current will be experienced when the vessel is in a loaded condition and the current is acting directly on the beam. The force is minimized if the ship is light in the water and its bow is headed into the current.
The depth of the water under the keel greatly affects current forces. As the under keel clearance decreases the forces due to current increases. The magnitude of current forces can be 3 times as great on vessels with small under keel clearances than for vessels in deep water.
Current force increases with the square of the current velocity. If the current velocity doubles, the current force is four time larger. Since current forces act on the submerged portion of the ship, they are likely to be most critical when the ship is loaded. While it is usually evident when the wind is blowing at or near gale force, high current velocities are not as noticeable to the ship's personnel.

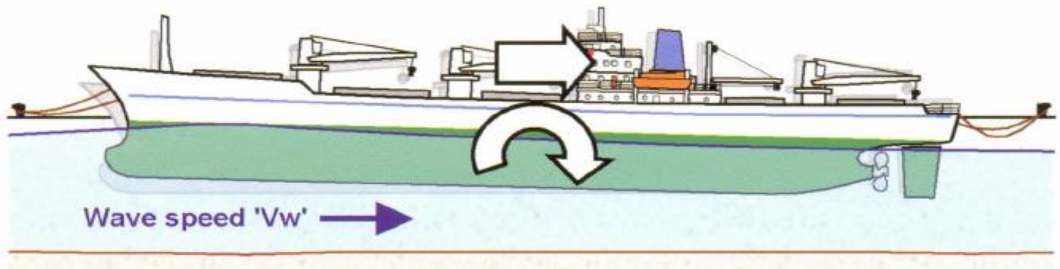
1.6.3 WAVES FORCES:

Waves are a major forces on vessels at exposed mooring locations. In such areas, ships are generally moored at sea-islands, single point moorings or multiple buoy moorings. Wave direction and frequency (period) are two factors that influence the effect of waves on a moored ship. Whether the ship responds by surging, swaying or yawing will depend on whether the waves are striking the moored vessel head-on, beam-on or quartering, the frequency of the waves and the relative direction. Ships do not usually respond to a single wave but to a system of waves. It is possible to observe individual waves having little or no effect on the moored vessel, yet the vessel is moving slowly in response to the entire wave system. This behavior is noticeable by observation of the rise and fall of the mooring line tension catenaries at a sea-island. In harbors, there are sometimes very long period waves present, which are very difficult to detect visually.

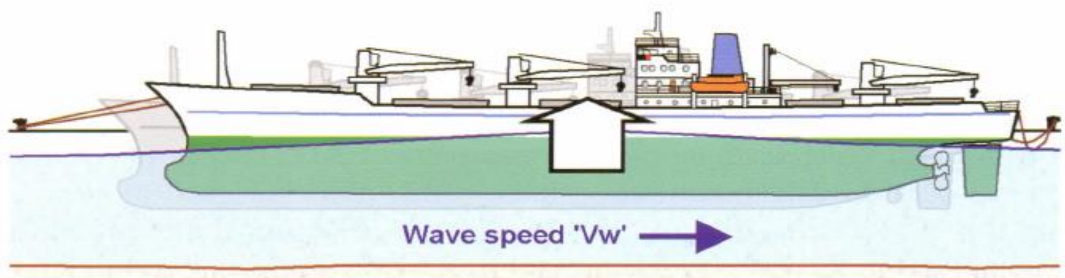


Vessel Motion

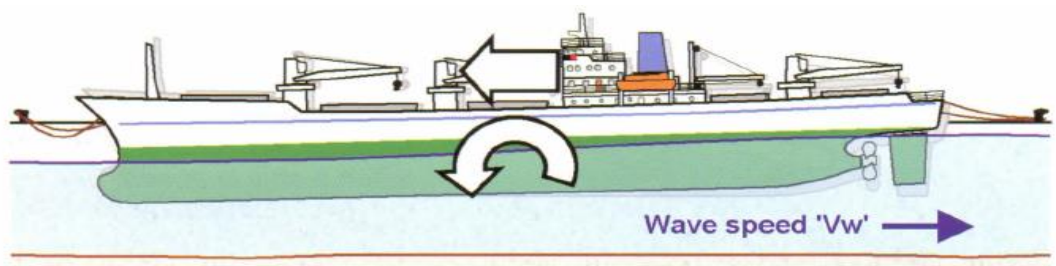
These waves are known as seiches (an oscillation of the surface of a landlocked body of water that varies in period from a few minutes to several hours) and they are potentially dangerous because of their ability to disturb moored vessels. Movements with periods of one to three minutes are typical and are best observed by noting the rise and fall of the mooring line catenaries. If a moored vessel is responding in this manner, the amount of ship motion can be modified by changing the tension of the mooring system (either by slacking-off or heaving-in mooring lines).



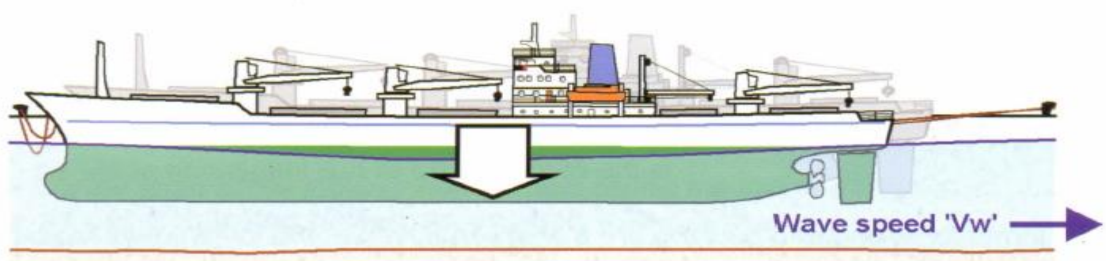
1 Wave crest at the bow: the ship is surging astern and pitching bow up



2 Wave crest amidships: head lines check the astern surge whilst the ship bodily rises



3 Wave trough at the bow: the ship is surging ahead and pitching bow down



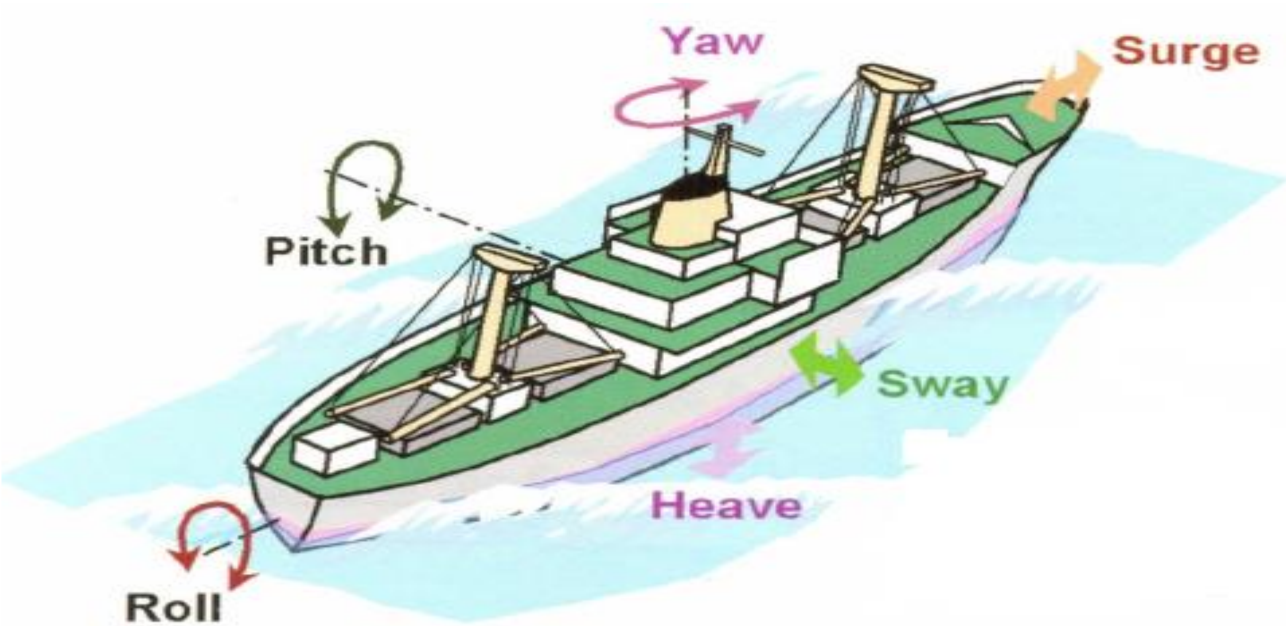
4 Wave trough amidships: stern lines check the ahead surge whilst the ship bodily falls

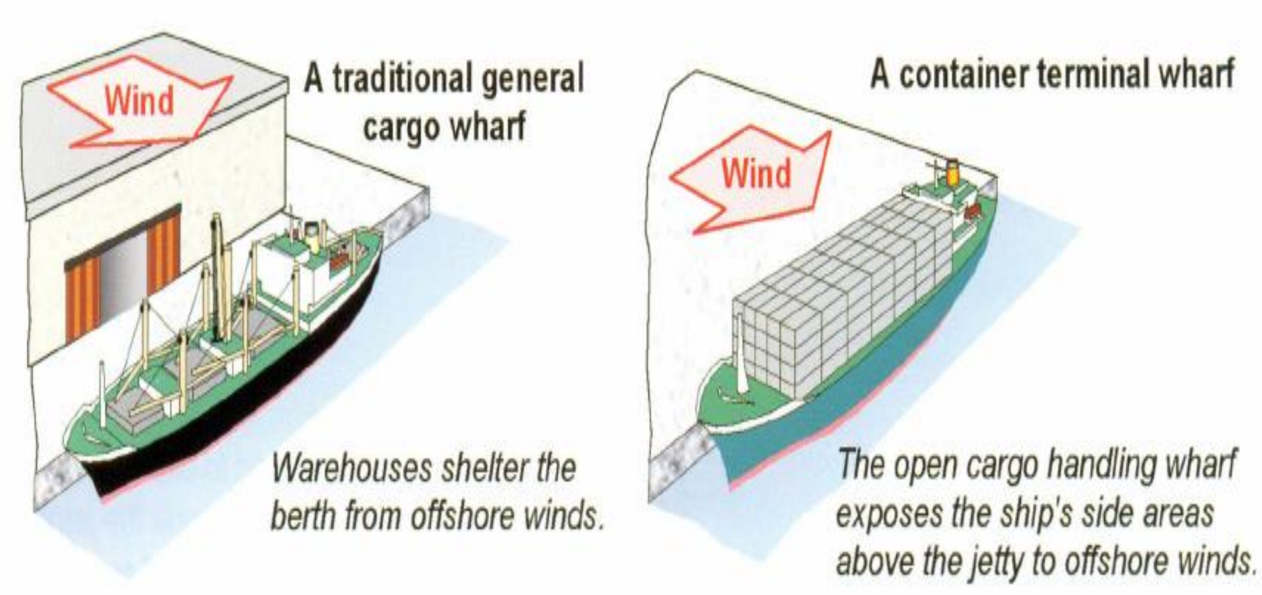
1.6.4 TIDAL FORCES:

Vertical forces due to the tidal rise and fall (not including the effects of tidal current) are predictable, as the variation in tidal patterns is well understood at most terminals. Changes in line's loads are not in response to increasing or decreasing external forces but instead to changes in the elevation of a vessel relative to a jetty or pier. Forces caused by tidal rise and fall can therefore be controlled by slacking-off or heaving-in vessel mooring lines. However, without line tending, increased mooring forces due to tidal rise can be quite severe at some terminals.

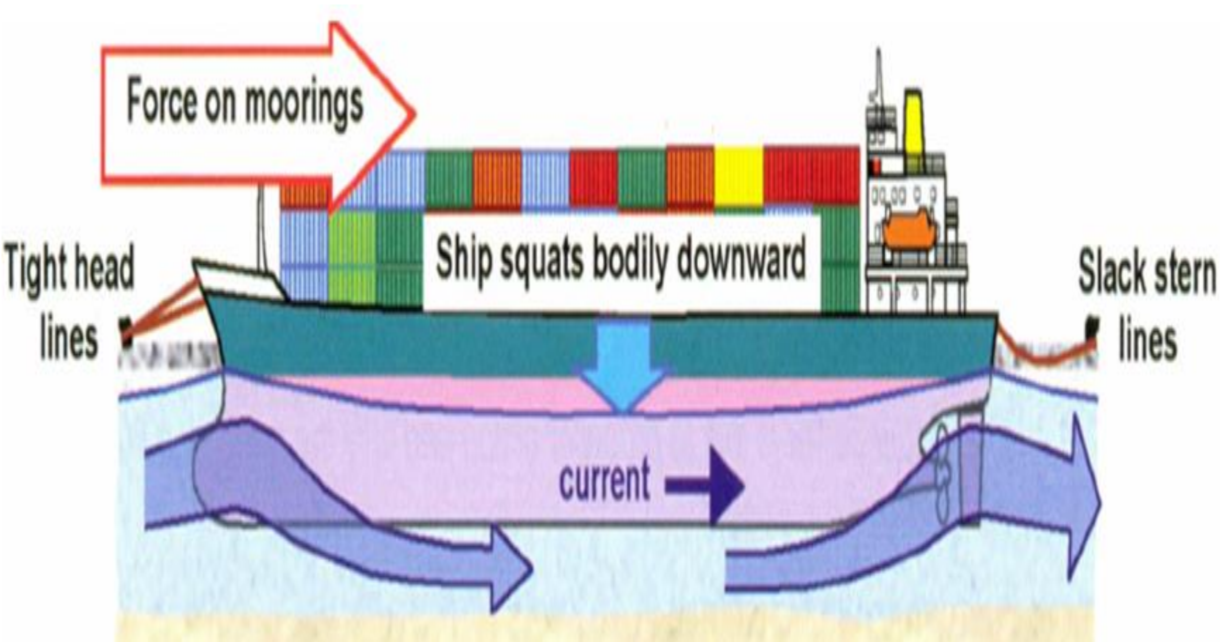
- A ship's vertical movement alongside a berth is created by both tides and cargo operations, affecting the tensions in the mooring lines, especially when a ship will have a combined vertical – horizontal movement (tide / current and change of draft).
- As the draft increases, the lines will become slack and the ship will move away from her designated position.
- The proportion between wind and current effects will change depending on draft / free board.

VESSEL'S MOVEMENT IN THE WATER:

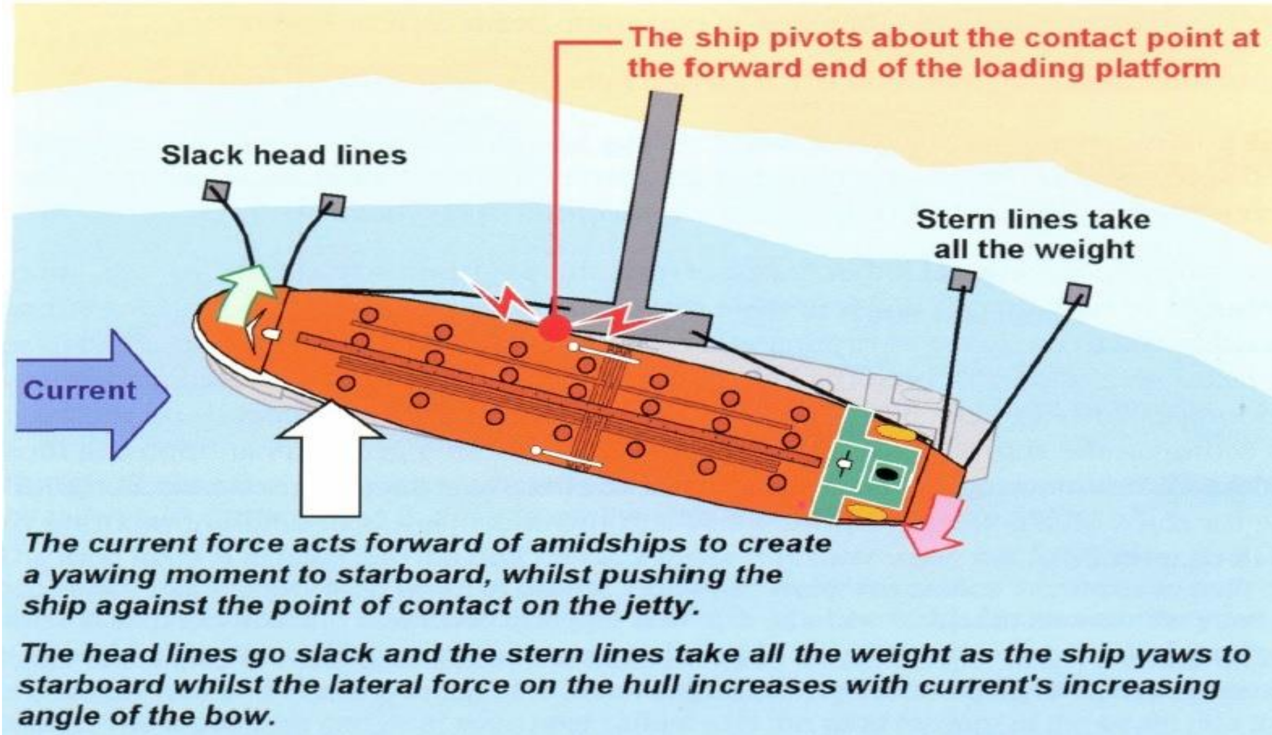




Most major ports have been redeveloped to allow greater ship's sizes, and consequently cargo berths are becoming increasingly exposed to offshore winds.



Effect of the squat: A ship moored on a shallow water berth in a current



Consequences of failing to keep a ship tight alongside in a current off the bow

1.6.5 PASSING SHIPS EFFECT FORCES:

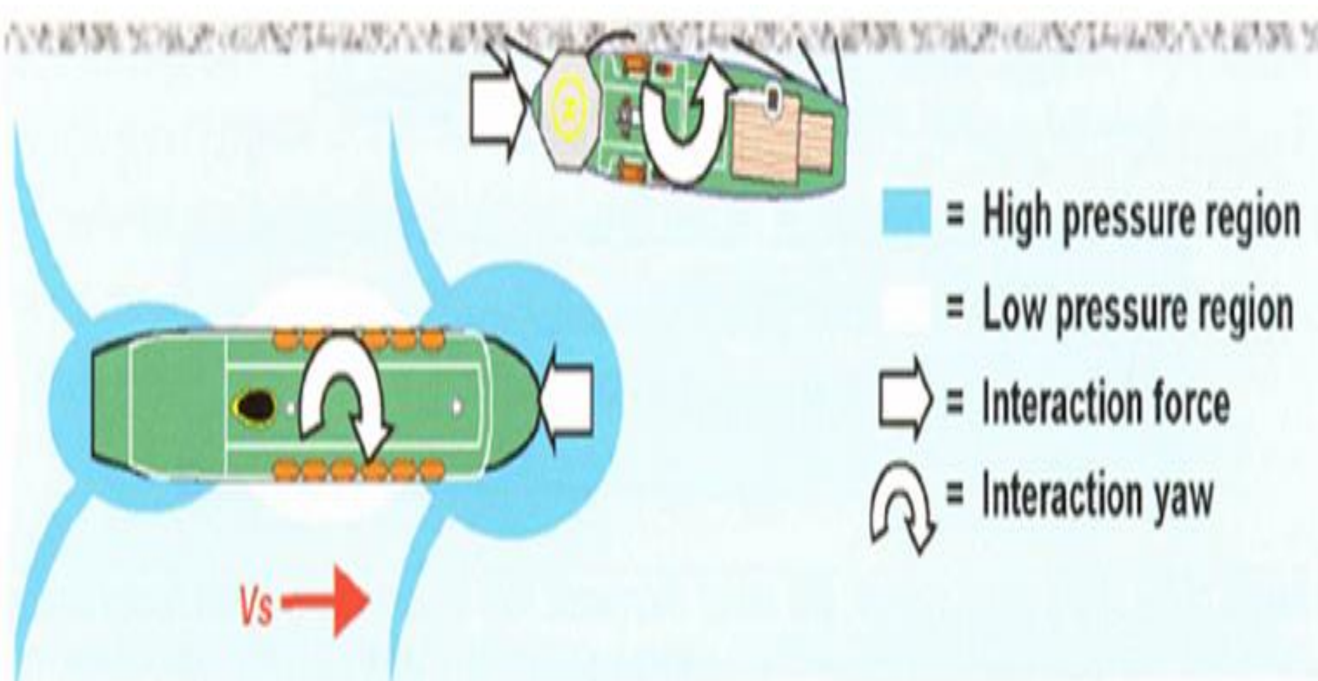
- High pressure ahead of the moving vessel repels the moored ship whilst pushing her bow into the jetty as it approaches.
- The low pressure amidships of the moving vessel draws the two ships towards each other as they come abeam, so the moored ship is pulled away from the jetty.
- High pressure at the stern of the moving vessel again repels the moored ship whilst pushing its stern into the jetty as the moving vessel passes clear.

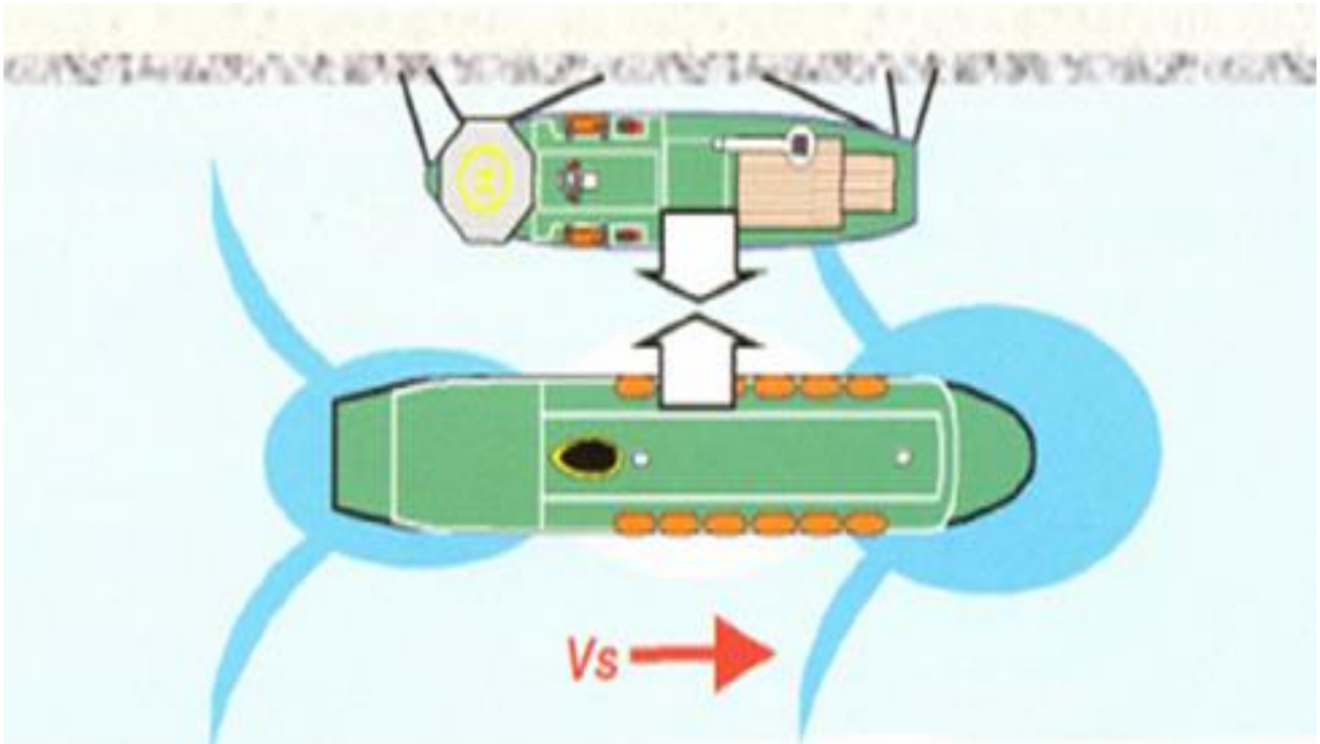
A ship moving through the water exerts forces on moored ships and other objects in the vicinity. The magnitude of these forces depends on: OKC of the moored vessel, distance between the passing and moored vessel, size of the passing and moored vessels and speed of the passing vessel.

Thus a moored vessel is most vulnerable when:
- she has small under keel clearance
- the distance between the ships is relatively small
- the passing vessel has high speed
- the passing vessel is of comparatively larger size.

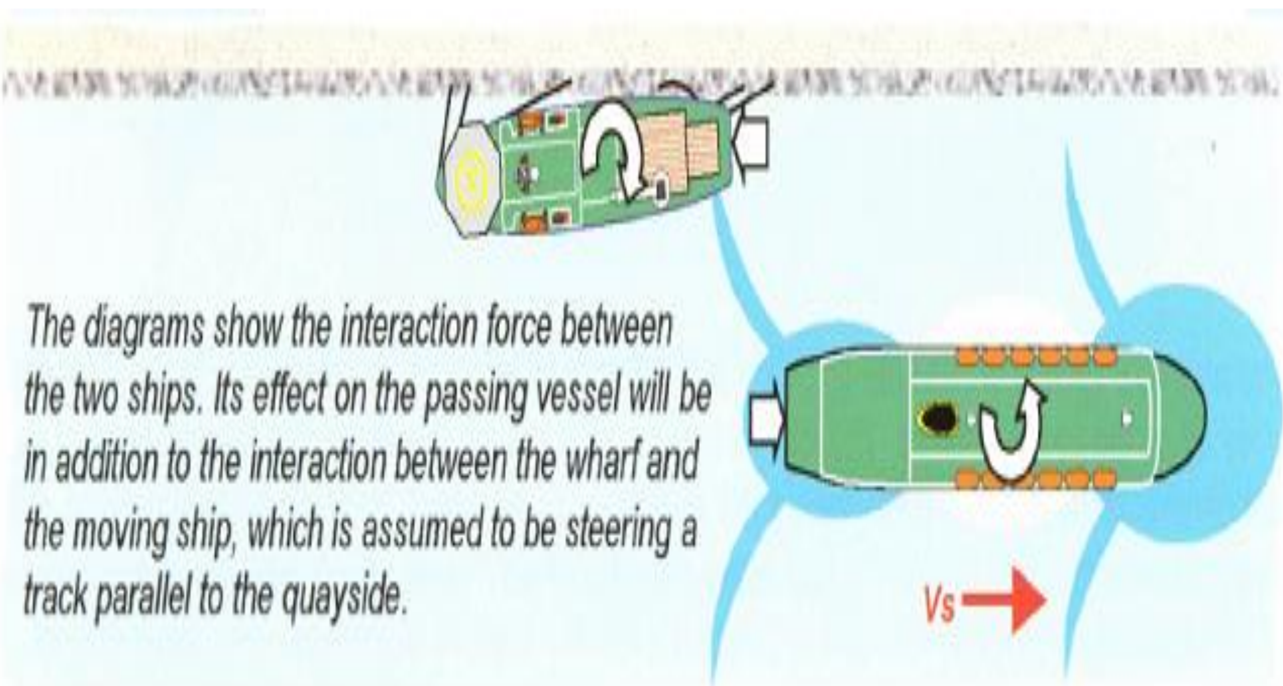
This can be particularly severe if mooring lines have already lost their pretension through reduced elevation as the ship falls with the tide. The most critical time for a loaded vessel (when moored) would occur at low tide, at which time the under keel clearance would be at its minimum. However, a passing ship cannot be disregarded any time the vessel is moored due to the water to landward of a ship at a jetty has restricted under keel clearance cannot flow easily under the ship to replenish the suction effect caused by a passing vessel.

As general counter-measures and in order to minimize own Vessel's exposure, the mooring lines must be checked as frequently as necessary, and adjusted according to prevailing circumstances.





Vs



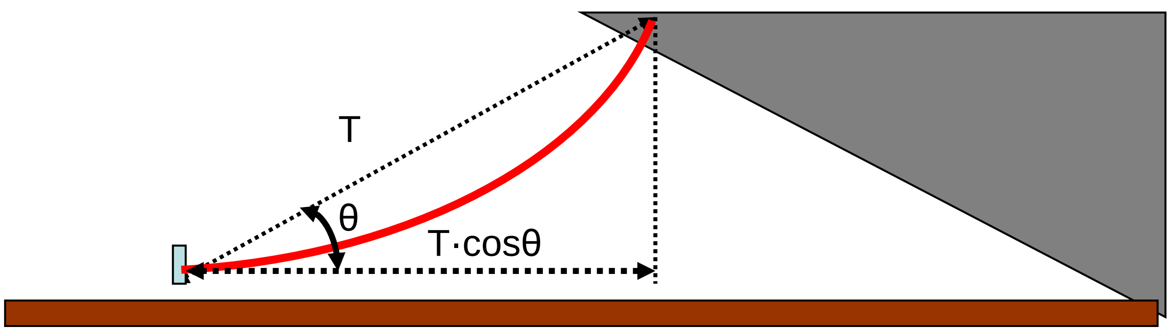
The diagrams show the interaction force between the two ships. Its effect on the passing vessel will be in addition to the interaction between the wharf and the moving ship, which is assumed to be steering a track parallel to the quayside.
Vs

1.7 FORCES ACTING IN MOORING LINES:

Mooring force is the horizontal component $T \cdot \cos\theta$ of tension needed to withstand the motion of ship exerted by external forces on the hull; accordingly, the horizontal mooring force is resolved using Tx = force on fore-aft direction and Ty = force on transverse direction.

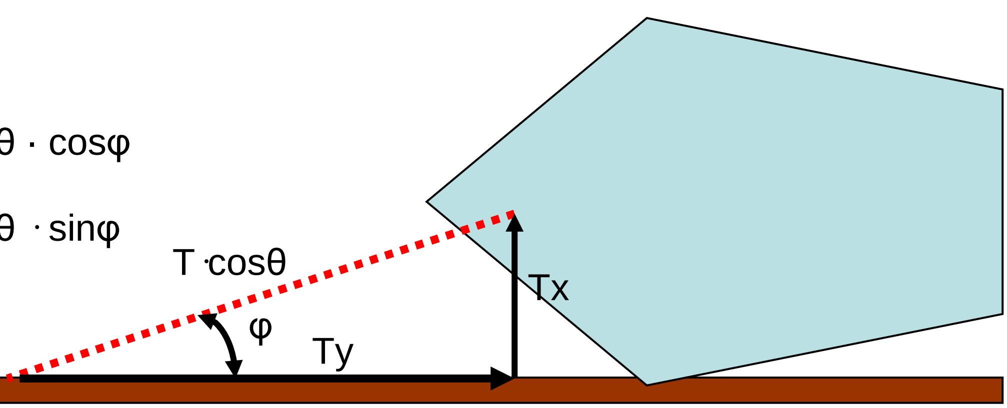
θ = angle of elevation of the mooring line
φ = horizontal angle to the face line on wharf.

Forces acting on a mooring rope



$$Tx = T \cdot \cos\theta \cdot \cos\varphi$$

$$Ty = T \cdot \cos\theta \cdot \sin\varphi$$



The sum of each mooring force, on both directions, is the resultant force.

Critical mooring force to cope with all external forces is determined by the condition that each component of external force should not exceed the corresponding component of the sum of each mooring force.

On the other hand, critical mooring force is determined in relation to the strength of mooring rope OR the breaking power of the mooring winch. That is, the load of each mooring line to withstand the external force on the hull should be always within the range of the SWL of the line or breaking power of each mooring winch.

Conditions of critical mooring

External force on hull < 60% of MBL of mooring lines (MBL = Minimum Breaking Load)

External force on hull<Breaking power of mooring winch

The smaller value of either of the above opposing forces becomes the critical mooring force. Assuming a ship free from external forces (such as wind and current), below table shows a calculated example of mooring force on the transverse direction; the line pull of winches is assumed to be 25 tons, and all mooring lines are equally pre-tensioned. The total mooring force on the traverse direction is approximately 128 tons, and the mooring force of each line is within the range of the settled line pull of the mooring winch.

LINE	Number of lines	Angle φ	Angle θ	Mooring force per line	TOTAL Force
1	3	26	14	11	33
2	2	40	32	14	28
3	2	6	22	2	4
4	2	6	26	2	4
5	2	40	36	13	26
6	3	26	16	11	33
TOTAL:	14 Lines				TOTAL 128T

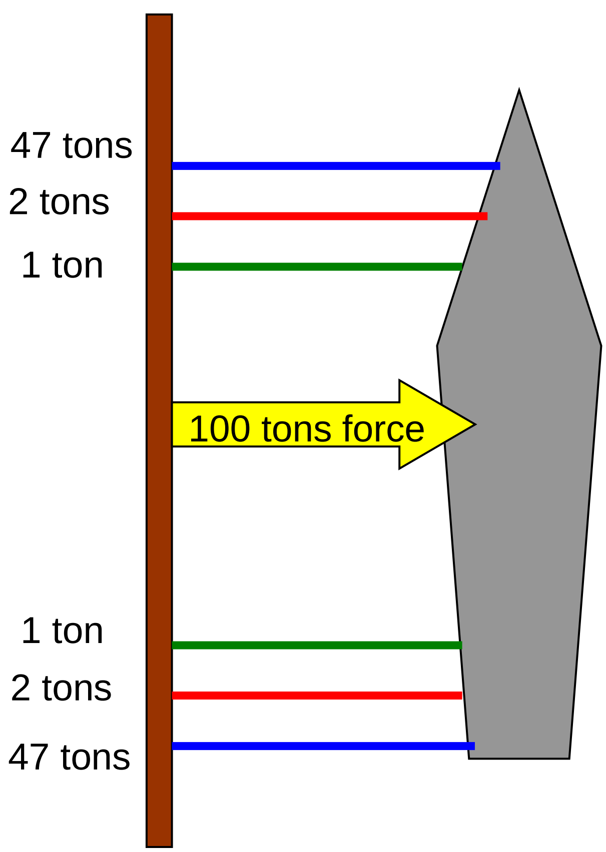
Maximum line-pull of a winch = rated load x 1.15-1.25

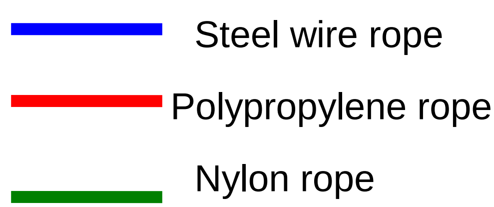
LATERAL SHIFT OF A VESSEL UNDER THE WIND EFFECT – EXAMPLE:

A PCC alongside with off-shore wind of 10 m/s, with 12 lines in pairs (2 head-lines, 4 breast-lines, 4 spring-lines and 2 stern-lines) will have a lateral shift of 1.6 meters.

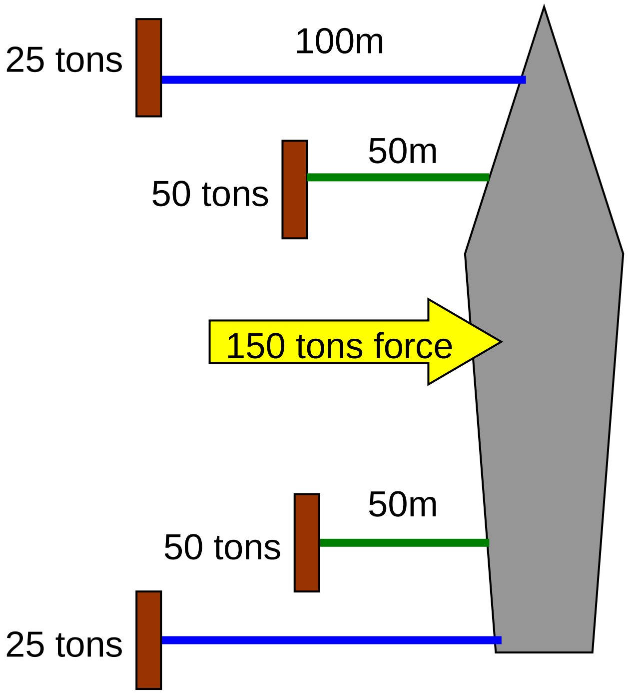
With one each additional: head-line, stern-line, breast line fore & aft → total 4 additional lines, will have a lateral shift 1.2 meters. With 2 additional wire ropes on the storm bits, the lateral shift will decrease to 5cm.

1.8 MIXED MOORING:





Two or more lines leading in the same direction should always be of the same material. It is not recommended to mix wire and synthetic fiber ropes leading in the same direction!



Load of short rope > load of long rope

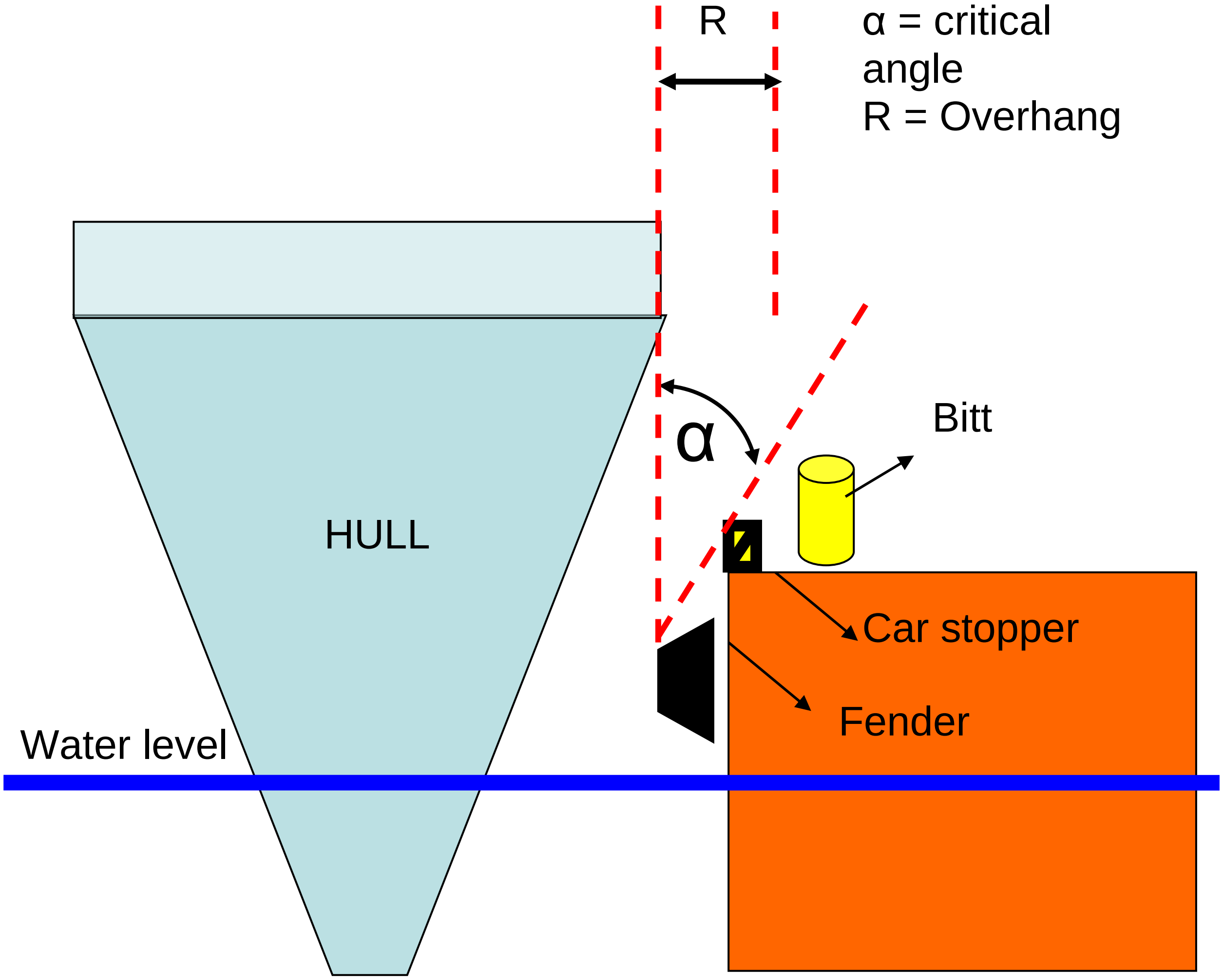
Two or more lines leading in the same direction should, as far as practicable, be of the same length.

1.9 POSITIONING A SHIP IN BERTHING OPERATIONS:

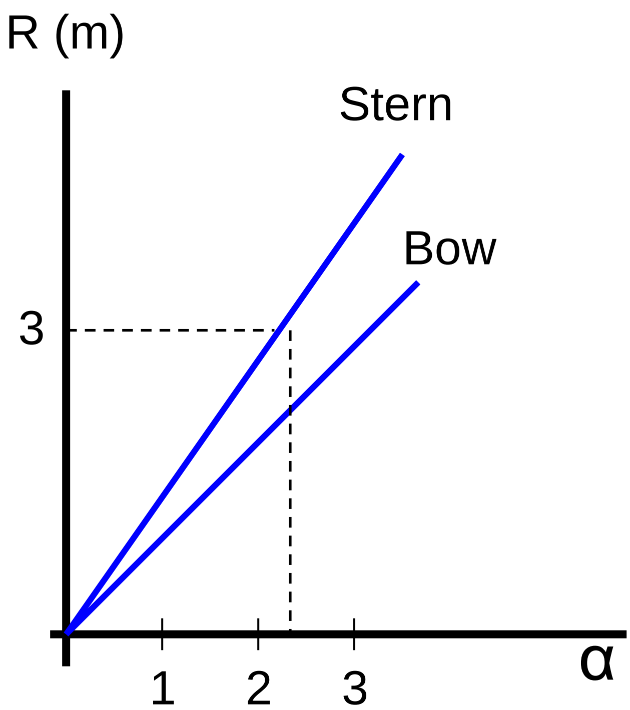
When a vessel with short parallel body (short straight length) is berthing, the bow or stern may come in contact with the corners of the wharf, car-stoppers or bitts, due to the directional difference between fore-and-aft line of the ship and the face line of the wharf.

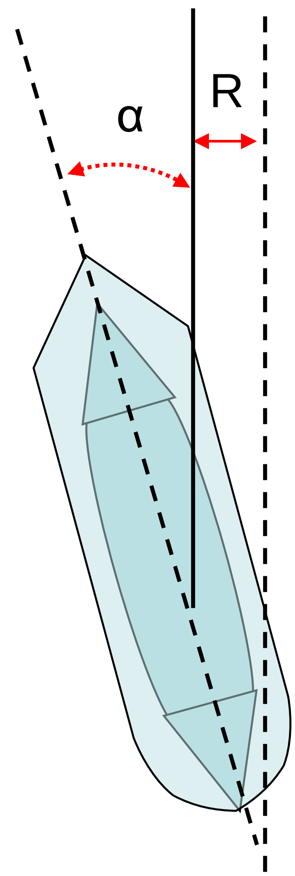
The range of critical positioning, wherein a part of the hull is not in contact with the wharf, is determined by the wharf face line and the angular deviation of the ship's heading from that wharf line.

In the graph is shown the permissible amount of overhang (R) versus the angular deviation from the wharf line. For example, for R = 3, the critical angular deviation of the stern is 2.3 degrees.



R
α = critical angle
R = Overhang
α
Bitt
HULL
Car stopper
Fender
Water level





Person's carrying out adjustments to the lines shall first take permission from the OOW. OOW shall carefully assess the effect towards vessel’s condition before giving permission. Following should be considered:

- moorings are to be adjusted in such a way that vessel does not move position or comes off the fenders or berth.
- adjustments shall also ensure that severe loads are not placed on individual lines.
- moorings are to be adjusted by putting the winch into gear, opening the brake and walking back the line.
- the moorings must not be slackened off by releasing the brake only.
- the tide timings and range shall be calculated, weather forecast, warning from port etc shall be monitored.
- during watch keeping, OOW shall pay attention to unpredicted change in weather conditions.
- mooring lines shall be regularly tended whilst the ship is moored at a jetty and when other vessels are passing close to the jetty and/or mooring unmooring of other vessels ahead or

astern of own vessel; traffic movement to be monitored and special attention to be paid during the passing of other vessels.
- frequently obtain weather information for local agent or other means. Take additional ropes or wires, as necessary. If considered unsafe, ask for tugs to be stand by. If required cast off and shift to sea, well in advance of onset of bad weather.
- brakes should be tightened at frequent intervals even if there is no signs of slipping, allowing for change of freeboard due to cargo operations and/or tides.
- do not surge synthetic ropes on the drum end; in addition to damaging the rope, as it melts it may stick to the drum or bitts and jump, with a risk of injury to people nearby.
- always walk a winch back to ease the weight off the rope.
- use main engine, bow thruster or tug assistance to keep the ship alongside, as required.

REMEMBER that the heaving power of the winch 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.

1.10 STRENGTH AND ELASTICITY OF THE MOORING LINES:

- The Strength means how big a load or weight it will take before it parts;

- Elasticity is how much a line will stretch when a force is applied ("Stretch under load"). Elasticity depends on material, diameter (thickness) and load.

- Wire mooring lines are very stiff compared to conventional synthetic fiber lines (if a wire mooring line was to be run parallel to a conventional synthetic fiber line, the wire would carry almost the entire load).

- At maximum load a wire cable might stretch just 1.5% of its length, while a conventional synthetic nylon rope can stretch up to 30% of its length.

- The effect of line length must also be considered. Elasticity varies directly with line length (a wire 60m long would stretch more than an equivalent size wire of 30m). The effect of this would be a reduced holding capacity on the longer wire.

- When 2(two) identical mooring lines (of the same thickness and material) are run out alongside each other, but with one being tied up to a bollard twice as far away as the other, then the shorter line will bear 2/3 of the vessel's load, while the longer one only 1/3.

The elasticity of a mooring line is a measure of its ability to stretch under load. Elasticity plays an important role in the mooring system for several reasons:

- high elasticity can absorb higher dynamic loads (terminals subject to waves / swell).

- high elasticity means the ship will move further off her berth, causing problems with loading arms or hoses.
- elasticity has effect on the distribution of forces among several mooring lines: if two lines of different elasticity are connected to a ship at the same point, the stiffer one will always assume a greater portion of the load.

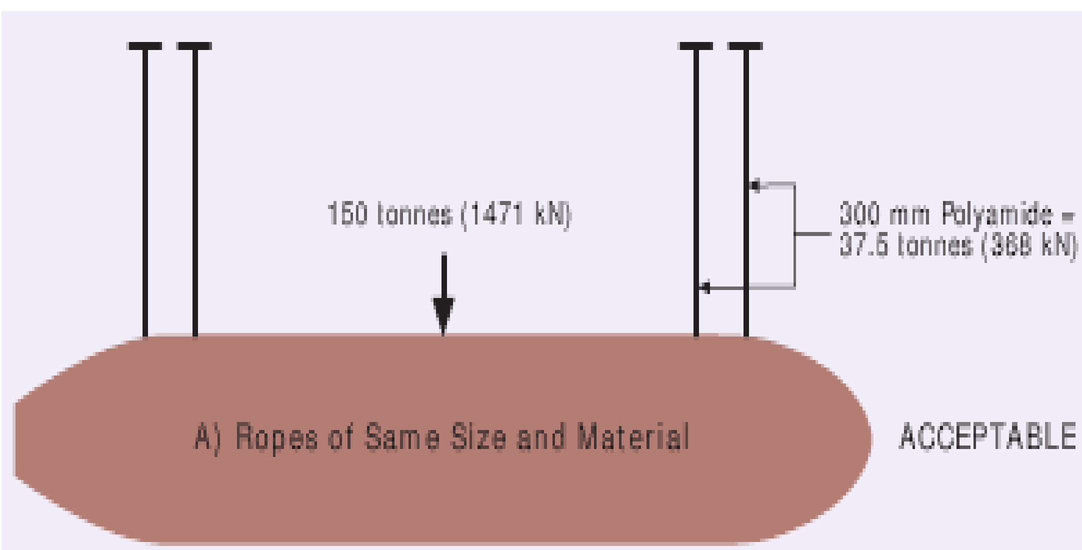
- The reason for this is that both lines must stretch an equal amount and, in doing so, the stiffer line assumes a greater portion of the load. The relative difference between the loads will depend upon the difference between the elasticity, and can be very large.

The elasticity depends upon following factors:

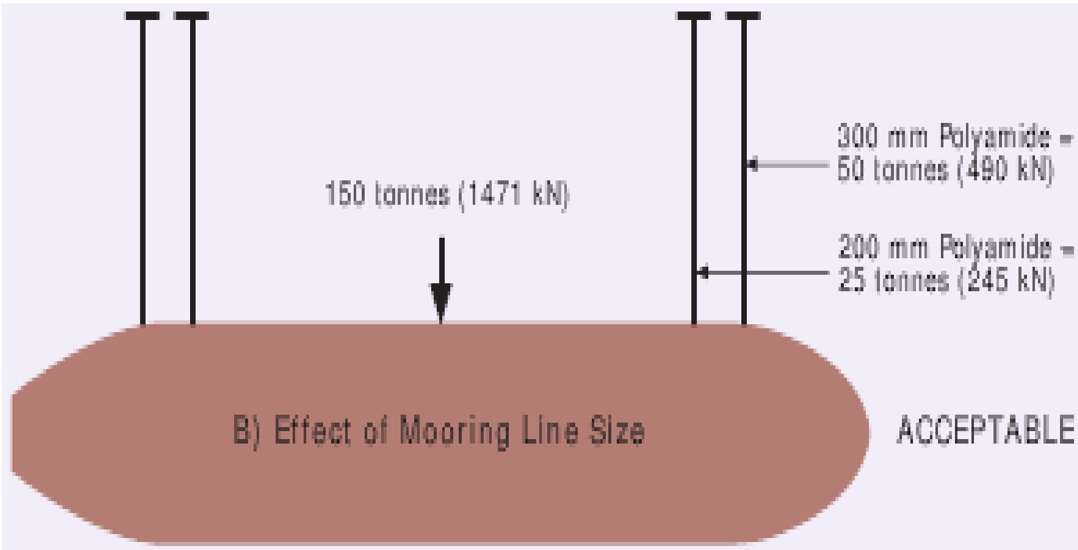
- material and construction
- length
- diameter

- Following demonstrates the significance of each of the above factors on load distribution. The most important points to note are the appreciable difference in elasticity between wire lines and fiber ropes and the effect of line length on elasticity.

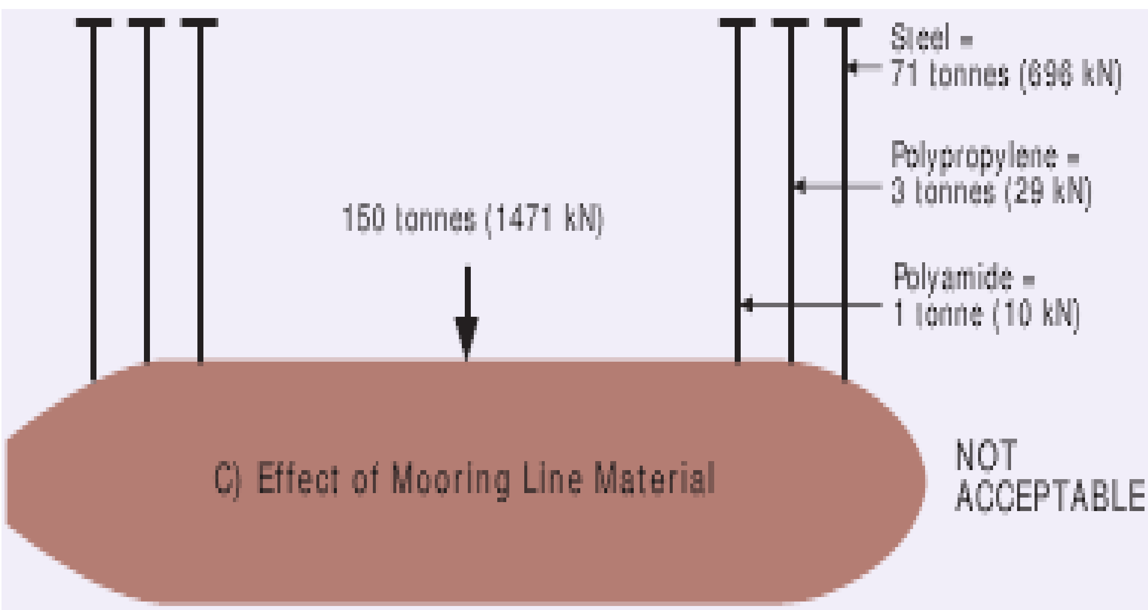
Case A shows an acceptable mooring where lines of the same size and material are used.



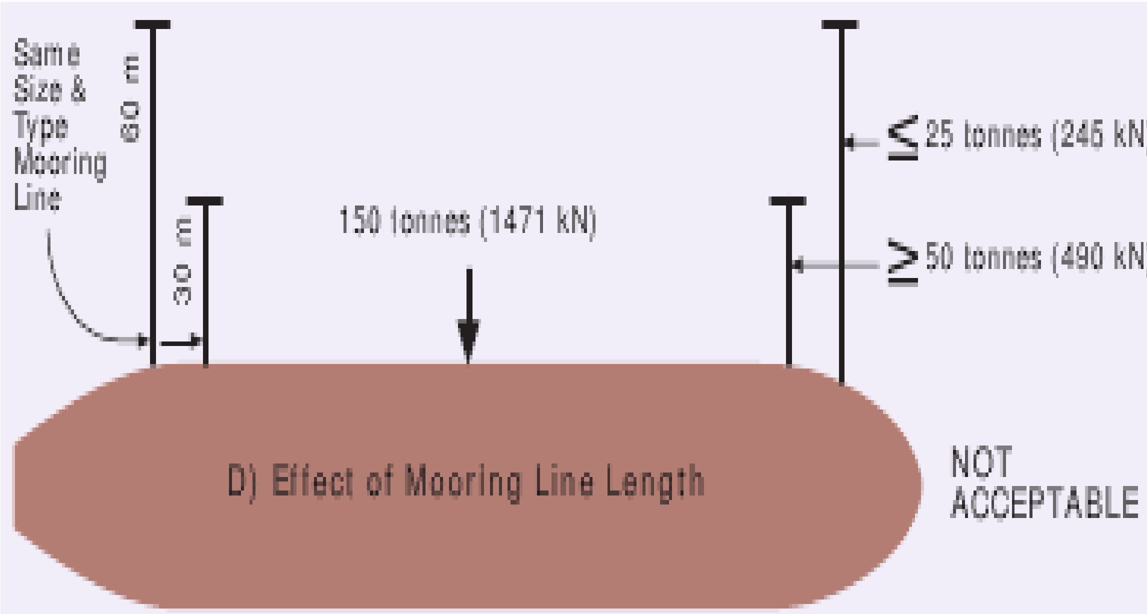
Case B indicates the sharing of loads between lines of the same material but of different size and each line is stressed to approximately the same percentage of its breaking strength.



Case C is an examples of mooring arrangements that should be avoided - Different mooring line material.



Case D is an examples of mooring arrangements that should be avoided - Uneven mooring line length.



- The effect of material on load distribution is critical and the use of mixed moorings for similar service, e.g. forward springs, is to be avoided.

- In some cases the fiber lines may carry almost no load, while at the same time some of the wires are heavily loaded, possibly beyond their breaking strength.

- The same could be true of mixed fiber lines of varying elasticity although the differences would generally not be as great unless the moorings also include high modulus synthetic ropes.

- **In practice**, mooring pattern for a particular berth must take into account the local operations, bollards location, weather, pier geometry and ship's design. For example, head and stern lines would be advantageous at berths where mooring points are too close to the ship and / or to avoid an excessive vertical angle in light condition.

- High winds and currents from a certain direction might require an asymmetrical mooring arrangement (i.e. more lines at one end of the ship).

- Optimum length of mooring lines must be considered. It would be desirable to keep all lines at a vertical angle < 25deg: if ship's chock is 25 meters above the shore mooring point, that mooring point should be at least 50 meters horizontally from the chock.

- Long lines are advantageous due to both load efficiency and line-tending; *however*, if conventional fibre ropes are used, the increased elasticity is a disadvantage, by allowing excessive movement of the vessel.

Chapter 2 – TYPES OF ROPES / WIRES USED IN MOORING OPERATIONS

The number, types, lengths, diameters and breaking loads of mooring lines with which a ship should be equipped are stipulated in the Equipment specifications.

Synthetic fiber ropes are made of various materials, such as nylon, polyester and polypropylene. High performance fiber ropes are now used for mooring lines: called high-modulus fiber ropes, much stronger and stiffer, almost same size as wire ropes.

Synthetic fiber ropes are highly resistant to chafing over flat surfaces, but poor resistance to chafing over sharp edges and sideslips; it also deteriorates under exposure to ultra-violet rays.

Ropes are generally made from vegetable (natural) fibres, man made fibre (synthetic) or metallic wires. This section provides some additional information on ropes used for mooring.

<u>Basically there are 3(three) main types of mooring lines</u>:

- Steel wire ropes, with a core of more steel or synthetic fiber (wires, cables);
- High modulus synthetic fibers (extra-high strength plastic / nylon);
- Conventional synthetic fibers (plastic / nylon rope-like materials);

- **<u>Wire</u>**:
  High strength and Low stretch.
  High maintenance
  Heavy and difficult to handle

- **<u>High modulus fiber</u>**:
  High strength and Low stretch
  Low maintenance
  Relatively light and easier to handle, comparing with wire

- **<u>Conventional synthetic fiber</u>**:
  Relatively low strength and High stretch
  Low maintenance
  Light and easy to handle

2.1 NATURAL FIBER ROPES

Manila Rope – fiber obtained from the leaves of the abaca, durable, flexible and resistant to salt water damage, used in ropes, hawsers, fishing nets.

- Manila ropes shrink when become wet. This effect can be advantageous under certain circumstances but should be considered.

- Shrinkage is more pronounced when rope becomes wet first time (the new rope is usually immersed into water and dried before first use, so further shrinkage will be reduced).

<u>Sisal Rope</u> – is an agave stiff fiber made from agave plant, used for twine, ropes, etc. Sisal is easily absorbing / releasing air humidity, causing expansion or contraction which will reduce strength.

- The natural fiber ropes should be kept in ventilated space, hung on wooden pegs or stowed down on gratings. Excessive heat will cause dryness which makes the fiber brittle.

- The life of Manila and Sisal is shortened by excessive heat and contact with salt water, so the ropes should be rinsed with fresh water.

2.2 SYNTHETIC FIBER ROPES

- Synthetic fiber ropes are made of various materials, such as nylon, polyester and polypropylene.

- High performance fiber ropes are now used for mooring lines, called high-modulus fiber ropes, much stronger and stiffer, almost same size as wire ropes.

- Synthetic fiber ropes are highly resistant to chafing over flat surfaces, but poor resistance to chafing over sharp edges and sideslips; it also deteriorates under exposure to ultra-violet rays.

Polyamide (Nylon) – Is a very strong synthetic fiber rope, good resistance to substantial loading. Is resistant to alkalis, oils and organic solvents, but is attacked by acids.
- Polyamide rope loses 10 15% of its strength when wet.
- It has the highest elasticity of regularly used materials with good temperature and abrasion resistance.
- It does not float. Specific Gravity 1.14

Polyester (Terylene) – Almost as strong as nylon and does not stretch as much as other fibers. Is resistant to acids, oils and organic solvents, but is weakened by alkalis.

Polyester is the most durable of the common materials. It has high strength, both wet and dry. It has good resistance against external abrasion and does not lose strength rapidly due to cyclic loading. Polyester's low coefficient of friction allows it to slide easily around bitts.

High melting point (256°C) ◊ less chances of fusion. Polyester is used for ropes where strength and durability are important and where moderate elasticity is required. It does not float, specific gravity = 1.38

- Polypropylene and polythene – Ropes made from these fibers will float on water. They have relatively low melting point. Both fibers are highly resistant to acids, alkalis and oils but may be affected by bleaching agents and some industrial solvents.

- Polypropylene is widely used as it has several advantages over natural fiber ropes, it is also less expensive than nylon and terylene and likewise is stronger than polythene.

Polypropylene ropes have approximately the same elasticity as polyester rope. Limited temperature resistance. Prolonged exposure to the sun's UV rays can cause polypropylene fibres to disintegrate. Use of moorings ropes 100% polypropylene is not recommended. However, suitable composites or melt mixes with other fibres such as polyethylene or polyester are available.

- High Modulus Polyethylene Rope (HMPE) – since Polyethylene ropes gave first been introduced in the market, their usage has become widespread in many applications. HMPE has not only replaced wire ropes, but have also replaced many traditional fiber ropes. Safety and long term cost savings are the primary reasons driving this decision. Advantages of this rope are that it is light weight, high strength, excellent abrasion resistance to UV and it floats. HMPE has outstanding resistance to both external and internal abrasion.

- Ropes made of 100% HMPE fibres float, but jacketed HMPE ropes can have a higher density and may sink. Fibre with high strength to weight ratio and low stretch characteristics, good resistance for axial compression and low friction coefficient.

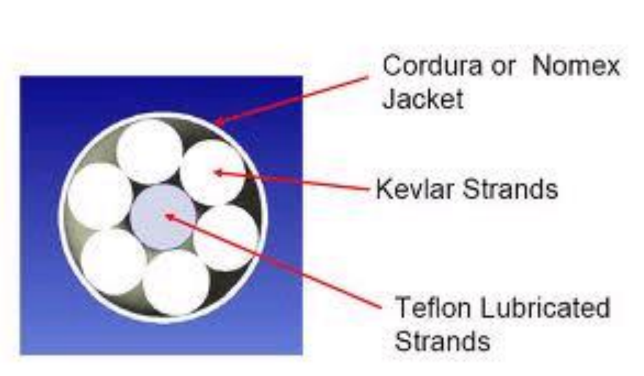
- HMPE fibres have very good fatigue and abrasion properties, but limited temperature resistance (max working temperature of 70ºC).

The term "High Modulus Fibre Mooring Lines" generally refers to ropes made from high modulus fibres such as:
- Aramid
- Liquid Crystal Polymer (LCP)
- High Modulus Polyethylene (HMPE).

These fibres are much stronger and stiffer than conventional synthetic fibres such as Polyamide, Polyester and Polypropylene.

- While these ropes are typically more susceptible to cutting and crushing in similar applications in which normal wear is experienced, HMPE ropes have proven to outlast wire ropes.

Aramid Ropes:
- High strength and low stretch.
- It does not creep and does not melt, but chars at high temperatures.
- Aramid ropes do not float.
- They may be covered (jacketed) with other synthetic fibre, such as polyester, to increase abrasion resistance and to protect against UV degradation.
- Aramid is susceptible of axial compression fatigue that occurs when tightly constrained fibres are compressed.



Liquid Crystal Polymer Ropes:
- LCP fibres have high strength and low stretch
- Excellent resistance to creep, cutting, abrasion and flex fatigue.
- Temperature resistance between HMPE and Aramid.

High Modulus Polyethylene:
- HMPE is a fibre with high strength to weight ratio and low stretch characteristics, good resistance for axial compression and low friction coefficient.
- HMPE fibres have very good fatigue and abrasion properties, but limited temperature resistance (max working temperature of 70ºC).
- Ropes made of 100% HMPE fibres float, but jacketed HMPE ropes can have a higher density and may sink.

- Synthetic Fiber ropes should not be stowed near boilers. They should be covered by tarpaulins when on deck as they can be harmed by exposure to sunlight; particularly polypropylene and polythene have relatively low melting point and tend to become sticky.

- Frictional heat is likely to develop at the warping drum which will tend to fuse the fibers so the rope should be walked back and not surged. As few turns as possible should be taken on the drum end with polypropylene rope but on whelped drums extra turns may be made to get a good grip.

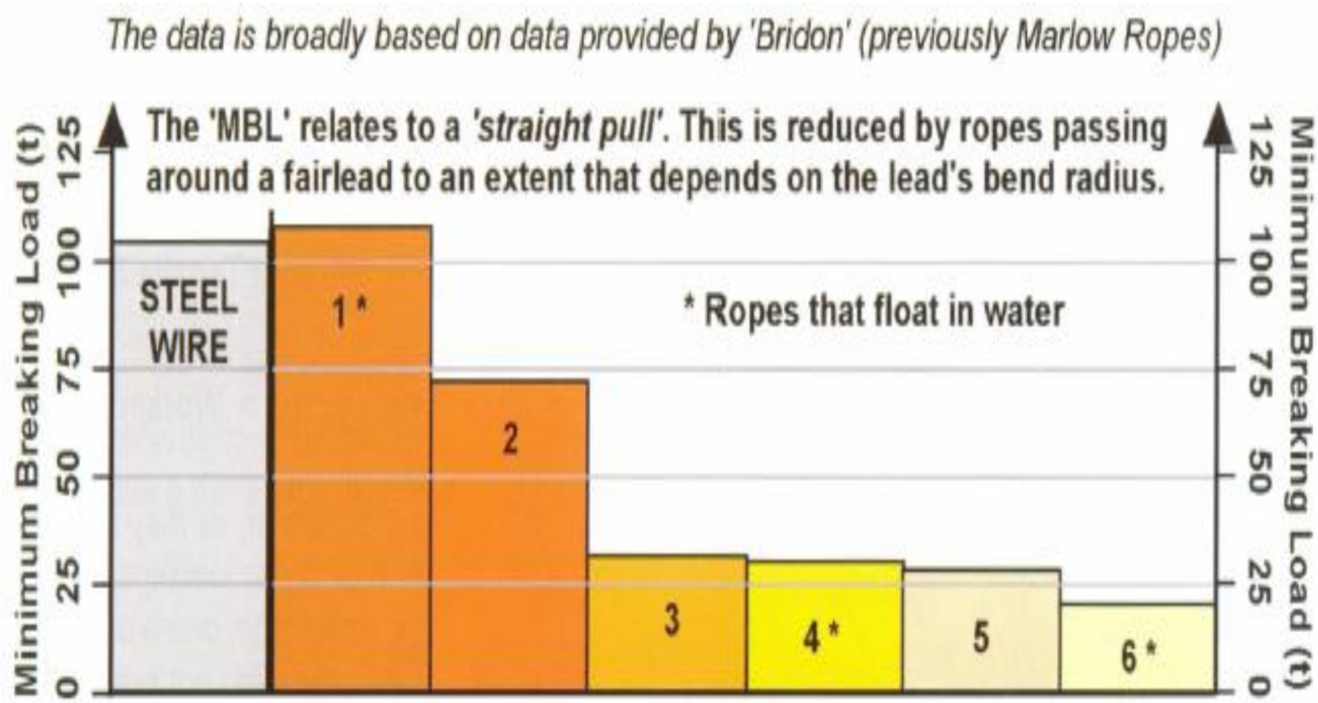
2.3 ROPES COMPARISON TABLES:

Table comparing 40mm rope from different fibers				
Mooring Rope	Breaking Stress (kg)	Specific Gravity	Melting Point (ºC)	Expansion at Breaking Load
Sisal	10.4	1.50	-	10 – 20 %
Manila	11.71	1.50	-	10 – 20 %
Polypropylene	19.4	0.91	165	25 – 40 %
Polythene	15.4	0.95	135	27 – 37 %
Terylene	23.9	1.38	260	23 – 33 %
Nylon	30.0	1.14	250	33 – 36 %

Conversion table of fiber ropes to standard diameter of Manila rope (Class NK regulations)

	DOUBLE BRAIDED ROPE		3-STRAND AND 8-STRAND ROPE			
Diameter of Manila rope [mm]	Polyester	Polypropylene	Nylon	Polyethylene	Polypropylene	Nylon
20	13	14	13	18	16	14
40	26	28	26	35	33	29
60	39	42	39	53	49	42
80	52	56	52	71	65	56
100	65	70	65	89	82	70

Material	Specific Gravity	Specific Modulus N/tex	Specific Strength N/tex	Dynamic Coefficient of Friction against Metal	Melt Point Deg. C	Other Characteristics
Aramid	1.44	49	2.03	0.15	Chars @ 500	Potential axial compression fatigue problems, but these can be overcome. Long tension-tension fatigue life
LCP (Liquid Crystal Polymer)	1.40	60	2.4	0.13	300	High strength and low stretch. Long term durability to fatigue
HMPE (High Modulus Polyethylene)	0.97	110	3.5	0.07	147	Low melt point. Lighter than water. Long tension-tension fatigue life
Steel wire	7.85	26	0.18	0.23*	1,600	Corrodes. Heavy. Moderate tension-tension fatigue life



1) High Modulus Polyethylene, or HMPE ('Dyneema' or 'Spectra') HMPE ropes are of similar strength and stretch to steel wire ropes of the same diameter but they are much lighter (to the extent that they float in water) so are easier and safer to handle (melting point, M.P. = 150° C).

2) Aramid ('Kevlar') Aramid ropes have about 75% the strength of wire ropes of equal diameter and are both heavier (they do not float) and less flexible than HMPE ropes (M.P. = 425° C).

3) Polyester ('Dacron' or 'Terylene') Polyester ropes have only about one third the strength of wire ropes of the same diameter and are heavier than HMPE ropes so they do not float, though they are very flexible and durable (M.P. = 250° C).

4) Polyamide ('Nylon'). Nylon ropes are slightly weaker, less dense (but do not float) and less durable than polyester ropes of the same size but they stretch more readily than any other fibre and are often used as shock absorbing tails on steel wire lines (M.P.=215°~250°C).

5) Polypropylene ropes are the weakest of the synthetic ropes commonly used as mooring lines with about 60% the strength of polyester ropes of the same size and similar stretch characteristics. However, polypropylene ropes are cheap, light (they float in water) and reasonably durable, they are commonly used on ships less than 30,000 tones displacement (M.P. = 165° C).

2.4 ROPES DESIGN AND STRUCTURE:

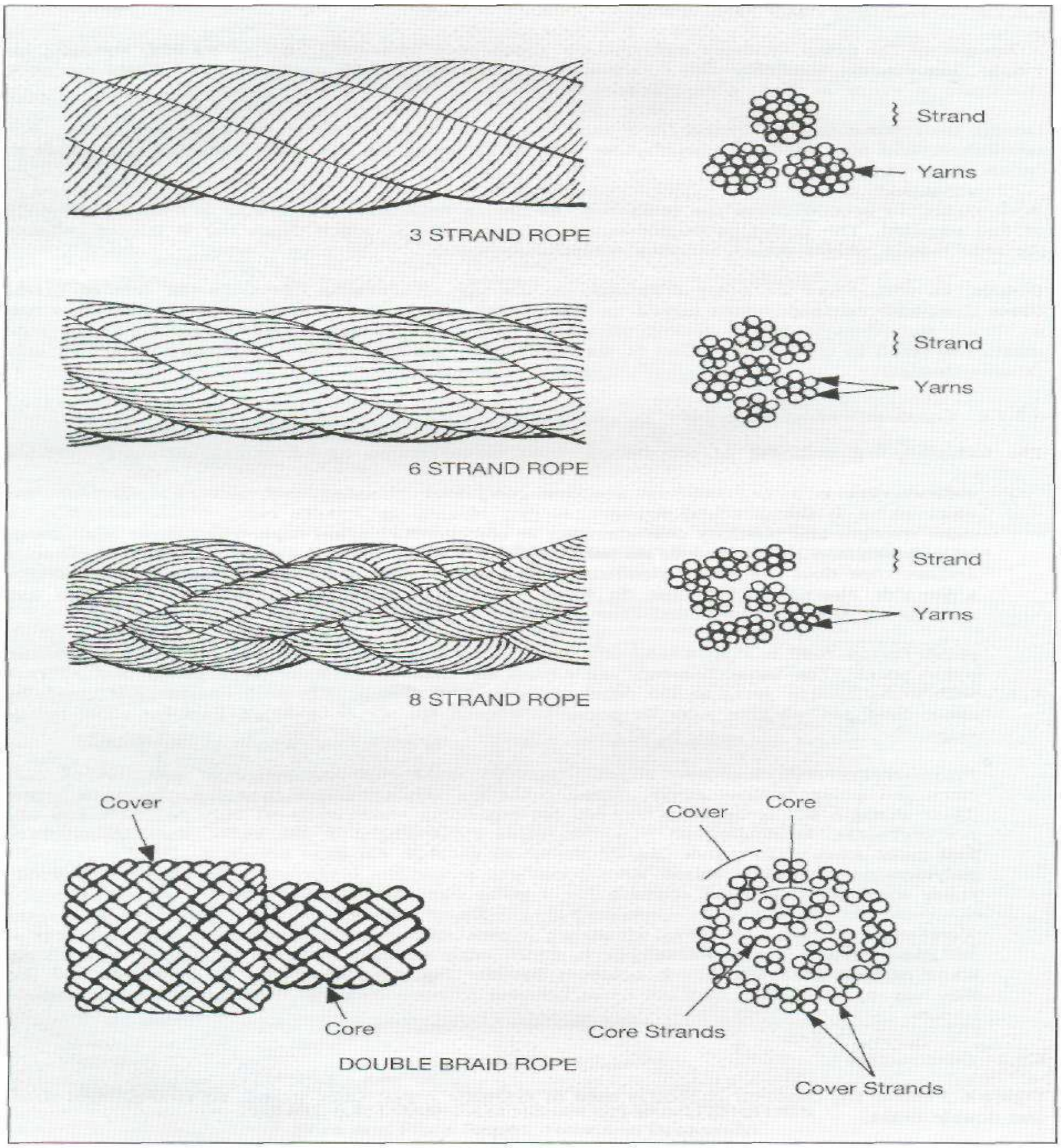


FIGURE 6.5: SYNTHETIC ROPE STRUCTURES

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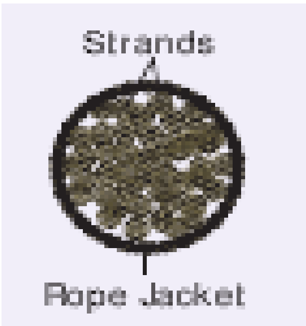
1. Parallel lay (parallel yarns or strands, assembled together under an outer - braided - jacket). They are commonly used for regular mooring ropes and as SPM mooring hawser.



2. Laid - generally 3-4 strand constructions with a considerable amount of twist.

3. Stranded - Twisted strands arranged in one or more concentric rings around a central core strand (similar to wire rope construction).

4. Plaited – Also known as ‘Square Braids’ or the 8-strand ropes (Octoplait) of a somewhat square cross section. Together with the 12-strand rope, they are made of left and right hand laid strands to give torque-free rope. They are easily spliceable and provide a good structure.

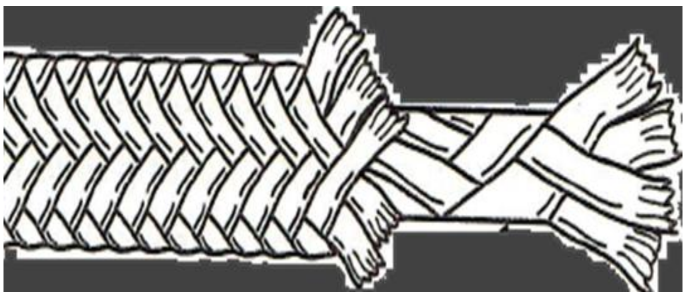

8 – Strand Rope

5. Braided - The braid consists of an equal number of interwoven clockwise and anti-clockwise strands. Includes the Double braided ropes sometimes called braid-on-braid are constructed of a core braided of many small strands and surrounded by a cover that is also braided of many small strands.

12-Strand Braided Rope

- The cover provides an integral component to the line's strength and neither the core nor the cover should provide more than 55% of the overall weight. They are commonly used for mooring at single point (SPMs) and for tails on wire ropes.

Double-braided Rope



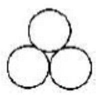
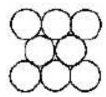
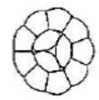
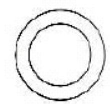
- A high degree of twist produces tight yarns and a more rounded strand that maintains the rope's shape better when it passes around obstacles whilst increasing the rope's resistance to abrasion and snagging.

- However, a high twist also produces a rope that stretches more readily and has a lower minimum breaking load than a similar rope with a low degree of twist.

LOW TWIST

HIGH TWIST

Types and Characteristics of Rope Structures

	Three- stranded	Eight-stranded (cross)	12-stranded	Double-braided (doubler)
Cross section				
Profile				
Structure	Rope of three strands twisted together	Rope combining a total of eight strands, comprising four parallel strands each twisted clockwise or counter- clockwise.	Rope combining a total of 12 strands, comprising six parallel paired strands each twisted clockwise or counter- clockwise.	Rope formed by making an inner layer core rope combining loosely twisted strands and further combining many outer layer strands.
Strength	○	○	◎	◎
Extensibility	High	High	Medium	Low
Wear resistance	○	○	◎	◎
Flexibility	△	○	◎	◎
Coiling	◎	○	○	○
Kink	△	◎	◎	◎
Weatherability	○	○	○	○
Workability	◎	○	○	△
Mass	Small	Small	Medium	Large

2.5 ROPE PROPERTIES:

a) Static properties:

- Elongation – Constructional or initial elongation of a rope is a non-reversible phenomenon to which a rope is subjected when it is first put under load.
- Breaking Strength – The strength of a rope is determined by its breaking strength. A rope will be able to withstand a certain load and once this load is exceeded, the rope will break – the rope will behave elastically up to a certain limit load.
- Creep – elongation experienced when a rope is under continuous load for a certain amount of time.
- Static Bending – When a rope is bent around a pin / bollard, etc, the rope strength will be adversely affected because the longitudinal load will be reduced whereas the lateral stresses will increase under the influence of bending.

b) Dynamic Properties (to determine how well / long a rope can withstand in service condition)

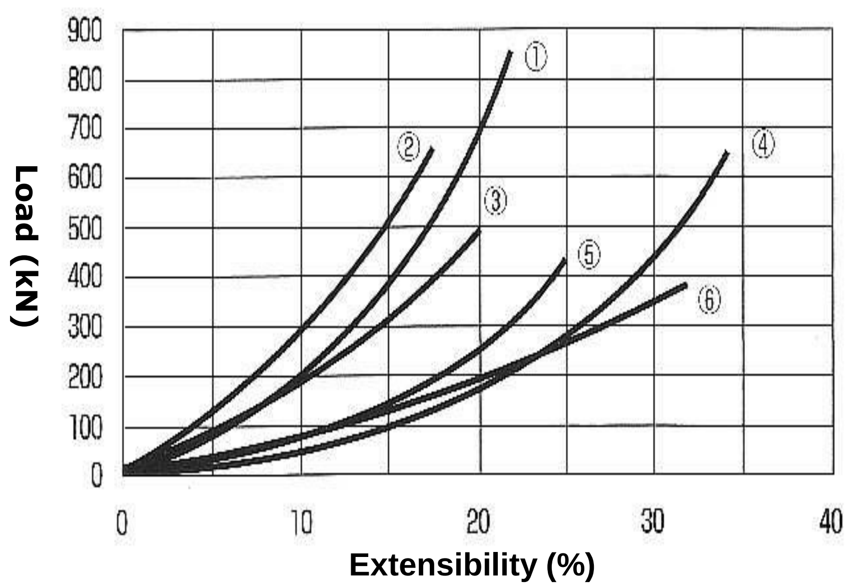
- Tension Fatigue – This can be done by calculating the load level, expressed as a percentage of the rope's nominal breaking strength, at which the rope (in wet conditions) can be cycle-loaded exactly a thousand cycles (in controlled/ laboratory conditions).
- Bending Fatigue – mooring ropes are passing over fairlead rollers, barrels, warping ends and over rounded surfaces (chocks, bitts, etc) result in yarn abrasion and the effect of the rope under a bend will result in a distortion of the distribution of the longitudinal and lateral loads.
- Yarn Abrasion **–** Ropes as they pass around rollers, bitts, etc will result in abrasion, chafing.
- External Abrasion – When a rope is first put into service, the outer filaments will quickly take on a furry appearance. This is a normal occurrence as the surface filaments break through slight abrasion while in service. This furry surface acts to protect the underlying fibres in the rope construction.
- Internal Abrasion – can also occur between strands and yarns in a rope. One of the signs is powdered fibre, indicating internal wear and a reduction in rope strength.

- Extensibility and Restorability of Mooring Lines:

Some synthetic fiber ropes restore much of their original length rapidly once they are relieved of load, while others do so only gradually. The greater the rate of extensibility, the closer the return of the rope to its original length, thus, the crew should have sufficient knowledge of the characteristics of the different types of ropes in order to use them properly.

Since simultaneous use of mooring lines differing in extensibility might invite concentration of the load on less extensible lines, care must be generally taken not to use mooring lines of different materials.

(Load/extensibility curves of different mooring lines [60 mm in thickness])



① Nylon doubler

② Polyester doubler

③ Polypropylene doubler

④ Nylon cross rope

⑤ Polyester cross rope

⑥ Polypropylene cross rope

Examples of Mooring Force Calculation

The number of mooring lines required by a ship at alongside may greatly vary with the weather condition, the strength of mooring lines, the braking power of winches, and the length and angle of the mooring lines. However, the crew should well take into consideration the capacities of their ship's mooring winches, other equipment and the MBL of the mooring lines in use, and other relevant information, and know in advance the number of mooring lines the ship requires under the influences of external forces.

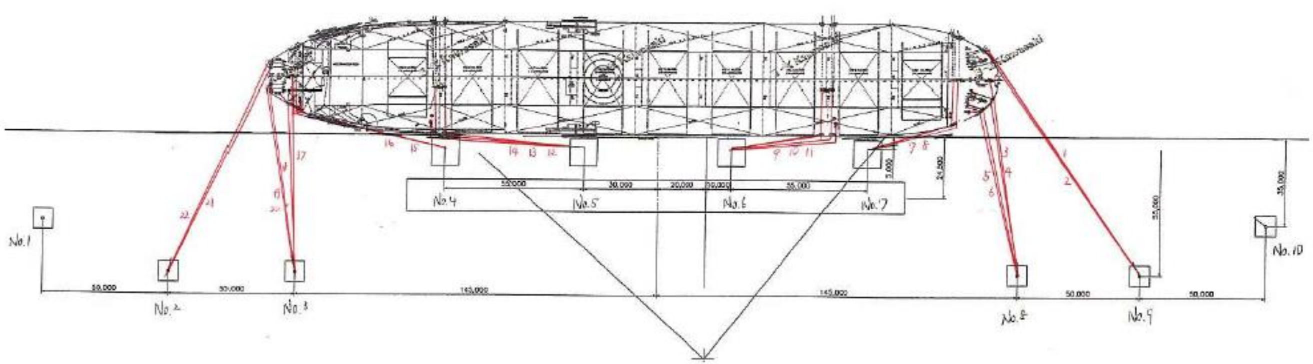
Example of Mooring case considered

Generally, bulkers are susceptible to greater variations in freeboard during cargo handling and, moreover, call at more ports where tidal variations are greater or strong currents are experienced, such as river ports. Therefore, they need particular attention to mooring lines (such as frequent checking and correcting of loosening).

The table below concerns a simulation of the tension working on each cable line and the extent of the ship's shift at the time of the completion of cargo loading (d = 18.2 m under full load) of the 180,000 DWT class bulker A Maru at the Port of Ponta de Madeira in Brazil.

As seen from the findings of the simulation, tidal currents at angles to the stem and the stern particularly affect the strength of mooring lines and the hull shift. Even at a current velocity of 1.0

knot, the shift of the hull reaches 4 m to 5 m in the transverse direction at a current inflow angle of 15 degrees. The ship's crew should give full consideration to the situation in which mooring lines loosen with variations in the ship's freeboard and on that basis pay particular attention when the ship is moored in a river port where strong currents flow.



Material of mooring lines: Nylon double braid (MBL: 80 tons)

Mooring arrangement: 2-4-5/5-4-2 (22 lines)

Current		Wind		Max. Tensile Line			Vessel shift**(m)	
Speed (kt)	Direction (deg.)	Speed (kt)	Direction (deg.)	Line No.	Tension (t)	% of MBL (%)	Longitudinal	Transverse
4.0	0	30	90	15	9.2	12%	4.3	0.9
4.0	180	30	90	9	10.2	13%	-4.4	3.6
3.0	0	21	90	15	5.1	6%	3.1	0.7
3.0	180	21	90	9	6.3	8%	-3.4	1.9
3.0	15	21	90	4	65.0	81%	-0.3	15.0
3.0	165	21	90	18	66.8	83%	-0.4	13.1
2.0	15	21	90	4	29.5	37%	-0.5	9.5
2.0	165	21	90	18	30.4	38%	0.0	8.2
1.0	15	21	90	4	8.3	10%	-0.2	4.7
1.0	165	21	90	18	9.2	12%	-0.1	4.0

2.6 WIRE ROPES:

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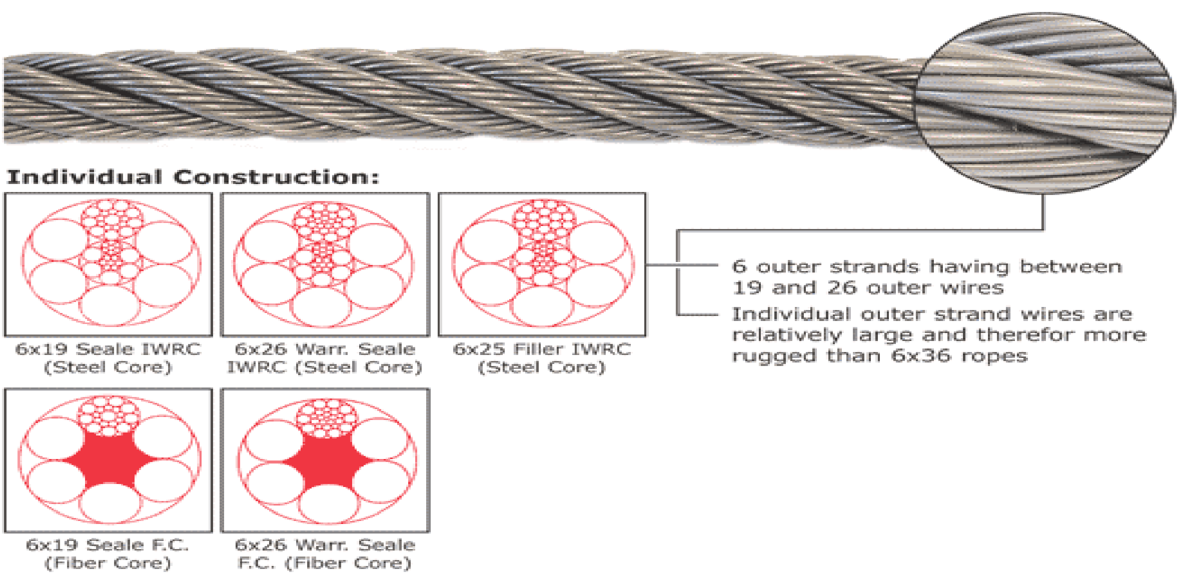
Rope which consists of several strands of metal wire laid into a helix. Initially wrought iron wires were used, but today steel is the main material used for wire ropes.

- Bare Steel Wire (un-treated, called "Black Wire" – used in a low corrosion environment;
- Galvanized Wire – the galvanizing process will protect the wire from corrosion;
- Stainless Steel Wire – for better corrosion resistance.

Wire ropes are made of different types of steel wires, with required tensile strength as per approved standards. Tensile strength of a wire rope can be 1560 N/mm2, 1770 N/mm2, 1960 N/mm2 or 2160 N/mm2.

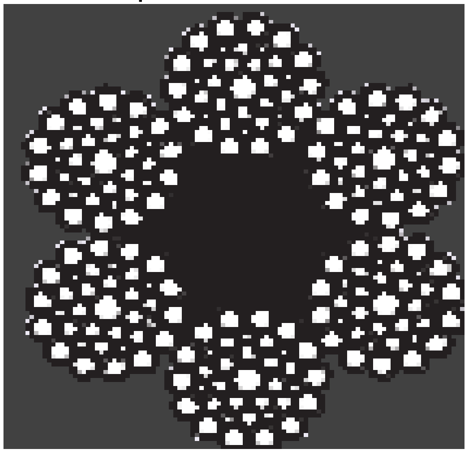


2.6.1 Wire rope construction – consists of several strands of metal wire laid into a helix.

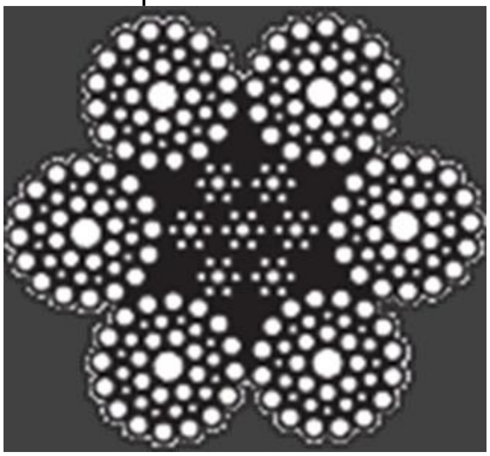
- While flaws in chain links or solid steel bars can lead to catastrophic failure, flaws in the wires making up a steel cable are less critical as the other wires easily take up the load. Friction between the individual wires and strands, as a consequence of their twist, further compensates for any flaws.

The CORE forms the centre (the heart) of the wire rope.
The STRANDS are laid around the core according to a specific lay to make up the wire rope.

Wire Rope with Fiber Core



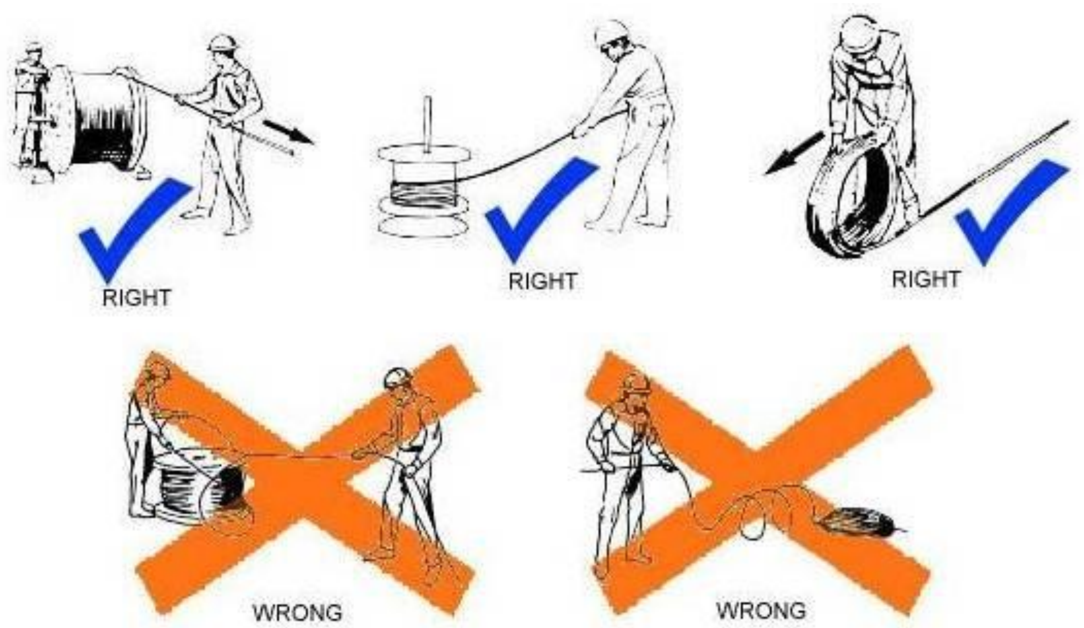
Wire Rope with Steel Core



Fiber core has many disadvantages, therefore most used on board wires are with Steel Core: IWRC (Independent Wire Rope Core) and WSC (Wire Strand Core).

2.6.2 Handling of Wire ropes

- When uncoiling wire rope it is important that no kinks are allowed to form, as once a kink is made no amount of strain can take it out and the rope is unsafe to work. If possible a turn table should be employed, the rope will the lead off perfectly straight without kinks. If a turn table is unavailable the rope may be rolled along the ground.



- In no case must the rope be laid on the ground and the end taken over, or kinks will result, and the rope will be completely spoiled. The life of wire rope depends principally upon the diameter of drums, sheaves and pulleys. Wherever possible, the diameter of the sheave should not be less than 20 times the diameter of the wire rope. The diameters of drums, sheaves and pulleys should increase with the working load when the factor of safety is less than 5 to 1 ratio.

- Wire rope should be greased, as rust can quickly destroy its integrity. Great care should be taken that the grooves of drums and sheaves are perfectly smooth, ample in diameter, and conform to the surface of the rope. They should also be in perfect line with the rope, so that the latter may not chafe on the sides of the grooves.

For example, it will be a large scale job when we uncoil mooring ropes and wires. And we need to remove twists from 3-strand ropes or wires that are always likely to be twisted.

Coil with a wooden reel

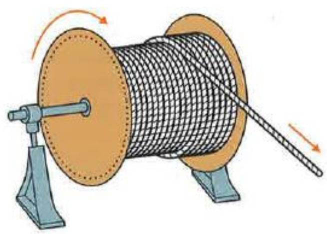
This is suitable for uncoiling mooring ropes wound around a wooden reel.

Insert a steel pipe and keep it on a strands, or hoist by crane.

Non wooden reel

Cross timbers and hoist it with a wire sling.

Steel bands binding the coil should be cut after hoisting it.



Please refer also to Appendix 10: The way of eye-splice of the Cross Rope

Chapter 3 – BASIC PRINCIPLES OF ANCHORING (SMS)

- The Chief Officer (or Officer as assigned by Master -ref Ch ZZ-S-P-02.10.02) shall confirm with Master the anchors to be used, expected depth of anchoring area and expected length of anchor chains to be laid out.

- In addition, in consultation of master, he directs the deck crew members to be ready to cast anchor in accordance with the following procedures:

  - Start up the windlass and test operate it to check for any abnormality; then take off the stopper;
  - Veer anchor chains to a' cockbilled state or walk back the anchor chains to expected full length and apply the brake and put out of gear to stand by the anchor lowering state;
  - When walking back the anchor chains under water, do it after the ship has sufficiently lost its head way;

Operations to Cast Anchor **-** The Chief Officer (or Officer as assigned by Master) on the master's order shall let go anchor in accordance with the following procedures:

- When letting go anchor into <u>deep water</u>, he shall do it in accordance with below:

> 25 meters: walk back the anchor under water close to the sea bottom (10 to 5 meters) and then let it go;
> 50 meters: walk back the anchor until it reaches the sea bottom and pay out the anchor chain under power to the scheduled amount of chain to be laid out while laying the anchor chain along the sea bottom (speed over the ground shall be max 0.5 knots).

- Pay attention to the speed in which the anchor and anchor chains fall;
- When the planned length of extension is reached, bring it up with the ship's residual inertia;
- After checking that the anchor has been brought up, put on the stopper, apply the brake on the windlass so as not to put a load on it, and put out of gear.
- While using stopper bar upon vessel being brought-up, it is required sufficient clearance between the vertical link of the chain and the stopper to detect any slippage of the brake.

Points To Be Observed When Anchoring **-** The Master, when anchoring at an anchorage with strong winds or currents, shall carry out risk assessment and shall be careful of the following:

- Pay Due consideration to the condition of hydraulic gear, windlass motors, anchors, cable, and brake lining;
- The anchor chain is liable to be subjected to an unexpected load causing the anchor to drag in the initial stage of laying out the chain after the anchor is let go, or causing the chain to lie curved/snaked on the sea bottom so that a good hold of the anchor can’t be obtained;

3.1 CALCULATION OF CRITICAL WIND VELOCITY:

- The calculation from SMS should be utilized in developing the anchoring plan and the anchor watch instructions / checks.
- This calculation provides only a guidance to grasp the wind velocity for dragging anchor; the ship may drag her anchor even if the wind velocity is less than the critical wind velocity, due to other additional factors such as swells, waves, currents, age & condition of anchor itself, its chain, shackles etc.
- Critical wind velocity is also subject to preconditions such as size or shape of the ship, depth of water, bottom sediment, etc.
- Note it is very difficult to heave up anchor if the weather, especially the sea condition, becomes heavy or unfavorable.

- Results of Calculation

Type of ship		Critical wind velocity [m/sec]	Calculation conditions			
			Frontal area of windage [m^2]	Anchor Type Weight	Anchor chain Dia. Weight	Others
Container (3800TEU)	Ballast	17	1108	AC-14 9.27 t	87mm 0.166 t/m	
	Full load	18	979			
Container (6300TEU)	Ballast	16	1620	AC-14 12.08 t	97mm 0.206 t/m	
	Full load	17	1490			
Bulk Carrier (200,000DWT)	Ballast	18	1207	AC-14 11.60 t	97mm 0.206 t/m	
	Full load	23	761			
PCC (6000RT)	Ballast	12	1060	AC-14 8.43 t	81mm 0.144 t/m	T=5×R
	Full load	13	980			
VLCC	Ballast	17	1875	AC-14 16.13 t	114mm 0.285 t/m	
	Full load	22	1125			
LNG Carrier (Moss type)	Ballast	15	1762	JIS 21.50 t	114mm 0.285 t/m	
	Full load	15	1684			

- Calculation Condition
  Depth of water: 30 m (bottom sediment: sand)
  Holding power coefficient of anchor: AC-14: 7.0, JIS: 3.5
  Length of anchor chain veered out: 10 shackles (275m)
  Holding power coefficient of anchor chain: 0.75 (bottom sediment: sand)
  Wind-pressure coefficient: 0.75
  Gust rate: 1.25
  Note: This calculation does not consider swells, waves, currents, etc.

- Remarks
  -Full Load means the condition when the ship is even keel with summer draft.
  -Critical wind velocities for dragging anchor shown in Fig. 1 are just for reference. Those values are subject to individual preconditions such as size or shape of the ship, type of anchor, depth of water, bottom sediment, etc.
  -Coefficients for above calculations are adapted from "SOSEN TSURON" by K. Honda, Seizando, 1989.

[COMMENT]

- The ship starts to drag its anchor if the wind velocity becomes greater than the critical wind velocity. It should be carefully examined to determine whether safe anchoring can be maintained when heavy weather is forecasted.
- Note that the critical wind velocity is subject to preconditions such as size or shape of the ship, depth of water, bottom sediment, etc.
- The followings are to be considered when examining the risk of dragging anchor:
  -Even if the wind velocity is not more than the critical wind velocity, the ship may drag her anchor due to other additional factors such as swells, waves, currents, etc.
  -It is very difficult to heave up anchor if the weather, especially the sea condition, becomes heavy.

Anchor and Anchor chain Holding power

The formulae in this page are to calculate the holding power of your vessel's anchor and anchor chain.
You can get the minimum necessary length of the chain under the external force you input.
To know the external force, you may use the formulae of other pages.

Input;

Expected total external force (MT)	65
Anchor weight (MT)	12.1
Anchor chain weight (MT/m)	0.206
Kind of Ancher (1: JIS, 2: AC14)	2
Water depth (m)	25
Hawsepipe height from the sea surface (m)	30

	Anchor Holding Factor:	7	Chain's friction factor: 0.6
Total height (Bottom to Hawsepipe):		55	m
Catenary length against the external force:		194.3	m
Contacted length of the chain:		0.0	m

RESULTS;

To get necessary hplding power, more than 194 m, 8 ss of anchor chain to be used.

In case you make the anchor free fall, final falling speed will be 7.1 m/sec
You are requested to control the falling speed by 3-4m/sec

WIND PRESSURE FORCE

This formulae calculate the wind force of your vessel at the wind speed you input.
The wind force factor in each kind of ship is calculated automatically.

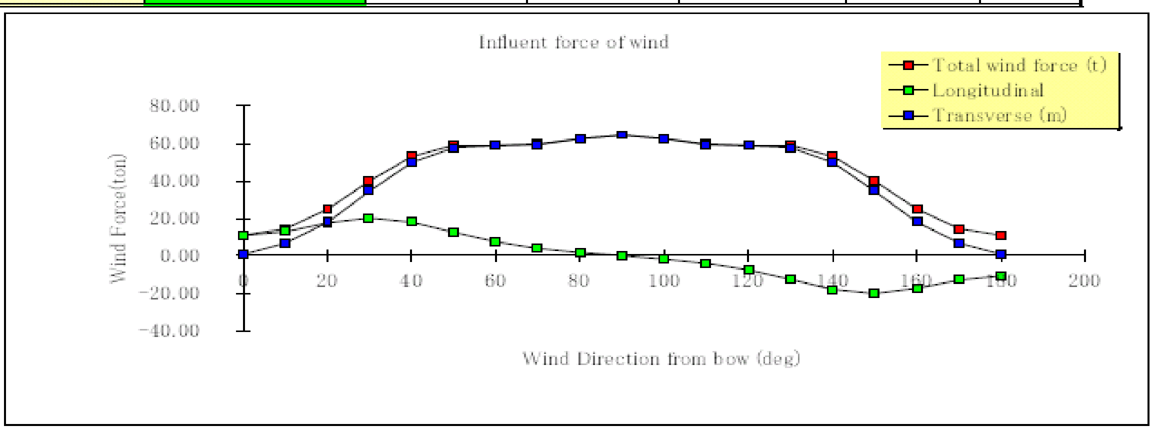
Input;

LOA(m)	330
Projected area (Front) (m2)	1,620
Projected area (Side) (m2)	6,000
Wind Speed (m/s)	12.0
Kind of ship	1

(Genl, PCC, Ctnr: 1 Passenger: 2 Tanker, Bulker: 3)

(RESULTS)

Wind direction from bow (deg)	Total wind force (t)	Longitudinal	Transverse (m)	Point of action	Angle of action	Factor
0	10.85	10.81	0.85	96.03	4.50	0.75
10	14.43	12.81	6.65	103.62	27.43	0.92
20	25.00	17.49	17.87	111.21	45.62	1.31
30	40.00	20.20	34.52	118.80	59.67	1.65
40	53.06	18.01	49.91	126.39	70.15	1.73
50	58.92	12.57	57.57	133.98	77.68	1.58
60	59.12	7.38	58.66	141.57	82.83	1.35
70	59.53	3.93	59.40	149.16	86.21	1.22
80	62.41	1.74	62.39	156.75	88.40	1.19
90	64.28	0.00	64.28	164.34	90.00	1.20
100	62.41	-1.74	62.39	171.93	91.60	1.19
110	59.53	-3.93	59.40	179.52	93.79	1.22
120	59.12	-7.38	58.66	187.11	97.17	1.35
130	58.92	-12.57	57.57	194.70	102.32	1.58
140	53.06	-18.01	49.91	202.29	109.85	1.73
150	40.00	-20.20	34.52	209.88	120.33	1.65
160	25.00	-17.49	17.87	217.47	134.38	1.31
170	14.43	-12.81	6.65	225.06	152.57	0.92
180	10.85	-10.81	0.85	232.65	175.50	0.75



When deciding the anchorage position, one of the most important factor to be considered is the **depth**.

- Maximum depth will be in accordance with windlass capacity, considering the weight of the anchor and chain shackles.
- As a thumb rule, if anchor will not touch the bottom when 4(four) shackles are lowered in water, the windlass will not be able to heave back the anchor.

3.2 CALCULATION OF MAXIMUM ANCHORING DEPTH:

CALCULATION OF MAXIMUM ANCHORING DEPTH, BASIS WINDLASS POWER (SAMPLE)

S.NO	CALCULATION	DATA		REMARKS
1	Lifting Load of the Windlass	66.00	MT	(Figure to be obtained from Windlass Manual)
2	80 % of the Lifting Load of the Windlass	52.80	MT	To allow for age of the vessel & weather condition
3	Weight of the Anchor	17.50		
4	Maximum allowable weight of Anchor Chain (when vertical)	35.30		
5	Chain Diameter	117	mm	(Figure to be obtained from Anchor & Chain Cable Plan)
6	Weight in Tons per 27.5 m (1 shackle)	7.98	MT	(see attached Anchor Chain weight table)
7	Number of shackles outside the Hawse pipe when anchor chain is up & down)	4.42		
8	Vertical distance from Hawse pipe to Water Level	10.00		
9	Maximum Anchoring Depth	111.6	m	

NOTE:

1	Following cells shall be filled up, basis Ship Specific Plans, Manuals etc.	
2	Following cells shall be filled up, basis attached Anchor Chain weight table	
3	Formula cells	
4	As far as possible, vessel's shall avoid anchoring in depths exceeding the figure as per S.NO 9 (Formula cell)	

3.3 CALCULATION OF LOAD ON THE WINDLASS:

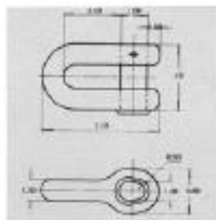
CALCULATION OF LOAD ON THE WINDLASS, WHEN HEAVING UP THE ANCHOR (SAMPLE)

S.NO	CALCULATION	DATA		REMARKS
1	Lifting Load of the Windlass	66.00	MT	(Figure to be obtained from Windlass Manual)
2	80 % of the Lifting Load of the Windlass	52.80	MT	To allow for age of the vessel & weather condition
3	Chain Diameter	117	mm	(Figure to be obtained from Anchor & Chain Cable Planl)
4	Weight in Tons per 27.5 m (1 shackle)	7.98	MT	(see attached Anchor Chain weight table)
5	Maximum Depth of water at the anchor position	120	m	
6	Vertical distance from Hawse pipe to Water Level	10.00	m	
7	Number of shackles outside the Hawse pipe corresponding to the depth of water (vertical height of Anchor Chain, when chain is up & down)	4.73		
8	Weight of Anchor Chain (when vertical)	37.72	MT	
9	Weight of the Anchor	17.50	MT	(Figure to be obtained from Anchor & Chain Cable Planl)
10	Total Weight acting on the Windlass when the Anchor Chain is up & down & the Anchor is off the bottom, when heaving up the anchor	55.22	MT	(see Note no. 4 & 5 below)

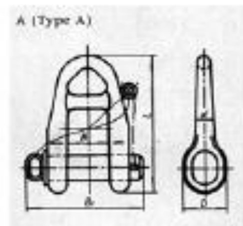
NOTE:

1	Following cells shall be filled up, basis Ship Specific Plans, Manuals etc.	
2	Following cells shall be filled up, basis attached Anchor Chain weight table	
3	Formula cells	
4	**If value of S.No 10 is greater than value of S.No 2, vessel shall avoid anchoring at that position and move to a position with lesser depth**	
5	**Value of S.No 10 must be less than or equal to the value of S.No 2, to enable the windlass to heave up the anchor safely.**	

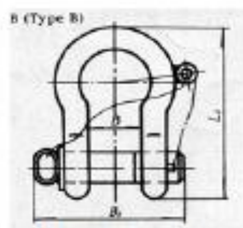
3.4 WEIGHT OF ANCHOR'S CHAIN:



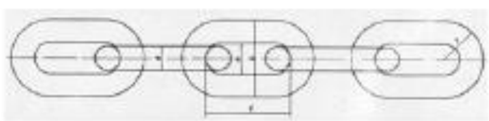
▲Joining Shackle Type D



▲Type A Buoy Shackle

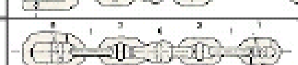
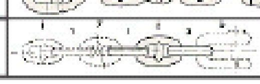


▲Type B Buoy Shackle



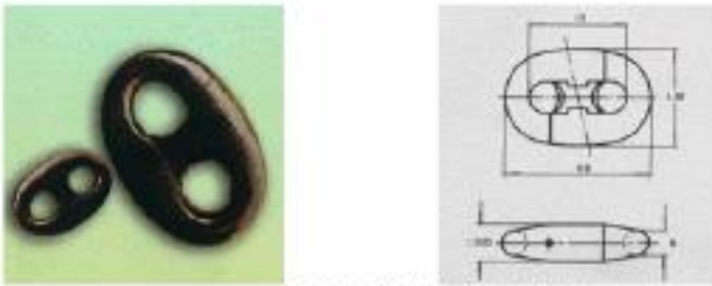
▲Mining Round Link Chain

▲Chafe Chain

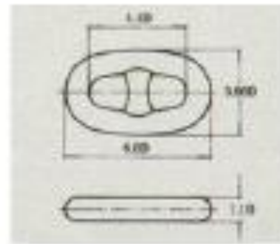
A.1 - Connection of two chain-cables	
A.2 - Standard length with joining shackle	
A.3 - Standard length with joining shackle and anchor shackle	
A.4 - End length with joining shackle, swivel and anchor shackle	
A.5 - Forerunner with joining shackle, swivel and anchor shackle	
B.1 - Connection of two chain-cables	
B.2 - Standard length with lugless joining shackle	
B.3 - Standard length with lugless joining shackles and ordinary anchor shackle	
B.4 - End length with lugless joining shackle, swivel and ordinary anchor shackle	
B.5 - Forerunner with lugless joining shackle, swivel and lugless anchor shackle	
B.6 - Three links adaptor piece	

The weight of the anchor and chain must be confirmed with equipment specification Manual.

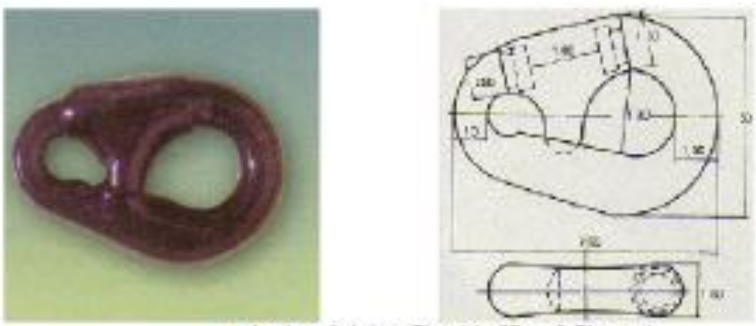
Anchor Chain



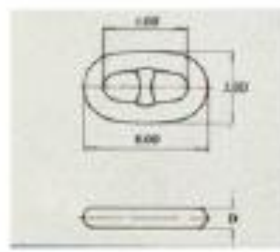
▲Joining Shackle Type Kenter



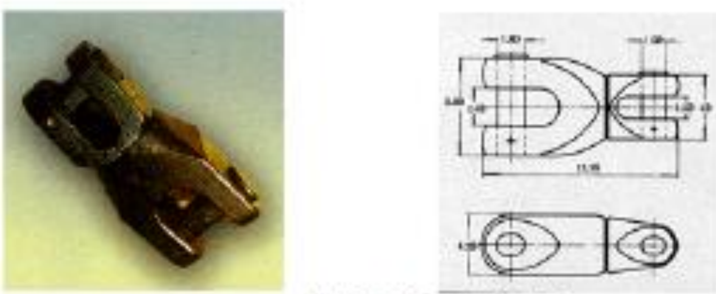
▲Common Link



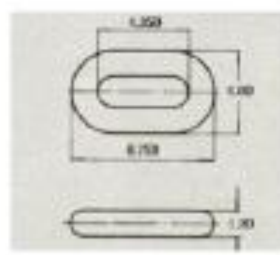
▲Anchor Joining Shackle "Pear" Shaped



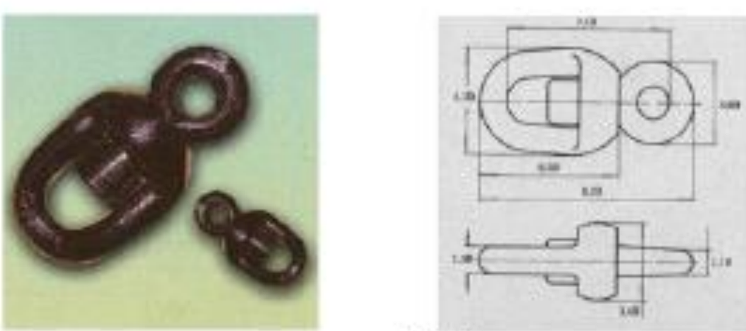
▲Enlarged Link



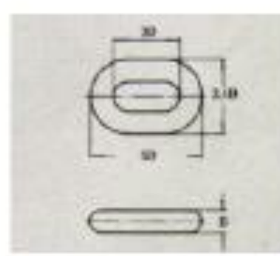
▲Anchor Swivel Shackle



▲End Link



▲Swivel



▲Studless Link

GENERAL INFORMATION

- The inside length (grip or pitch) of one link is 4 wire diameters.
- The outside length of one link is 6 wire diameters.
- The outside width of one link is 3.56 wire diameters.
- The gauge-test length is the outside length over 6 links and equals 26 wire diameters.
- The weight of one links is about 3-1/3 times its wire diameter cubed.
- Doubling the wire diameter of one link multiplies its weight by 8.
- The weight of 1 linear foot of chain is 10 times its wire diameter squared.
- The length of a standard "shot" = 15 fathoms = 90ft.= 1080".
- The weight of a 90ft. shot = 900 times its wire diameter squared.
- Doubling the wire diameter of a 90ft. shot multiplies its weight by 4.
- Doubling the size of chain theoretically multiplies its strength by 4, in practice, by a trifle less than 4.
- The safe working load of chain is ordinarily assumed as one half the proof test.

CONVERSION

1 lbs = 0.454 kg.
1 ton (long) = 1016 kg.
1 N = 0.102 kg.
1 foot = 304.8 mm

1 cwt = 50.8 kg.
1 KN = 102 kg.
1 inch = 25.4 mm
1 fathom = 1.828 m

Maximum Anchoring Depth Guidelines & Calculation (GI/FLT/039/11)
==

As far as practicable, vessels shall avoid anchoring in depths greater than the Maximum Anchoring depth, calculated basis 80% of the Lifting Load of the Windlass.

Maximum Anchoring depth, based upon 80 % of the Liftable Load of the Windlass = <u>111.6 metres</u>

Maximum anchoring depth, based upon 90 % of the Liftable Load of the Windlass = <u>134.4 metres</u>

Contact Vessel Manager immediately if vessel is unable to obtain suitable anchoring position with depth less than <u>134.4 metres</u> (basis 90 % of the Liftable Load of the Windlass)

Chapter 4 – SAFETY OF MOORING OPERATIONS

4.1 JOB HAZARD ANALYSIS AND RISK ASSESSMENT:

4.1.1 TERMS AND DEFINITIONS

- Hazard: a condition or source of danger that has the potential to cause harm; hazard should be identified.

- Hazard Analysis: The process of formalizing the very specific scope and/or effect of each hazard in the system, and deciding whether it is rationally applicable to the matter in question.

  E.g.: Working on high places exposes a person to the hazard of falling down due to two sources (among others) - one falling down due to gusting strong winds; and two, falling down due to psychological weakness of vertigo. However, when we are carrying out risk assessment for shipboard work with trained and experienced seamen, the scope of vertigo will most likely be disregarded.

- Consequence: Is an outcome or severity of an accident

- Cause: Is a reason why that accident occurred. There can be a 'Primary' or root cause and a 'Secondary' or contributory cause.

- Frequency: Is the actual or estimated rate of occurrence of an accident in any given time.

- Risk: Is a chance of some thing adverse happening; or, mathematically speaking, is the combination of frequency and consequence of an accident arising out of a hazard.

- Risk Analysis: Is the systematic use of available information to arrive at a concrete judgment about the acceptability of a risk within the parameters prescribed by the organization or by law.

- Risk Mitigation: Is the process undertaken to reduce or remove one or more factors which are raising the risk level of any process.

- Countermeasures: Are means of controlling one or more elements that give rise to risk.

- Safety: Is freedom from danger; or is a situation where the overall risk is judged to be 'As Low as Reasonably Practicable' (ALARP). Safety does not mean that the hazard does not exist, or ceases to exist.

- Risk Management: Is the overall systematic application of management policies, procedures and practices to the task of controlling risks.

- Risk Assessment process cover all on board activities, operations, jobs and tasks including non-routine repairs.

In case of routine tasks, for which detailed risk assessments are not done or in the judgment of the assessor the risks posed are trivial in nature, a Job Hazard Analysis (JHA) shall be done as per ZZ-S-P-09.02.00 'Hazard Analysis and Hazard Identification' serving as an Initial Risk Assessment.

A detailed risk assessment as per SMS procedures shall be done if during the initial risk assessment non trivial risks or significant hazards are identified.

- If the risk related to the job is assessed once, it is not necessary to be assessed again as long as the circumstances of the work activity have not changed; It is acceptable to review the last job assessment and amend if deemed necessary.

4.1.2 Responsibilities and Person in Charge (PIC)

The Master is responsible for ensuring that the Risk Management procedures are properly implemented for all applicable jobs performed onboard and/or in the vicinity involving ship's crewmembers. The Master may delegate department heads as PIC to carry out the Risk Assessment accordingly.

Regarding the jobs, requiring Risk Assessment, that involve more than one department, all involved parties / departments should carry out the Risk Assessment.

Risk assessment is overall process of hazard analysis and risk evaluation. In the face of uncertainty, assessment of risk increases the chance of successful action by improving available information and control measures of risk involved in a work- activity.

4.1.3 Risk assessment process involves following steps:

Which shipboard work activity to be assessed for risk? = **Identification of work activity**

What might go wrong? = **Identification of Hazard associated with activity** (a list of all possible accident scenarios with potential)

What will be the outcome if identified hazards actually take place = **Effect of hazard and outcomes.**

Can matters be improved? = **Risk mitigation which includes existing control measures and additional control measures**

How bad and how likely? = **Assessment of risk factor i.e. Frequency, consequences and level of risk**
(devising regulatory measures to control and reduce the identified risks);

What actions should be taken? = **Recommendation for decision-making**.

While reviewing the risk it shall be born in mind that 'Safety' does not mean that the hazard does not exist, or ceases to exist from danger. Contrary to that situation shall be assessed where the overall risk is judged to be **<u>'As Low as Reasonably Practicable' (ALARP).</u>**

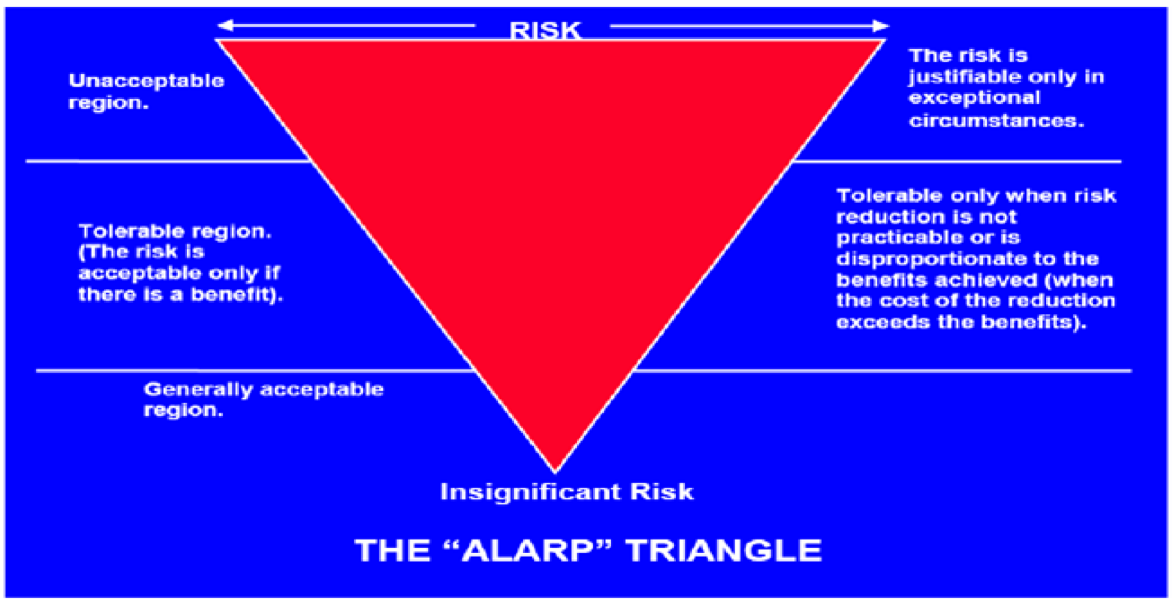


Table 5: Risk Reduction Matrix

Frequency	CONSEQUENCE Catastrophic C4	Major C3	Minor C2	Negligible C1
Frequent (< 6 months) **F5**	H	H	M	L
Probable (6 months to 1 yr) **F4**	H	H	M	L
Likely (1-5yrs) **F3**	H	H	M	L
Occasional(5-15yrs) **F2**	H	M	L	L
Remote (>15yrs) **F1**	M	L	L	L

4.1.4 RISK ASSESSMENT OF MOORING OPERATIONS:

Vessel shall carry out a Risk Assessment of Mooring Operations, which shall include following:

a) Mooring arrangement & lay out as per plan.

b) Condition of mooring winches, fairleads, rollers, bitts and other equipment.

c) Condition of mooring ropes, wires, tails, chocks and stoppers.

d) External factors including tides, current and weather conditions such as sea, swell, winds, fronts and squalls likely to be experienced.

e) Snap-back and safe zones.

f) Communications.

g) Berth lay out or other shore mooring arrangement.

h) Safe working practices.

i) Ship to Ship transfer operation, mooring to buoys or other special operations.

The result of risk assessment shall be filed and this shall be reviewed prior every mooring operations. If any parameters are different from the hazards identified earlier, additional measures to be taken shall be considered.

The Chief Officer shall discuss and highlight the safety precautions to be taken during the daily job order meeting, on or prior to the day of mooring. This shall serve as constant reminder and prevent accidents.

Please refer to attached Appendices:

Appendix 1 – Standard Job Hazard Analysis for Berthing / Un-berthing
Appendix 2 – Standard Job Hazard Analysis for tending to moorings in port
Appendix 3 – Standard Risk Assessment for Anchoring
Appendix 4 – Standard Risk Assessment for Berthing / Un-berthing
Appendix 5 – Standard Risk Assessment for Mooring to Buoys
Appendix 6 – Standard Risk Assessment for Winch Failure

4.2 SNAP BACK ZONE:

- Handling of mooring lines has a higher potential accident risk than most other shipboard activities.

- The most serious danger is snap-back, the sudden release of static energy stored in the synthetic line when it breaks.

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

- Snap-back is common to all lines. Even long wire lines under tension can stretch enough to snap back with considerable energy. Synthetic lines are much more elastic, increasing the danger of snap-back.

- Synthetic lines normally break suddenly and without warning. Unlike wires, they do not give audible signals of pending failure; nor do they exhibit a few visible broken elements before completely parting. (Synthetic lines are much more elastic, increasing the danger of snap-back, breaking suddenly and without warning. Unlike wires, they do not give audible signals of pending failure; nor do they exhibit a few visible broken elements before completely parting).

- Line handlers shall stand well clear of the potential path of snap-back, which extends to the sides of and far beyond the ends of the tensioned line.

- As a general rule, any point within about a 10 degree cone around the line from any point at which the line may break is in danger.

- 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 snap-back 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.

If an activity in a danger zone cannot be avoided, the exposure time can at least be reduced by observing some simple rules:

- When it is necessary to pass near a line under tension, do so as quickly as possible.

- If it is a mooring line and the ship is moving about, time your passage for the period during which the line is under little or no tension.

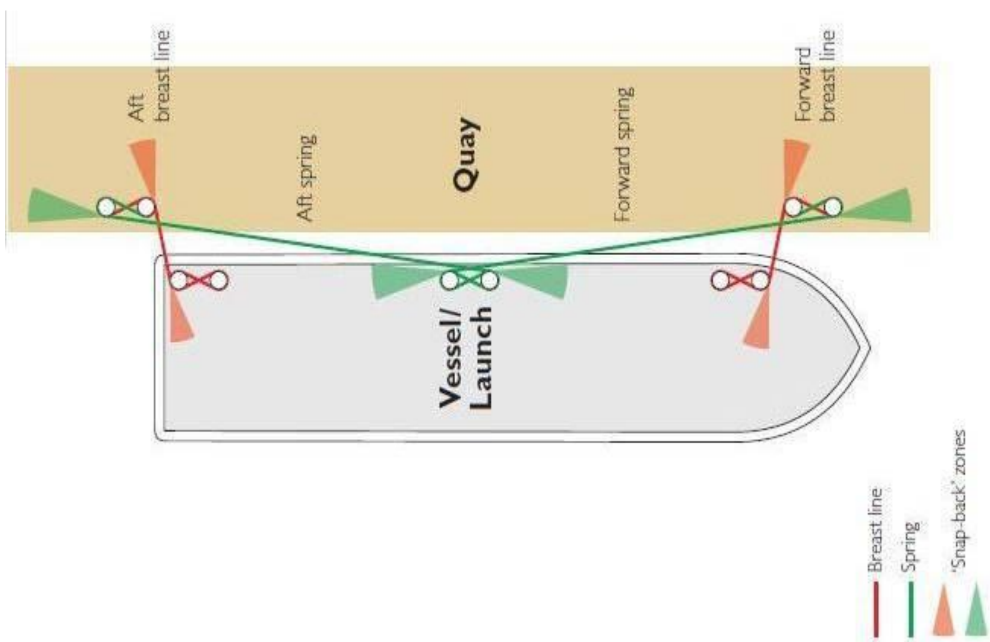
- If possible, do not stand or pass near the line while the line is being tensioned or while the ship is being moved along the pier.

- If you shall work near a line under tension, do so quickly and leave the danger zone as soon as possible.

- Plan your activity before you approach the line.

- Never have more people than necessary near the line, Instruct observers to stand well clear.

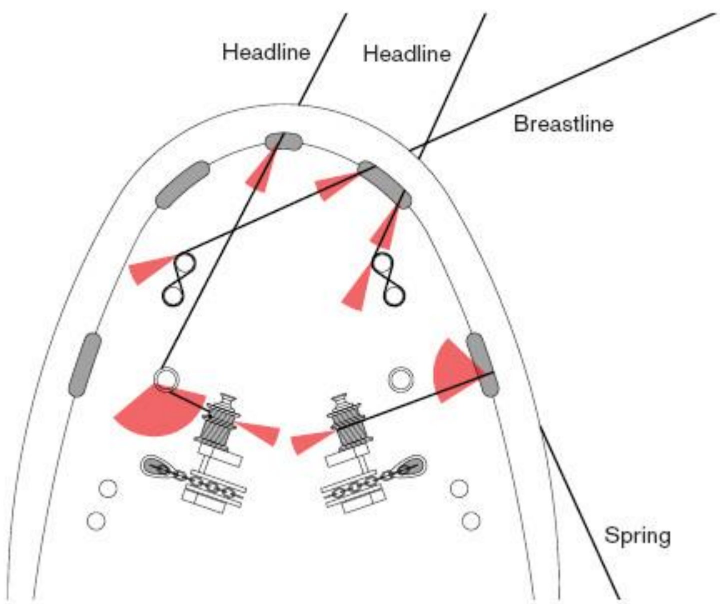
- If the activity involves line handling, make certain that there are enough personnel to perform it in an expedient and safe manner.



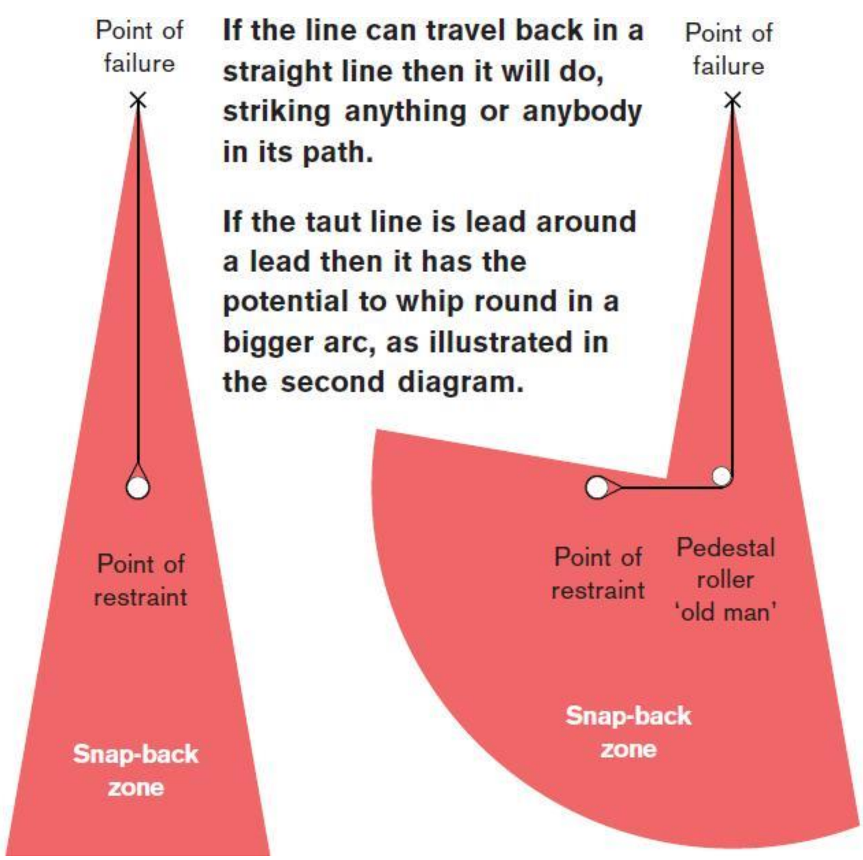
- Once a line has been placed on the bollard, move well away from the bollard whether the strain has been taken on the line by the vessel or not. When considering what distance to retreat, one must think in terms of 20 or 30 feet. A Nylon rope parting under tension 30 feet from a bollard will fly back 20 to 25 feet; a sisal rope will probably not fly back at all, but steel wire will fly and snake unpredictably, depending on the angle of the line and how it parted.

- Sudden tension applied to a line either by ship's winches, or movement of the vessel by surging or listing can cause the line to snake without parting. Anyone in the near vicinity, i.e. putting another line on the same bollard, can be dealt with a severe blow.

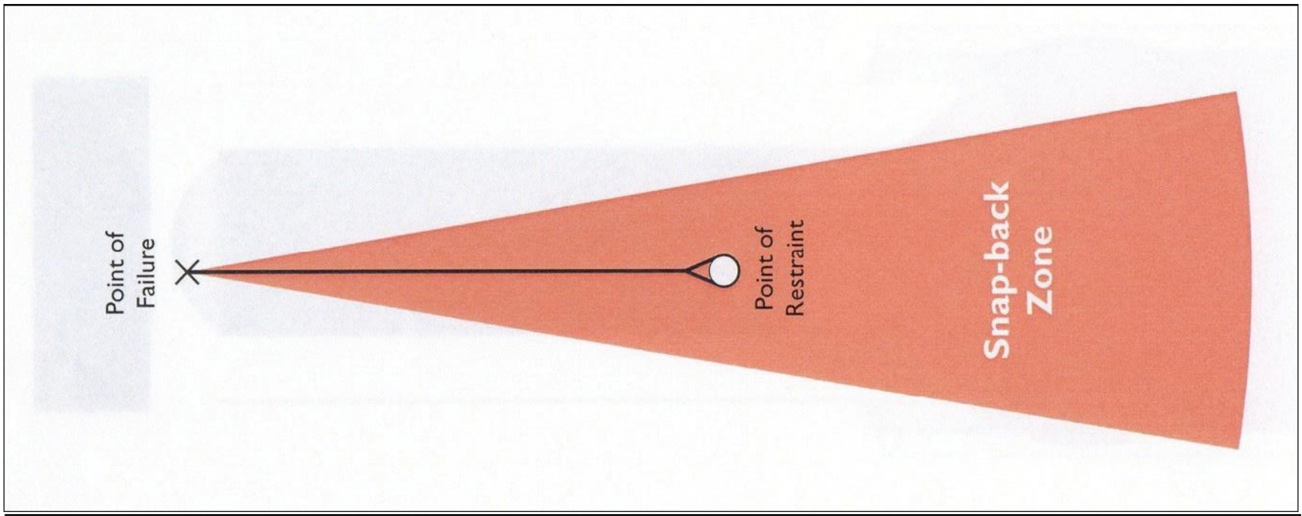
- If an isolated mooring platform with no means of escape from such event is present, a safe place of shelter should be provided to afford protection from breaking mooring lines.

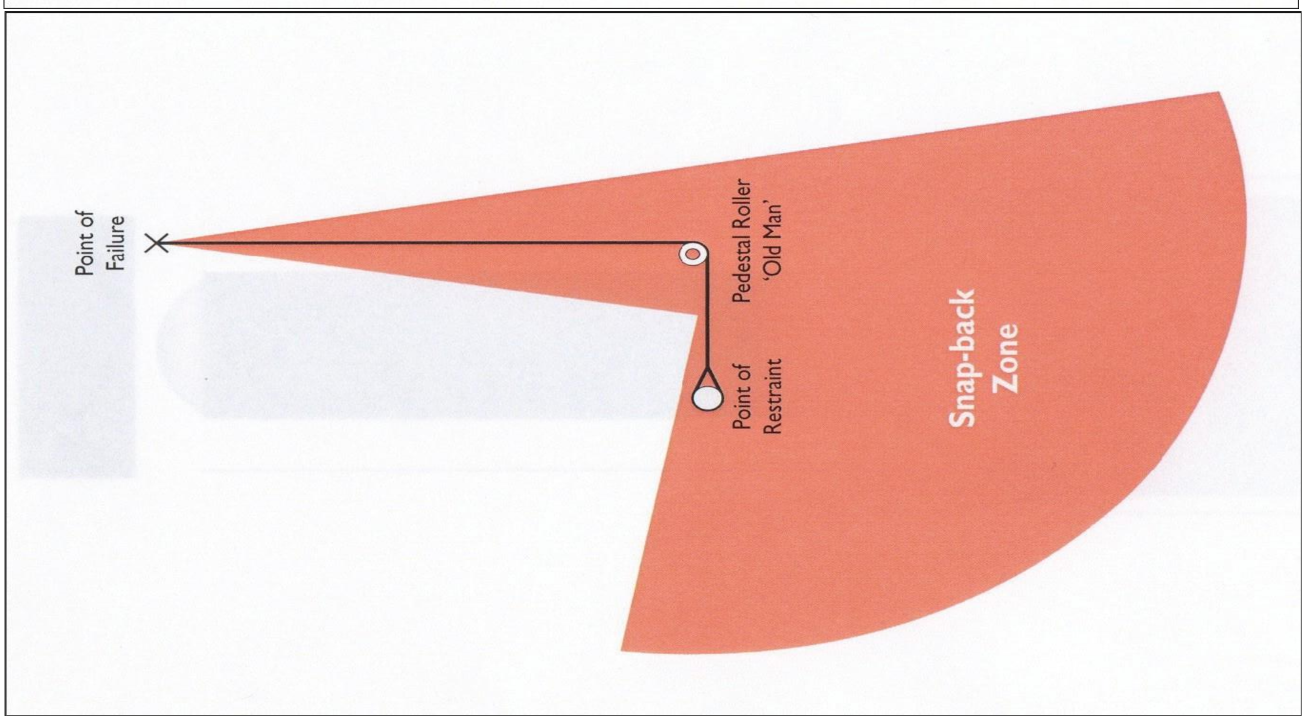


- If snap-back zones are painted on the deck then crew will be alerted to the danger when they notice they are standing in a highlighted zone. Painting these areas also helps supervising officers instruct crew to keep clear when lines are coming under tension.



- Highlighting mooring line snap-back zones ensures that crew can visibly see the danger areas without having to purposely think about them while working.





4.3 GENERAL PRECAUTIONS DURING MOORING OPERATIONS:

REMEMBER, you stand a greater risk of injuring yourself or your shipmate, during mooring and unmooring operations than at any other time!! Following shall be taken account to ensure safety during such operation:

a) Stand clear of all wires and ropes under heavy loads even when not directly involved in their handling.

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

c) Always endeavor to remain in control of the line.

d) 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.

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

f) Do not leave winches and windlasses running unattended.

g) Do not stand on machinery itself to get a better view.

h) 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.

i) Do not work too close to the drum when handling wires and ropes. The wire or rope could "jump" and trap your hand. Stand back and grasp the line about one meter from the drum or bitts.

j) Always wear safety helmets with chin straps properly tightened during mooring operations.

k) Very short lengths of line shall be avoided when possible; as such lines will take a greater proportion of the total load, when movement of the ship occurs.

l) Two or more lines leading in the same direction shall, as far as possible, be of the same length.

m) Two or more lines leading in the same direction shall always be of the same material. Never mix wire and soft moorings, if you can avoid it.

n) Always stand well clear of a wire under load.

o) Always wear gloves when handling ropes and wires.

p) Upon completion of mooring the winch shall be left with the brake on and out of gear.

q) Do not leave the ropes on the warping drums but fast on bitts.

r) Always use stopper ropes of material which is compatible to mooring ropes (e.g. Manila rope stopper should not be used with polypropylene ropes).

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

t) When making synthetic fiber ropes to bitts, do not use a "figure of eight" alone to turn them up. Use two round turns (but not more) around the leading post of the bitts before taking figure of eight for large size bitts, or around both posts before figure of eight for bitts with smaller circumference posts. This method allows better control of the rope, is easy to use and is safer. Do not apply too many turns; generally 4 turns shall be taken with synthetic lines- if too many are applied then the line cannot be released in a controlled manner. Take at least 4-5 figure of 8 turns of wires on bitts.

u) 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.

v) Do not allow oil leaks from hydraulic winches to go unnoticed; it could lead to slips on deck.

w) Spray shields/guards should be fitted to protect personnel and adjoining equipment/motors from the risk of leaks.

a) SAFETY PRECAUTIONS DURING BERTHING:

- Lifting the lines: mechanical assistance may be required in some situations (mooring lines have to be lifted more than 5 meters vertically, or brought more than 10 meters over land).
- When heaving a mooring line ashore, *haul sufficient slack straight onto the quay* and then, with one or more persons holding the weight of the line, walk the slack line along the quay to the bollard.
- When the eye of the line has been placed on the bollard, tell the person(s) holding the weight to ‘let go’. *Do not throw the slack of the line over the quay edge* until the others are clear.
- When handling a line, if excessive load comes onto the line as it is being handled, let it go, *do not attempt to hold it back*.

- DO NOT hold any mooring line by the crown of the eye. When placing the eye on a bollard, always hold the rope by the side of the eye or the standing part and throw the eye over the bollard. Never let hands or fingers get trapped between the line and the bollard.
- Always 'dip' the second line onto a bollard when placing the eye of a second mooring line over a bollard. The eye of the second line is brought up through the eye of the first line. This prevents the lines becoming jammed. When doing so always make sure that there is plenty of slack.
- Wire ropes are notorious for 'spragging' (broken lines or strands) anywhere along its length, but in particular at the eye and splice. These sprags can inflict very painful injuries, even through leather gloves. Never let a wire rope slip through your hand and never slide your hand along the line. The wearing of rings can be a hazard. Serious hand injuries have been caused by rings being caught on sprags.

- When making fast to trip hooks make sure that the hook lock is secure before placing the eye.
- When using sunken bollards, rings or hooks, which are normally covered when not in use, move the cover plates to a safe position. This will usually be behind the line so that the line will not foul it and also that others and yourself will not trip over it.
- Never stand in a loop or 'bight', or eye of a mooring line. If the line tightens rapidly people may be caught or hit by the line.

- Beware of weighted heaving (throwing) lines being thrown from the vessel. Many have a knot (monkey's fist) on the end that acts as a weight to enable the line to be thrown. Some may have an additional weight added such as a large metal nut.

- When hauling in or out the ships line never use your hands to assist the rope/wire to the fairlead.
- Never stand between the quay edge and a mooring line.
- Never walk over a slack mooring line between bollard and vessel, if the vessel heaves or moves the line will become taught rapidly.

- Never stand astride, stand on or walk over taught mooring lines.
- Be aware of the extreme danger to someone in the water from ships thrusters, propellers and being crushed between the vessel and quay.
- Stand clear of bollards when waiting. Do not sit on the bollard or the quay edge. Be alert to what the ship's crew is doing and what your colleagues are doing.

b) SAFETY PRECAUTIONS DURING UN-BERTHING:

- Go to the bollard only when the line to be released is slack; release the line and stand well clear.
- When the vessel has 'singled up' (one line forward and one aft) and making ready to depart, extra strain may be put on the spring lines when 'springing off'.
- Invariably when a ship is 'springing off' the ship will be using its engines and propeller to obtain extra leverage. This means extra strain on lines.
- The number of rounds to be run around a split drum should be just enough to hold the mooring hawser.
- An off shore wind will increase the loading on mooring lines, particularly on a large vessel with deck cargo which acts as a sail.
- As with mooring when releasing any line from a bollard, the line should be grasped by the side of the eye. Never slide your hand along the line and never let your hand or fingers get between

the line and the bollard.

- When releasing a dipped line always pull sufficient slack through the eye(s) of the other line(s) and then turn the dipped line eye over the bollard. If it is jammed by one of the other lines, pull the clear part right over the top of the bollard so that it can be pulled free; then signal to the crew on the vessel to haul it free.

4.4 PERSONAL PROTECTIVE EQUIPMENT:

- Personal protective equipment shall be used only when risks cannot be avoided or reduced to an acceptable level by safe working practices that cause no health risk to any worker. This is because PPE does nothing to reduce the hazard, and can only protect the person wearing it, leaving others vulnerable.

- PPE shall also be used wherever risk assessment indicates that there is a risk to health and safety from a work process which cannot be adequately controlled by other means, but which can be alleviated by the provision of such clothing or equipment.

- It should be noted that the use of personal protective equipment may itself cause a hazard - for example, through reduced field of vision, loss of dexterity or agility.

Types of Equipment

- Overalls, gloves, Safety helmet and suitable footwear are the proper working dress for most work about ship but these may not give adequate protection against particular hazards in particular jobs. When the need for special protection will be identified by the risk assessment carried out and identified in the daily job order meeting.

- Personal protective equipment shall always be selected according to the hazard being faced and the kind of work being undertaken, in accordance with the findings of the risk assessment.

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Personal Protective Equipment

Personal Protective Equipment - Matrix

Figure

	Outside of Accommodation	Go into Machinery Space	Cargo Operation (Other Tankers/Gas)	Anchoring	Mooring Operation	Ballast Tank Inspection	Cargo Hold/ Void Space Inspection	Lifting/ Moving Work	Crane / Lifting Gear Operation	Painting Work	De-rusting / De-scaling Work	Welding / Cutting Work	Steam / Hot Water / Heat	Pressure Vessel / Pipe Line	Electrical Maintenance Work	Handling Chemicals	Work in Dusty Environment	Work at High Place	Work Over Side / Work on Lifeboat	Work at Cold Area	Ice Removal Work on Deck	Garbage Burning
Work Cloth	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎
Warm Cloth																				◎	◎	
Heat Protective Cloth													◎									
Helmet	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎
Eye Protector (Glass Type)			◎		◎	◎	◎	◎	◎	◎			*									
Eye Protector (Goggle Type)				◎							◎		*	◎		◎	◎					
Eye Protector (Welding Goggle / Glass)												◎										
Face Shield													*									◎
Dust Mask				◎						◎	◎						◎					
Chemical-cartridge Respirator																						
Ear Plugs / Ear Muffs		◎									◎											
Safety Shoes / (Anti Static Type – Tankers/Gas)	◎	◎	◎	◎	◎		◎	◎	◎	◎	◎	◎	◎	◎		◎	◎	◎	◎			◎
Safety Rubber Boots (Anti Static / Thermal Type)						◎														◎	◎	
Insulated Boots												◎			◎							
Safety Harness																		◎	◎		◎	
Leather Glove				◎	◎		◎	◎		◎	◎	◎		◎								◎
Rubber Glove						◎									◎	◎						
Winter Glove																				◎	◎	
Heat Insulating Glove													◎									
Flotation Work Vest																			◎			
Leather Apron												◎										
Rubber Apron																◎						

◎ : At All Times * : At all times (Select Suitable PPE as situation)

(blank) : As Required depending on circumstances.

Remarks:-

- Select Area or Work Activity about to be undertaken from the list in top of the table.
- Then check off the required safety requirements from the list in the left hand column.
- For PPE requirement Cargo Operations on Tankers and Gas Carriers, please refer to "Personal Protective Equipment – Cargo Operation on Tankers S-091000-02FIG".

Type	Examples
Head protection	Safety helmets, bump caps hair protection
Hearing protection	Ear muffs, ear plugs
Face and eye protection	Goggles and spectacles, facial shields
Respiratory protective	Dust masks, respirators, breathing apparatus equipment
Hand and foot protection	Gloves, safety boots and shoes
Body protection.	Safety suits, safety harnesses, aprons,high visibility clothing.
Protection against drowning	Lifejackets, buoyancy aids and Lifebuoys
Protection against hypothermia	Immersion suits and anti-exposure suits

PPE REQUIRED FOR MOORING OPERATIONS:

A. Head Protection - Safety Helmets

- Safety helmets are most commonly provided as protection against falling objects, crushing or sideways blow, and chemical splashes.

- The shell of a helmet is one piece seamless construction designed to resist impact. The harness or suspension when properly adjusted forms a cradle for supporting the protector on the wearers' head. The crown straps help absorb the force of impact.

- They are designed to permit a clearance of approximately 25mm between the shell and the skull of the wearer. The harness or suspension should be properly adjusted before a helmet is worn.

B. Hearing Protection – During anchorage (let go anchor)

- Protectors are: ear plugs and ear muffs.

1. Ear plugs of rubber or plastic also have only limited effect, in that extremes of high or low frequency cause the plug to vibrate in the ear canal causing a consequential loss in protection.

2. Ear muffs provide a more effective form of hearing protection. They consist of a pair of rigid cups designed to completely envelope the ears, fitted with soft sealing rings to fit closely against the head around the ears.

C. Face and Eye Protection: Due to exposure to particles and foreign bodies during anchorage and mooring operations. Goggles are recommended.

D. Respiratory Protective Equipment: Respiratory protective equipment is essential for protection when work has to be done in conditions of irritating, dangerous or poisonous dust, fumes or gases. Respirator filters are recommended.

E. Hand and Foot Protection

E.1 – Gloves: Leather gloves should generally be used when handling rough or sharp objects, and same should be used during mooring / anchorage.

E.2 – Footwear: It is strongly advisable that all personnel whilst at work on board ship wear appropriate safety footwear.

Injuries are commonly caused by impact, penetration through the sole, slipping, heat and crushing. Safety footwear is a must during mooring / anchorage operations.

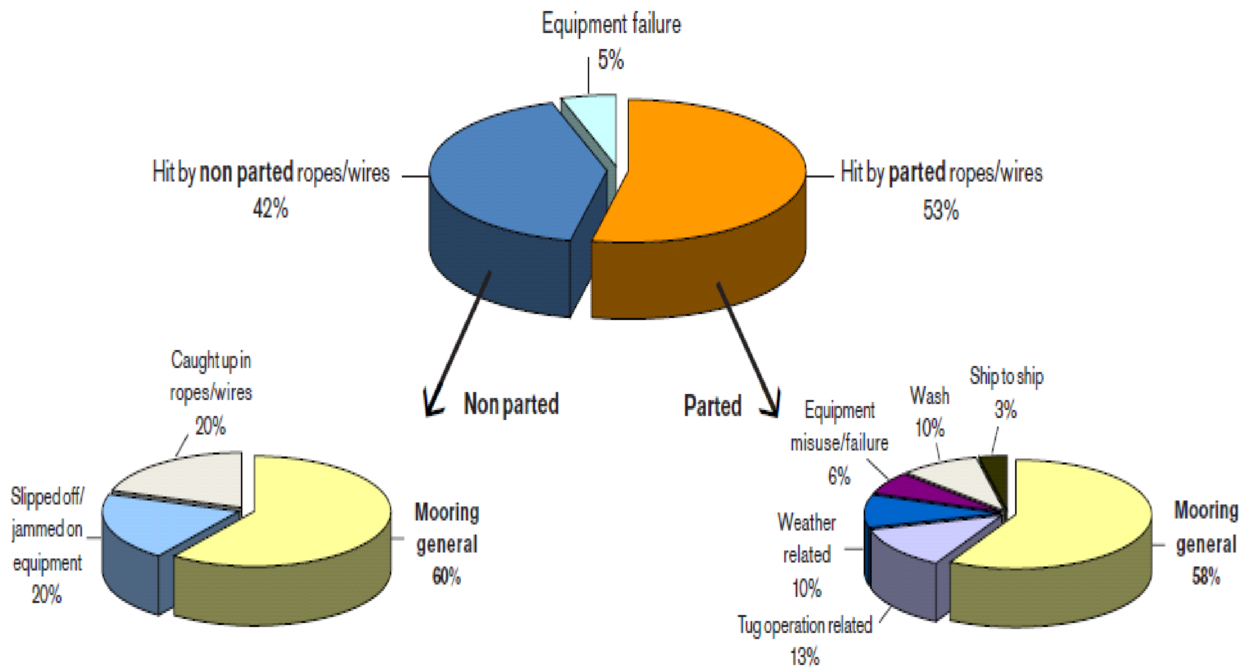
F. Body Protection: High visibility clothing should be worn when it is important to be seen to be safe: during cargo operations, anchorage and mooring maneuvers, etc.

PCC Vessel – BSN and A/B lowering the ramp.

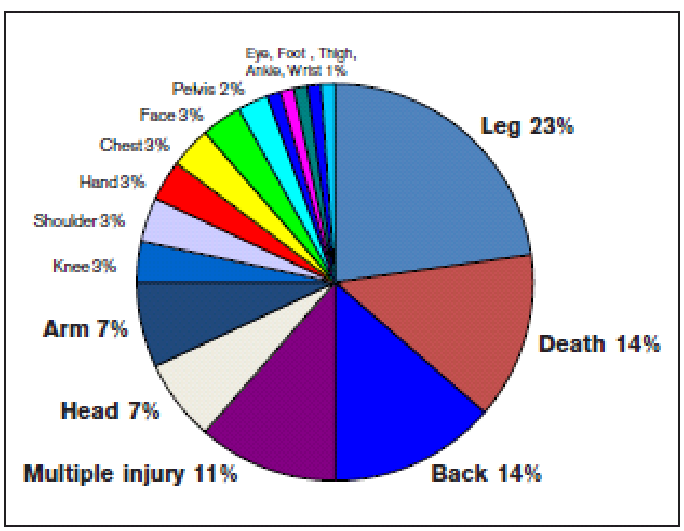
CHAPTER 5 – MOORING ACCIDENTS AND INCIDENTS

MOORING OPERATIONS ARE WIDELY RECOGNIZED AS ONE OF THE MAIN SOURCES OF ACCIDENTS ON BOARD THE SHIPS.

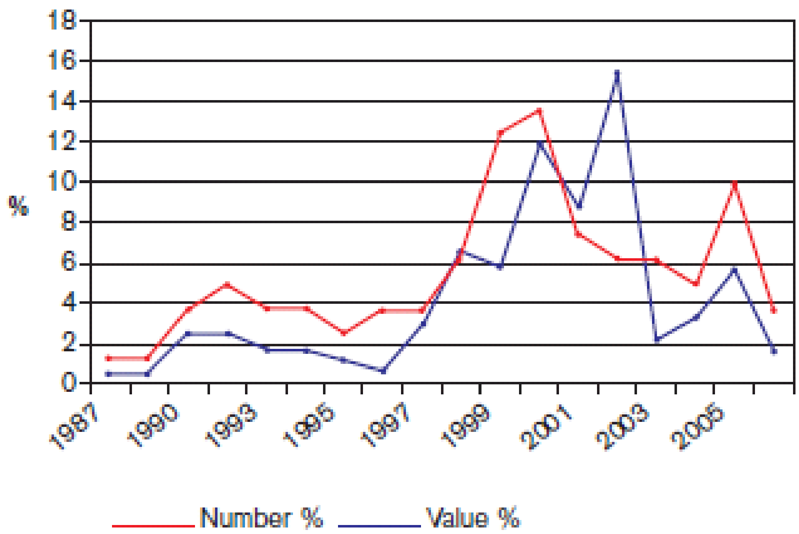
5.1 STATISTICS OF MOORING ACCIDENTS:



Injuries from mooring incidents

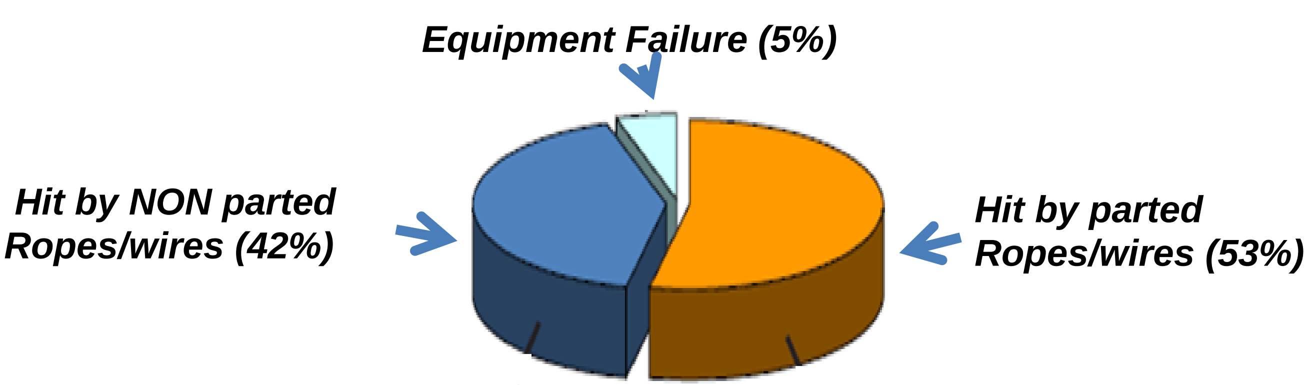


The worrying statistic is the apparent increase in number and value of these claims over the past 9 years (see graph below).

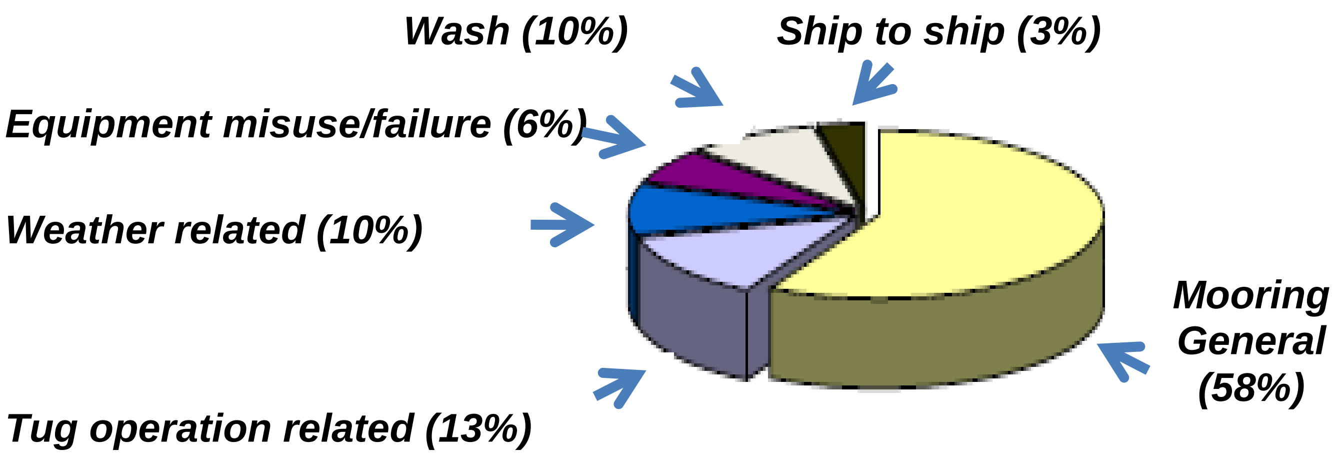


Accidents that have occurred during the handling of ropes or wires:

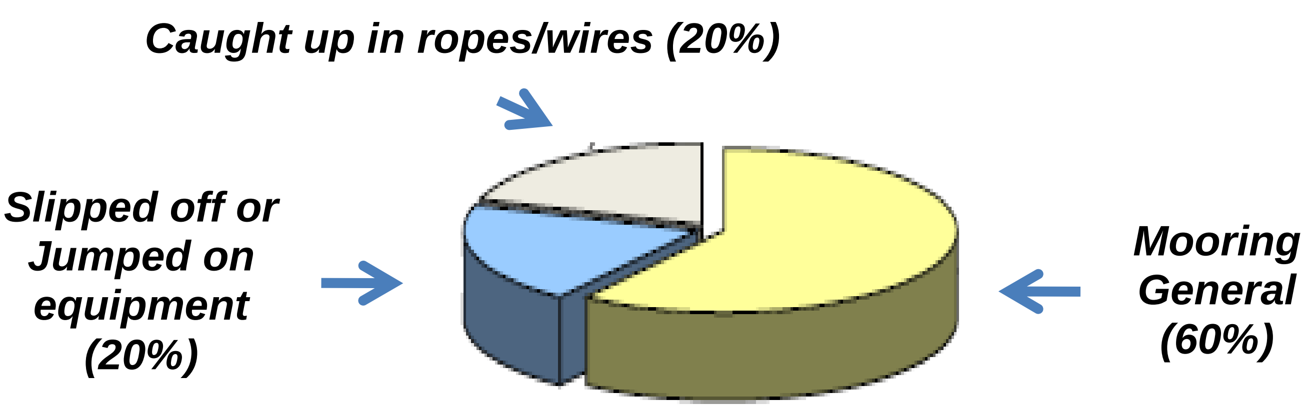
Where ropes or wires have parted (53%)
Where ropes or wires have jumped or slipped off drum ends/bitts (42%)
Caused by actual equipment failure (5%)



Injuries from Parted ropes or wires during: general mooring, tug operations, ship to ship operations, equipment failure or misuse, wash damage and weather also playing a role.



Injuries from NON parted ropes or wires due to: general mooring, crew being caught up in ropes or wires, ropes or wires slipping off and becoming jammed on drum during normal mooring operations.



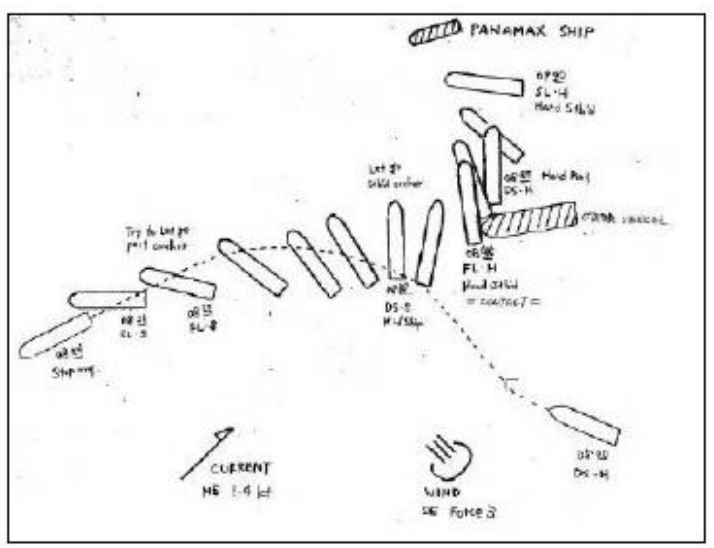
Please refer also to <u>Appendix 7</u> – Understanding mooring incidents (UK P&I Club)

5.2 INCIDENTS IN OUR FLEET:

1. Bulker: Collision during anchoring maneuver (arrival at anchorage)

Upon arrival Eastern bunkering anchorage Singapore, Master ordered port anchor to be dropped, but anchor could not be dropped; then ordered stbd anchor to be dropped, but it took 6 minutes to prepare stbd anchor to be dropped; during that time NYK bulk-carrier collided with another vessel at anchor.

Both ships were dented, but no human injury and no pollution.



Root causes and findings:

- lack of BTM procedures and poor planning
- lack of communication Master – Ch Officer
- not following SMS procedures regarding equipment testing and preparations prior arrival
- poor BRM: Duty Officer did not informed Master about vessel's position and drifting direction
- poor shiphandling – underestimating the current / wind effects

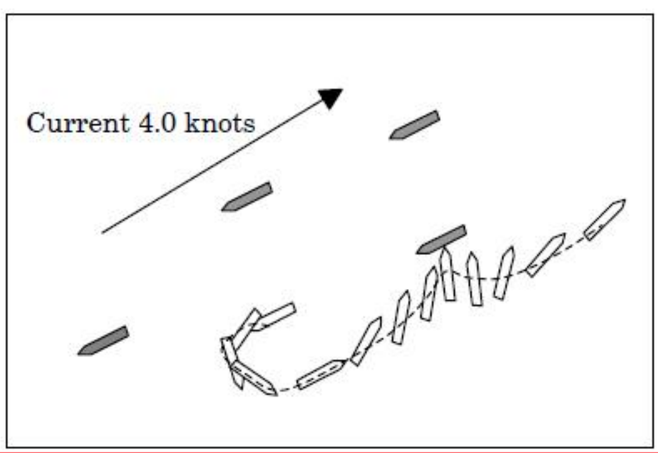
Counter-measures:

- Master and Officers should do a proper planning of anchorage maneuver.
- C/O should check the condition of anchors well in advance, before required to be used
- Duty Officer should monitor the vessel's position and track, even if Master has the con.
- Contingency plans should be considered in case of emergency.

2. Woodchip: Collision during anchoring maneuver (leaving the anchorage)

A woodchip vessel in light condition was shifting from anchorage to berth in a confined river channel, the vessel lost the control due to strong current and collided with another vessel at anchor. Full astern engine used, but the collision could not be avoided.

Both ships were dented, but no human injury and no pollution.



Root causes and findings:

- lack of BTM procedures, poor planning and lack of communication
- lack of situational awareness
- poor BRM: Duty Officer did not informed Master about vessel's position and drifting direction, Ch Officer did not report distances
- poor shiphandling – underestimating the current / wind effects, Master not fully familiar with maneuvering characteristics of the vessel (ROT, turning circle to port, stopping distance, etc.)

Counter-measures:

- Master and Officers should do a proper planning of maneuver.
- Ch Officer should be pro-active in reporting the distances, challenging Master's decision and situational awareness
- Duty Officer should monitor the vessel's position and track, even if Master has the con.
- Contingency plans should be considered in case of emergency.
- Master to be familiar with Vessel's maneuvering characteristics.

3. Container: BSN injured while securing the pilot ladder

BSN was securing the pilot ladder by himself after picking up the pilot. While adjusting the ladder suddenly the rope jumped and caught his fingers of one hand. He could not get the hand out of the rope and as he was far away from controller he could not stop the reel. He moved around with the reel and was finally pulled in by the rotating reel. This resulted in **fracture of three ribs**.

Root causes and findings:

- Procedure violation: BSN was working alone, job was not included or discussed in the Tool Meeting, no Permit to work Overside issued
- Lack of safe mind

Corrective actions:

- Such jobs to be attended by sufficient number of crew
- Jobs to be included in Daily Job Order, Permit to be issued.
- Winch operator must not leave the station without control lever being locked in neutral / stop position.

4. Fatality during Mooring Operation (shifting)

2/O engaged in mooring operations at the aft station for shifting berth **died** after he was caught by the incoming line and the running winch drum. When the incident occurred, the 2/O was heaving in the mooring lines by himself and had the winch-control lever in the “heave in” position. Two able seamen at the aft station were engaged in other work and were not aware of the occurrence of the incident.

Root causes and findings:

- Procedure violation: 2/O was working alone, and left the winch in “heave” position without proper attendance.
- Lack of safe mind.

Corrective actions:

- Such jobs to be attended by sufficient number of crew: roles, supervision and procedures to be identified and monitored.
- Winch operator must not leave the station without control lever being locked in neutral / stop position.

5. Bulker: Accident during securing the Tug’s line

Aft ship’s line was used as tug line. During securing on the bit, It was tensioned in the line and slowly run out. The officer and OS tried to stop that line’s running out by making more figure-eight turns on the bitts. At the sometime, one AB ran to the aft end and stepped on the line to help stop it. His right foot then got caught between the mooring line and the fairleader roller.

Root causes and findings:

- Procedure violation: A/B acted alone, without order given by PIC.
- Lack of safe mind: Crew must never step on ropes or try to hold the rope with hands or feet.

Corrective actions:

- For such jobs roles, supervision and procedures to be identified and monitored.
- Officer should maintain good communication with the tug

6. PCC: Fatality during Mooring Operation (berthing)

While a PCC was coming alongside the port, the forward station crew was sending two mooring ropes to the mooring boat, and the crew member operating the winch for the mooring ropes got entangled in the mooring winch gear and **was killed**. Upon discovery of the accident, the winch was stopped by the other crew members on duty.

Root causes and findings:

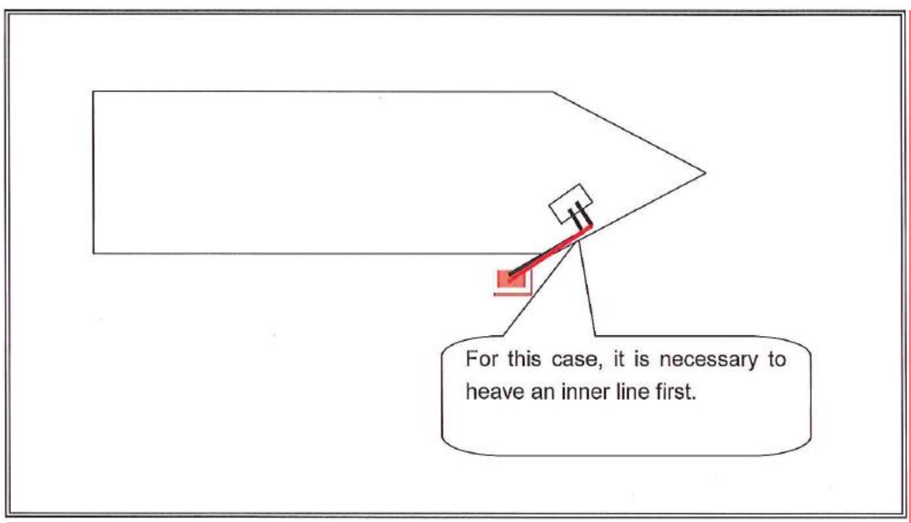
- Entangled crew slipped while operating the winch and got caught in the moving gear wheel.

Corrective actions:

- For such jobs, the roles, supervision and procedures to be clearly identified and monitored.
- Proper PPE wearing: a lose boiler suit or any other improper accessories during handling the machineries may get caught in the moving gear (ring, watch, scarf, large / long sleeves, etc.)

7. Delay due to improper mooring Operation

During mooring operation, crew members are commenced to heave first (inner) spring line and then tried to make fast second (outer) spring line at first. However, first (inner) spring was covered and pushed by second (outer) spring line and hull become of still low tension of first (inner) spring line. Then crews have to slacked again second (outer) spring lines and adjust tension and make fast both of line.
Delay of mooring operation has sometimes experienced by this cause.



8. PCC: Parting of mooring lines while alongside

Mooring lines broke because of strong winds during stay at berth. Such accidents occur because the countermeasures against strong wind and the maintenance of mooring lines are insufficient.

Please refer to Appendix 11: Countermeasures against strong wind on PCC during stay at berth.

9. Tanker: contact with other vessel during STS unmooring operation

STS operation was stopped due to rough weather. Daughter vessel was casting off from Mother vessel with assistance of one tug in inclement weather.
The securing wire of Yokohama Fender parted. The hull of daughter vessel came in contact with Mother vessel resulting in indentation of hull and internal structure in way of 2 S WBT. Injury, breach of hull or oil spill was not reported from on both the vessels.

Cause(s) & Contributing Factors:
1) STS unmooring in inclement weather.
2) Parting of fender securing wire due to undue strain caused by movement of vessels in inclement weather.

Lessons Learnt:
1) <u>Casting off and unmooring should be considered well before the onset of bad weather, to have a better control on the situation.</u>
2) Ship side fender wires should be frequently checked for any signs of damage.
3) Portable fenders should be kept ready at fwd and aft for use in emergency.
4) Checking of fenders and wires certificate from the Mooring Master should be considered.

10. Tanker: parting of rope on at BP Refinery Terminal

Vessel made fast portside along side with mooring 3+2+2 fwd & aft. Wind speed was 25 knots with swell about 01 meter.
Due to strong wind and swell Master decided to send additional spring lines on 10 June 2012. On 11 June 2012, due to surging movement one aft breast line parted and subsequently one stern line parted.

Cause analysis

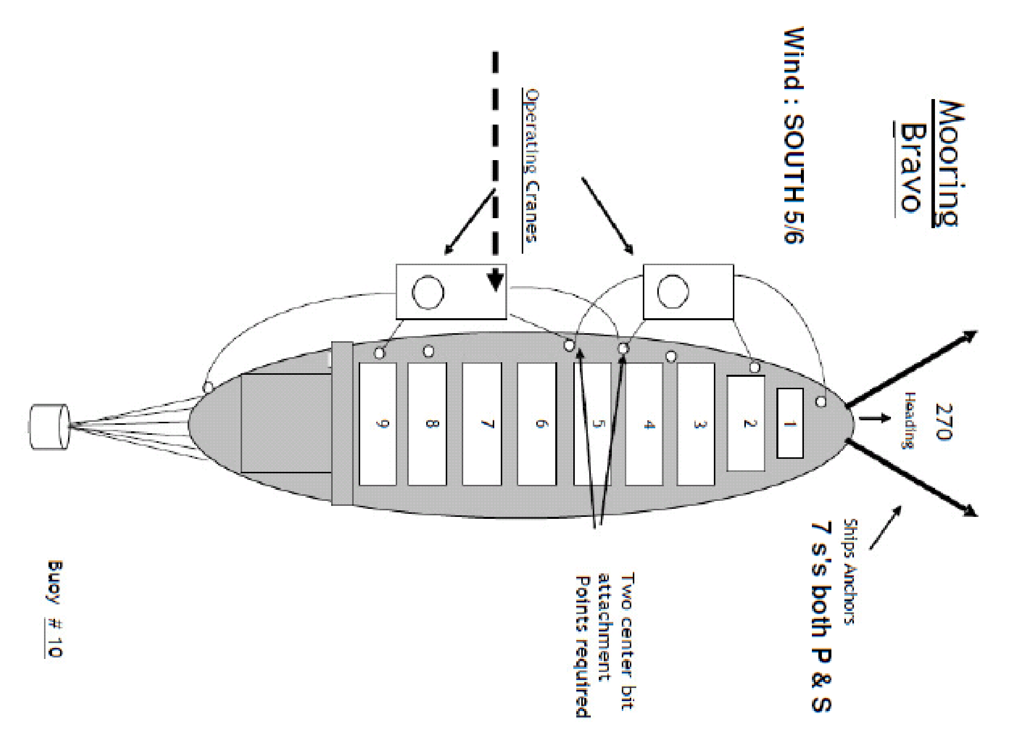
1. Chaffing of rope due to vessel movement and long stay at berth.
Vessel had onshore gust wind (25 – 30kts), pushing her to the fenders which resulted in swaying motion due to recoil from fenders. This resulted in chaffing of ropes. After 2 days 06 hrs, due to prolonged and excessive chaffing, one breast and one stern rope parted.
2. Delayed corrective action from vessel to replace the ropes.
Vessel was monitoring the weather and condition of rope, lubricated rope at turn of lead and used fire hose to minimize damage due to chaffing. Vessel identified the damage to rope strands well in time, however, did not initiate the corrective action of replacing the chaffed rope. The ropes replaced only after it was parted. On second occasion, vessel informed terminal to replace the rope, however, the notice given to terminal was insufficient and mooring rope parted before it could be replaced.
3. Use of synthetic rope instead of wire / tail: Synthetic ropes used were more prone to chafing under existing weather conditions, than if wires were used.

Corrective action by vessel / company

Subject to permission by Terminal, use of wires in lieu of Synthetic ropes to minimize chafing, or request terminal to allow at least the springs (fore and aft) as wires.
Vessels shall continue monitoring the rope status. As soon as rope shows sign of damage due to chafing, terminal shall be informed to provide shore mooring crew to replace the rope.
Vessel shall confirm in pre cargo operation meeting regarding the notice required to mobilize shore mooring crew for replacing any rope.
In strong wind condition, vessel shall use 4+3+3 (4 head / stern line, 3 breast ropes and 3 springs) mooring configuration fore and aft.
A Risk Assessment listing all possible hazards shall be carried out for mooring at this terminal and reviewed prior every visit.

11. Bulker: aft Mooring Lines Incident

Vessel was loading with two floating cranes from a barge on port side at port of Prodeco, Colombia. Vessel had lowered both anchors (7 shackles) in the water. The stern was made fast to a single mooring buoy using 6 mooring lines.
Due to sudden strong gust of wind (Local) from vessel's port side (S'LY WIND, Force 5/6) for sufficient period of time, resulted in prolonged stress on all the mooring lines. All stern mooring lines became tight beyond brakes' holding capacity and the all 6 mooring lines gave away and fell in the water due to slip of brakes.



Cause(s) & Contributing Factors:
1) Lack of monitoring and laxity: no regular tending and no weather reports.
2) The "U" clamps holding the end of mooring ropes on the winch were lose, resulting in ropes ends slipping away.
Lessons Learnt / Countermeasures:
1) <u>Crew to be properly briefed regarding Vessel's monitoring while alongside.</u>
2) All "U"-clamps to be checked and maintained in good condition.

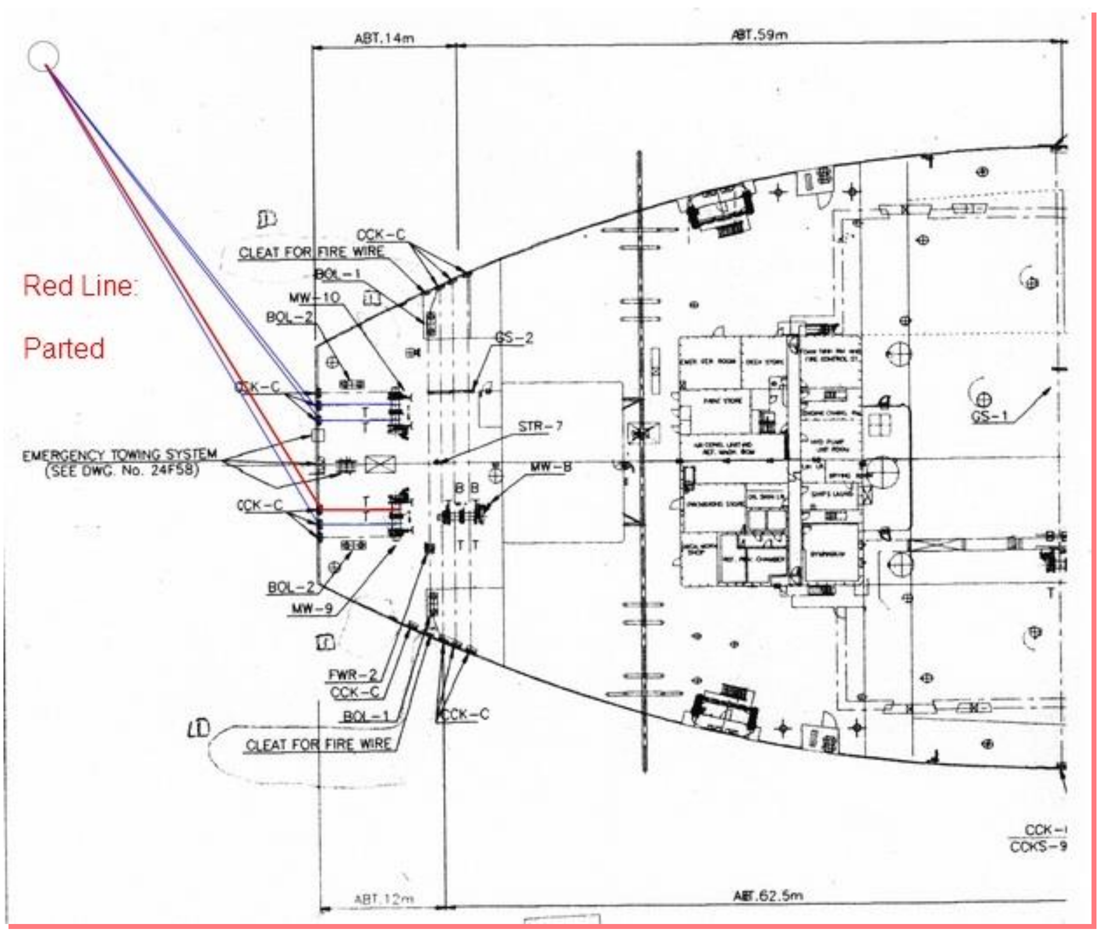
12. VLCC: Stern Line Parted At Kiire (Japan) During Cargo Operations.

Vessels stern mooring wire line parted during cargo discharge operations. Weather conditions were reported to be fine during the incident.

Cause(s) & Contributing Factors:

1) Damage of splice part of the wire, including age deterioration.
2) Poor maintenance and not proper mooring adjustment.

Lessons Learnt / Countermeasures:
1) <u>Regular inspection of the mooring ropes and wires.</u>
2) Brake holding capacity to be tested yearly.
3) Brakes to be tightened using torque spanner to the specific torque as per number of turns on the winch drum.



13. Container: bow moved away from jetty due to sudden wind gust, and mooring lines parted, Ningbo Port

Soon after making fast, vessel encountered local thunderstorm and bow moved away from jetty due to strong wind force.

Four forward mooring lines out of six mooring lines parted. Vessel bow turned about 60 deg angle with jetty in short time.

Immediately Master asked for two tugs for assistance and got vessel back alongside safely by using main engine and bow thruster. Vessel's hull, Internal and jetty were inspected and no damages were observed, other than some scratches on the berth caused by ship's gangway while moving away.

Cause(s) & Contributing Factors:

1) Strong off-shore wind combined with uneven tension on the mooring lines moved the bow away from the jetty.

2) Brake test not conducted as per SMS.

Lessons Learnt / Countermeasures:

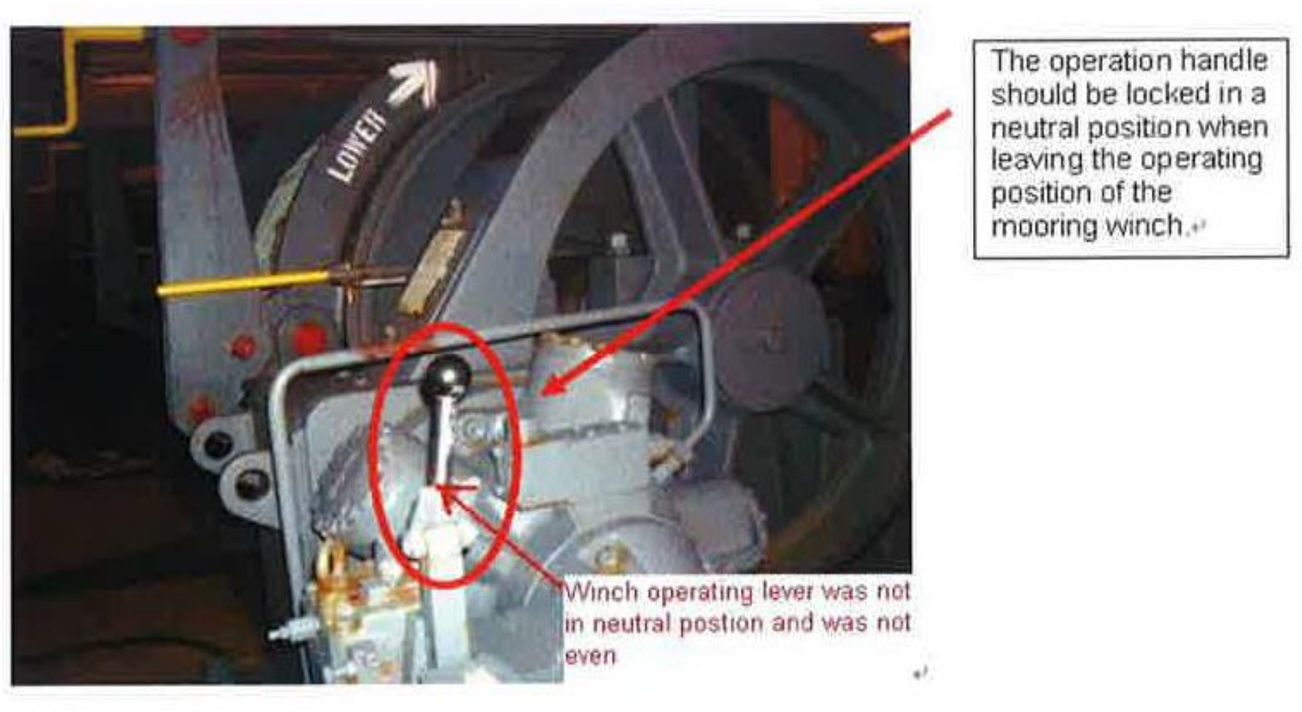
1) <u>Regular inspection of the mooring ropes and wires.</u>

2) Brake holding capacity to be tested as per SMS interval.

3) Constant / proper vessel’s monitoring while alongside.

14. PCC: Injury during maintenance work – mooring winch

While vessel underway, an A/B was greasing on mooring winch at poop deck. The winch started to rotate slowly, catching the crew's leg and hand in the gear wheel and clutch. The hydraulic winch was connected with a movable ramp motor, operated by another crew-member, and the winch operation handle was not in neutral position.



Example of counter-measure:

15. PCC: Injury during maintenance work – mooring winch

While vessel underway, an crewman was conducting a break test on a mooring winch at poop deck, and it was necessary to connect the hydraulic piston to the housing part of the test kit. When connecting, the crewman put his hand in the movable part, catching his finger between the bracket and the housing part.

16. LNG: Injury during maintenance work – messenger line parting

- While vessel underway, BSN, AB and OS were to carry out greasing maintenance work on mooring wire which had to be run outboard of the gunwale and back on board. To assist in this, a messenger line (24mm) was used to heave the wire back o/b. The messenger rope was connected to the eye of the tail rope by a cow hitch.
- The BSN was driving the winch and the AB was stationed on the drum to heave the messenger.
- AB had taken 5 turns on the drum, when the cow-hitch reached the fairlead and got snagged at the lower edge of the lead.
- Instead of investigating the excessive tension in the messenger, the team decided to take another turn in the drum, to force clearing the snag.
- The messenger rope parted and hit the AB on the legs, just above the knees.
- AB has been transferred to hospital for first aid, later declared fit for duty.

<u>FINDINGS</u>:
- the age of messenger rope was un-known, due to missing records;
- some points in JHA were not discussed during the tool-box meeting;
- SMS clearly states the maximum number of turns (4) that should be taken on the drum when heaving a rope;
- BSN and OS were either unable to identify the problem, or they were not aware of the risk of taking extra-turns; the AB was within the snap-back zone and he did not have a clear view of the rope he was heaving;
- the fairlead was appreciable grooving which may have contributed to the incident.

Fairlead with Grooves

Reconstruction

17. PCC: Un-safe mooring operations, significant nearmiss

During vessel's berthing maneuver, an Officer and 4 crew-members were at forward station, with 2 head-lines ashore from the central winch, heaving up by a crewman, under Officer indication. In the same time, other 2 lines were being sent to mooring boat, using the port side winch, under Bsn indication.

Crewman A couldn't see Bsn, so he climbed on the winch structure, resulting a dangerous / unsafe situation.

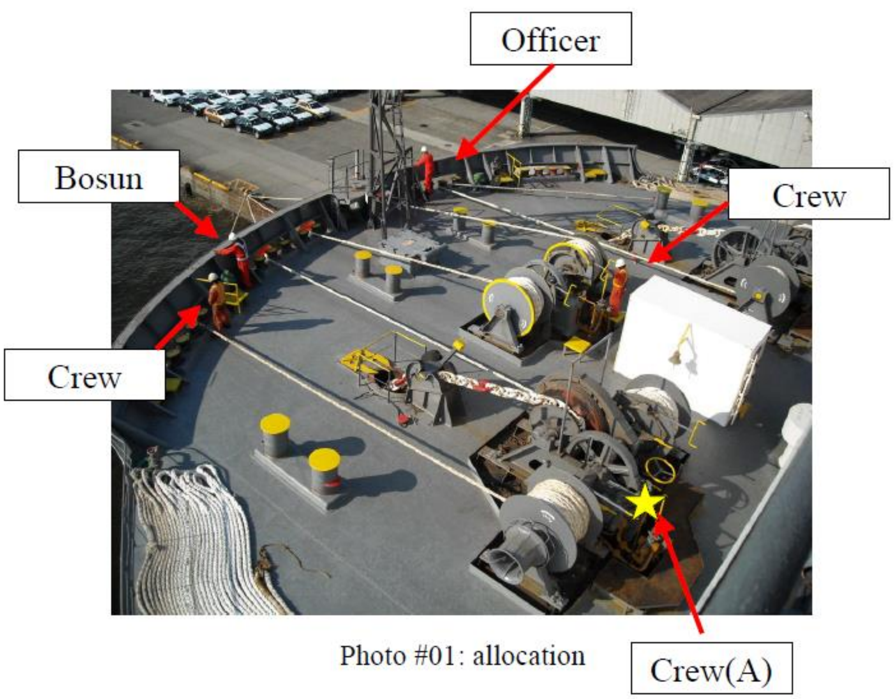


Photo #01: allocation

*General

1. Review the mooring operation of your vessel and check if there are any unsafe acts or conditions.
2. To maintain safe conditions, hardware modifications shall be considered if necessary. The master should discuss the necessity of such modifications with the owner/manager before taking measures.
3. Clearly identify dangerous places and apply safety markings where necessary.

*Before working

1. Appropriate numbers of crewmembers shall be assigned in consideration of workload, difficulty, and crew experience.
2. Tool box meetings should be held and involve all concerned crewmembers.

* During a mooring operation

1. Officers on-site should properly supervise the safety work of crew.
2. Conning positions should be considered. An on-scene director must take the proper place for managing crew and equipment.
3. Maintain good oral and visual communication with each other.
4. Crewmembers should take action only in compliance with clear orders from the director, and should not take any action based on uncertain information or guesswork.

18. Tanker: O/S injured by parting breast-line during checking the ropes

WHILE ATTENDING THE MOORING ON AFT POOP DECK, ONE OF THE BREAST LINE PARTED AND INJURED O.S., WHO WAS SENT TO HOSPITAL FOR MEDICAL HELP. ONE OF THE SYNTHETIC BREAST ROPE ON THE WINCH DRUM PARTED WHILE THE SEAMAN WAS CHECKING THE STERN LINES. ONE CAUSE WAS THE EXCESSIVE WEIGHT ON THE ROPE DUE TO TIDE RISING FAST.

Cause(s) & Contributing Factors:
1) Insufficient number of crew tending the lines (O/S was alone).
2) Lack of supervision and safe mind.

Lessons Learnt / Countermeasures:
1) Review of the SMS, standard RA and JHA, proper line tending procedures.
2) Proper supervision and adequate number of crew for moorings.

19. Fatality during picking up the Tug's line: messenger rope slipped off from the warping drum

Aft mooring team was picking up the tug's line – heavy wire rope – the messenger line was improperly guided towards the warping drum and led to wrong side of the pedestal roller. In fact 2(two) messenger lines were used and rolled up on the same drum, crushing each other.

Messenger rope sprang off the drum and got entangled with the neck of one crew-member, who succumbed to his injuries.

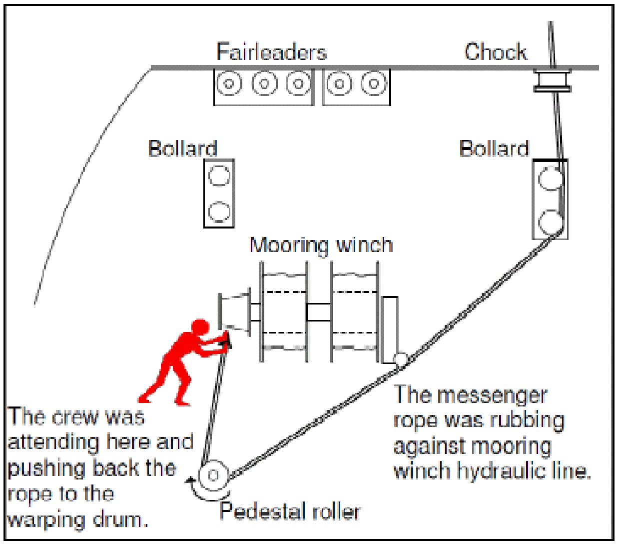


Fig.1 Path of messenger line when casualty occurred

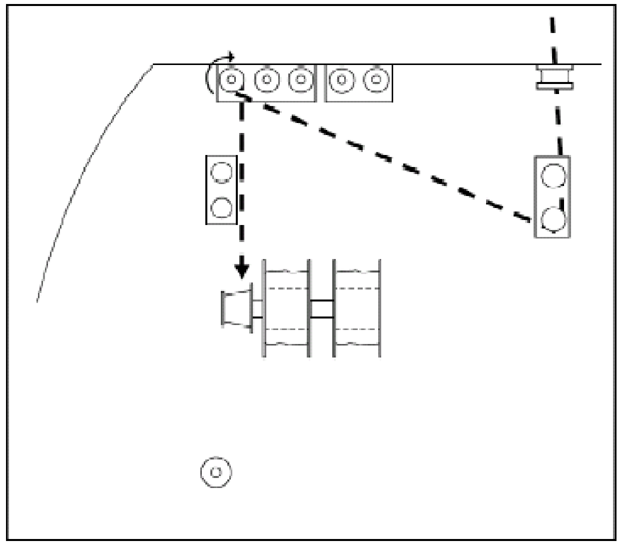


Fig.2 Preferable path recommended by the management company of the ship after the casualty

Normally, fairleaders or stand rollers are arranged so that ropes can be guided straight to the warping drum. On the other hand, if guiding direction is wrong, crush of the rope on the drum can happen easily.
(See Fig.3 and Fig.4)

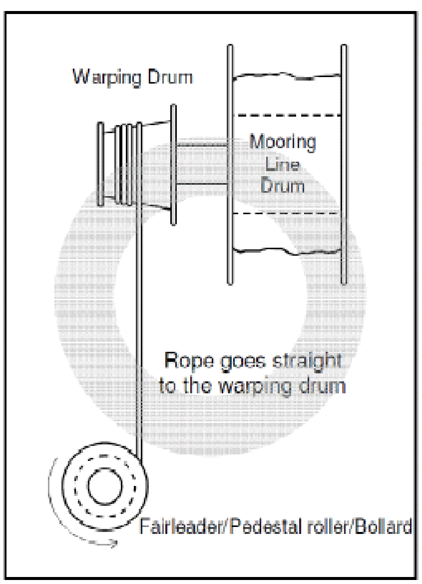


Fig.3 Proper usage

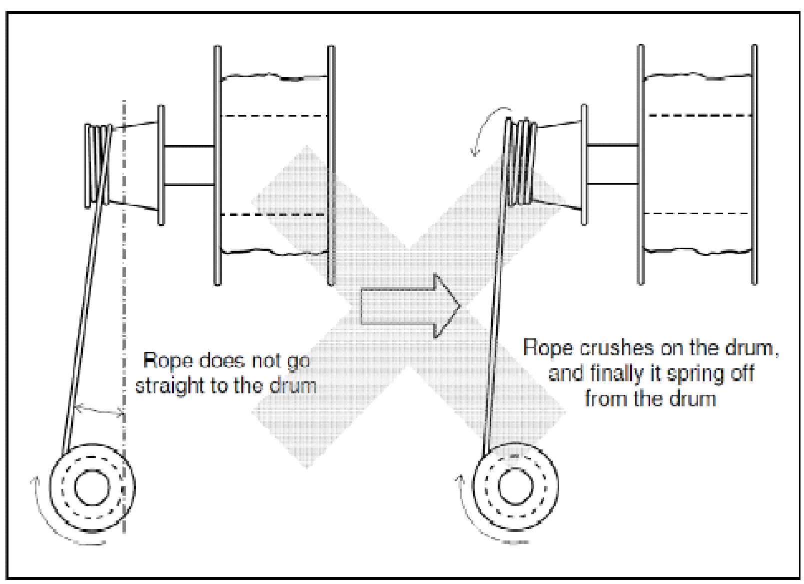


Fig.4 Improper usage

[COMMENT]
a) We would like to emphasize, especially to team leaders of mooring stations, to check the mooring equipment on board your vessel. On some vessels the path of the messenger ropes from a specific chock / fairlead to warping drums may be complicated. If you could not find out a good path, please discuss with the master or vessel manager.
b) We would also like to draw your attention to use messenger lines of adequate strength whilst picking up mooring lines or tails. There is also a danger due to snapback from the messenger rope in case of parting of messenger rope.
c) Crewmembers who in engage mooring operations shall be familiar with operation of mooring equipment and signals used in the operation. Besides they shall have knowledge of potential risks of mooring operation.
d) Even if the operation is completed 90%, when unsafe condition is found, the operation shall be reviewed. If deemed necessary, the operation shall be restarted again from the beginning. Always keeping safety as a priority.
e) Needless to say, kindly keep safe distance from mooring ropes under strain, in case a rope needs to be held temporarily, kindly use correct rope stopper for the job.

5.3 INCIDENTS IN OTHER FLEET:

20. Contact of shore worker with spring line

During mooring operation, the first spring line was heaved correctly but the second spring line caught other shore side bollard while taking slack the line. To make clear the second line, shore workers approach to the bollard to solve problem. However, the first spring line, which has already heaved, was suddenly slacked and contacted shore workers. As a result, one person owed the laceration of back of the head and another bruised his shoulder.

【Attention】
Details information are unknown because this incident has occurred in the other shipping company. But all master required to remind safety procedure as follows,

・Never slacken or wind mooring wire without Master's order or confirmation of shore signals.
・Officers in charge at forward and aft station should be checked the safe condition for shore workers and mooring crew.
・Officer should be arrange the mooring crews at the safe position to be seen from the shore workers.
・To be communicated by voice if it is possible.
・Use the hand signal or whistle signal properly.

21. Severe injury during un-mooring operations

1 Summary

The accident occurred on the forecastle deck during the mooring operation at departure from Singapore. When heaving the spring lines, the messenger lines got entangled. This resulted in the spring lines tightening. Subsequently a rope guide broke and a spring line hit an AB on his right hip. The AB was slung against the windlass and sustained injuries to his hip, head and arm.

2 Conclusion

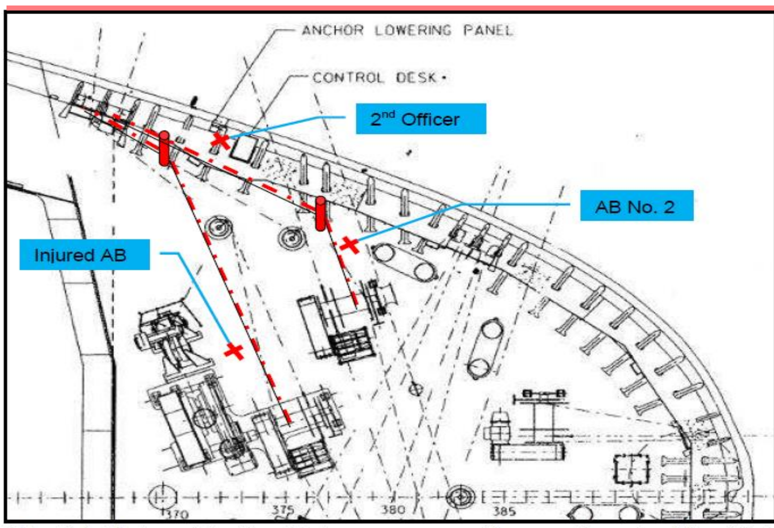
The mooring winches were operated at high speed, which caused the messenger lines to entangle as the ends of the spring lines approached the roller fairleads. As a consequence the spring lines tightened. **(6.1)**

The rope guides did not have enough strength to absorb the load from the sudden tightening of the spring lines. **(6.1)**

It is the assessment of the Division for Investigation of Maritime Accidents that the 2nd officer and the ABs either did not realize the risk associated with the job they were doing or tolerated the risk, given their previous experience in similar situations. **(6.2)**

It is the assessment of the Division for Investigation of Maritime Accidents that consistent safety planning and communication in connection with the mooring operation was lacking **(6.2)**

It is the assessment of the Division for Investigation of Maritime Accidents that the safety assessment of the rope guide concept was inadequate. **(6.2)**



Picture 1: Accident scene before the accident. *(Arrangement by courtesy of Maersk Line)*

6.1 Immediate causes

Unsafe actions
The mooring winches were operated at the highest speed.

The injured AB and his colleague were guiding the spring lines on the storage drums while they were being heaved at high speed.

During the mooring operation, the injured AB changed position from forward of the mooring line to aft. In this position, the AB stood in a latent snapback zone.

The 2nd officer was inattentive for a moment.

The mooring winches were operated at high speed, which caused the messenger lines to entangle as the ends of the spring lines approached the roller fairleads. As a consequence the spring lines tightened.

Unsafe surroundings
The aft rope guide bended and the aft spring line flipped over the rope guide and snapped back.

The forward rope guide broke off and the forward spring line snapped back.

The winches did not stop at once when the control handle was released due to inertia in the winch system.

The rope guides did not have enough strength to absorb the load from the sudden tightening of the spring lines.

Rope guide design
The design, installation and implementation of the rope guide concept on a particular vessel are only managed on board. The structural design is approved by the chief engineer on board the particular vessel.

It had been observed previously that rope guides had been bended by mooring lines.

It is the assessment of the Division for Investigation of Maritime Accidents that the safety assessment of the rope guide concept was inadequate.

Picture 2: Spring line and rope guide. *(Picture by courtesy of Maersk Line)*

Maersk Line has commenced a fleet campaign on safer mooring.

The main themes of the safer mooring campaign are:
- Better planning means safer mooring
- Complacency causes accidents
- Always know where your team members are
- Good communication with the bridge is essential

Recommendations
In the period 1997-2005, OKE has processed 17 serious or very serious marine casualties related to mooring operations on merchant vessels, which have been compiled in a safety survey issued on 1 December 2006. The publication is in Danish and can be found on:

http://www.soefartsstyrelsen.dk/ulykkesopklaring/publikationer/Sider/Temaundersøgelser.aspx

22. Severe injury / disability during mooring operations – Please refer to **Appendix 8** – Safety Alert Severe Injury Mooring Incident.

CHAPTER 6 – BASIC KNOWLEDGE ABOUT MOORING EQUIPMENT

- “Mooring Equipment” means the items of equipment mounted on board a ship to handle the loads needed to secure the ship in a berth or to another ship.

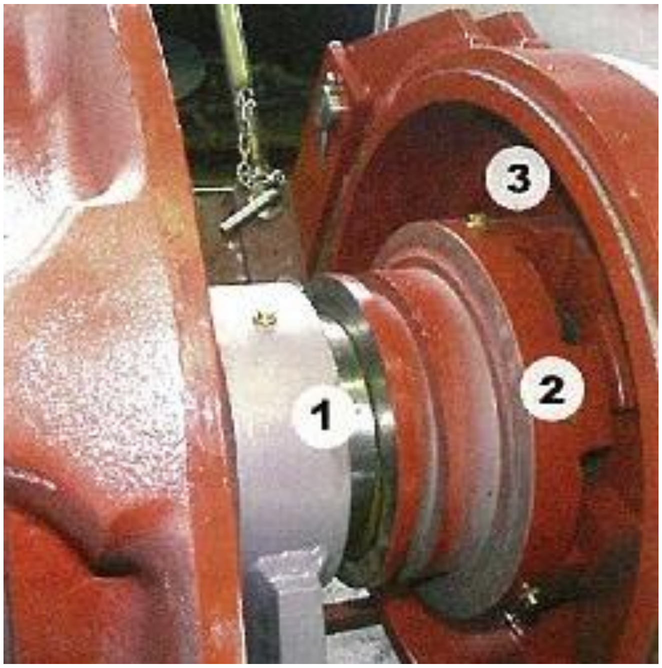
- Mooring equipment includes fittings such as bitts, winches, chain stoppers, fairleads, chocks and capstans.

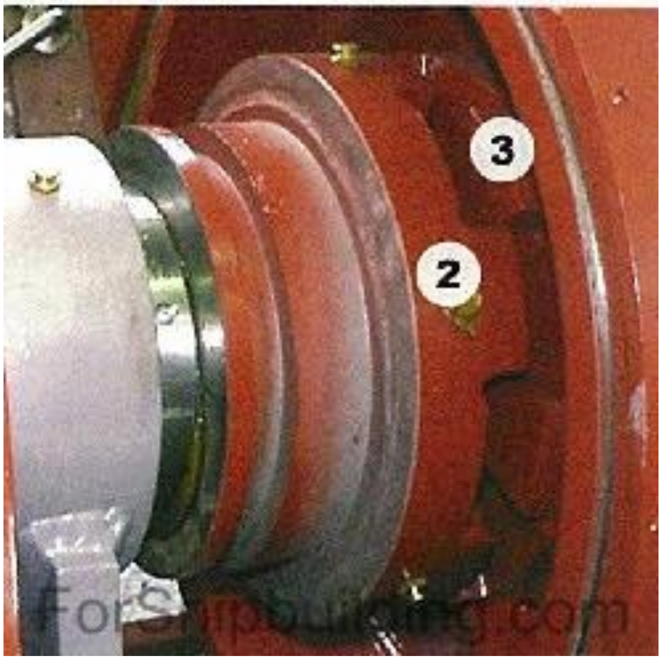
- “Safety Factors” generally account for uncertainties such as additional dynamic loads, normal wear or corrosion, small material defects, and for uncertainties in the design calculation model used.

Master, deck Officers and Crew must be fully familiar with own Vessel’s mooring equipment:

- specifications, number, location, maintenance condition, operating condition, type, characteristics and technical parameters;
- power and limitations, arrangement, markings;
- illumination, safety issues, emergency procedures;
- calibration and testing, abnormalities, malfunctions and damage history, etc.

6.1 Mooring Winch – a mechanical device that is used to pull (wind up) or let out (wind out) or otherwise adjust the tension of the rope or wire rope. Most common on ships are large geared winched powered by hydraulic, pneumatic or internal combustion drives which have solenoid or mechanical brakes that prevents the winch from unwinding.





Mooring Winch – Clutch in and out

1 = Bearing; 2 = Sliding claw; 3 = Fixed claw

FUNCTIONS OF MOORING WINCH:
- Secure the shipboard end of mooring lines
- Adjustment of the mooring length to fit the pattern
- Compensate for changes in draft and tide
- Serve to store the mooring line when not in use
- Keep ship in position against environmental forces

6.1.1 TYPES OF MOORING WINCHES:

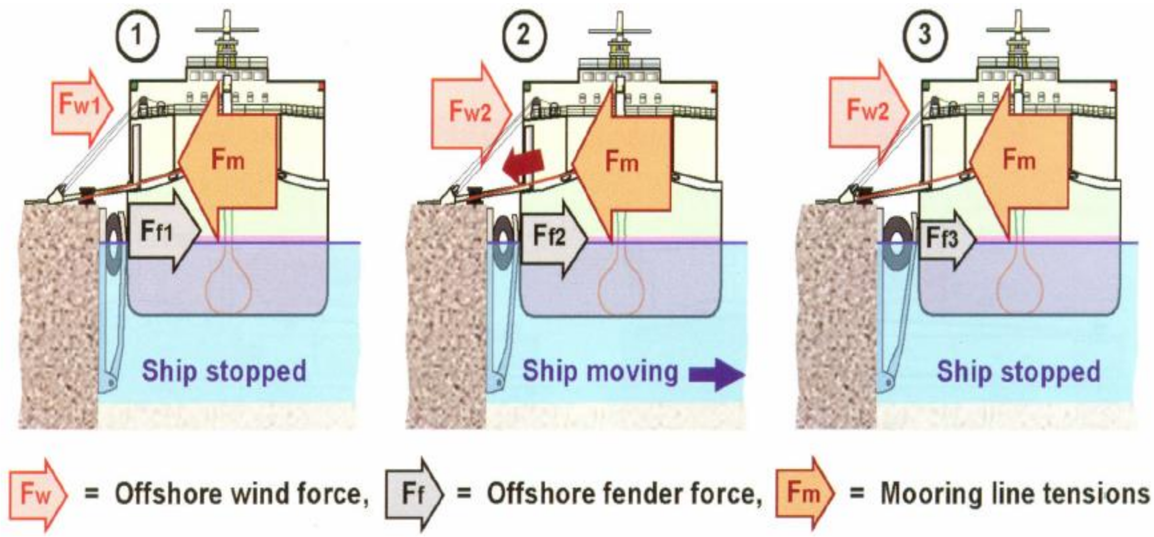
- BY Control type: Automatic tensioning, Manual tensioning

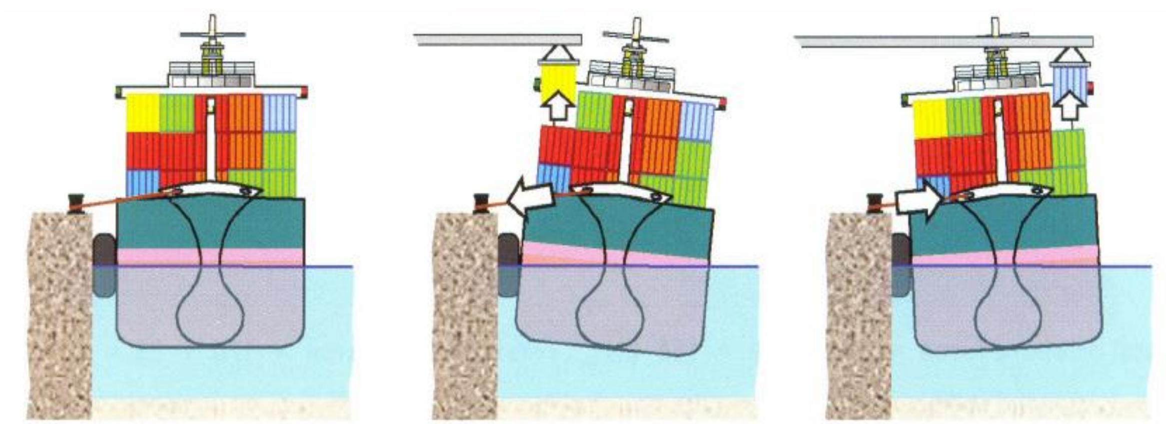
- BY Type of drums: Split, Undivided

- BY Drive type: Hydraulic, Electric, Steam

- BY Number of drums: Single drum, Double drum, Triple drum

- BY Brake type and brake application: Band, Disc, Mechanical screw, Spring applied





The set line tension holds the ship tight alongside the wharf when it is upright.

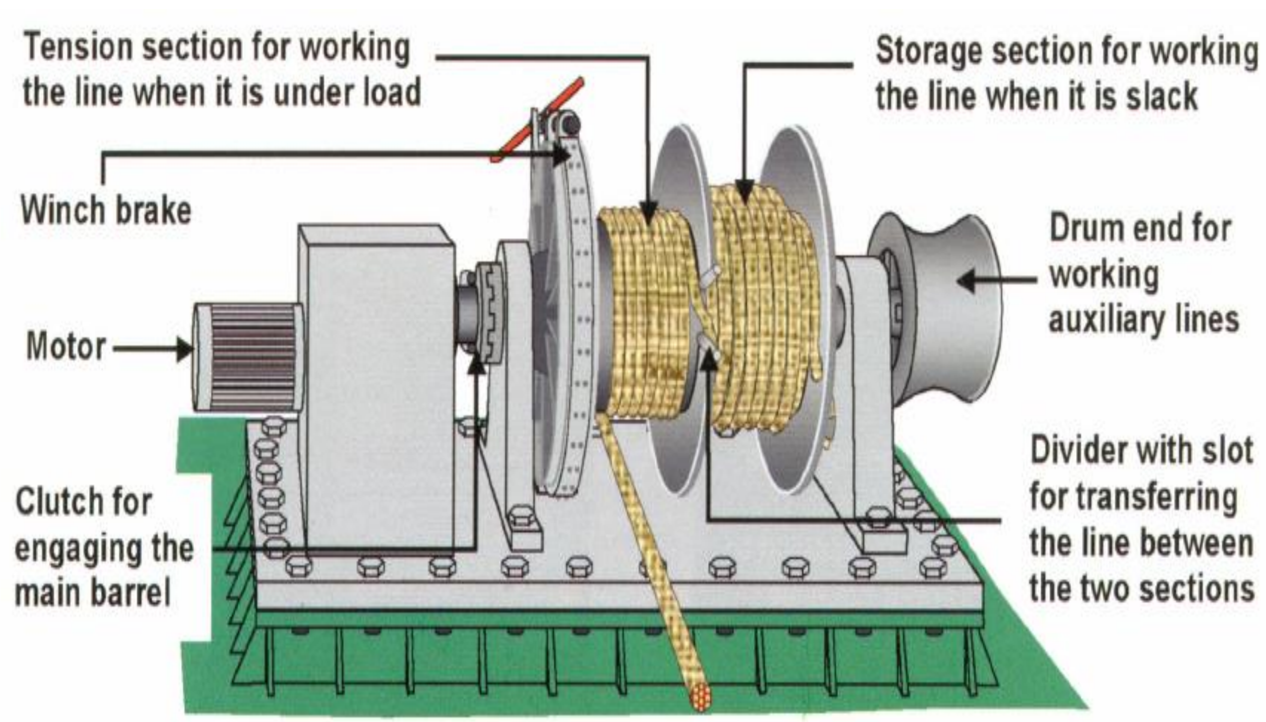
The winches pay out at the set tension as the ship heels away from the wharf.

The winches haul in at the set tension as the ship heels in towards the wharf.

There are two main types of winch drum, ‘undivided’ and ‘split’.

- Although there are advantages and disadvantages in both systems, the split drum has one main **advantage**: when properly deployed, the mooring line is always run off the first layer of the tension drum, thereby maintaining a constant and effective brake holding capacity and heaving force.
- The drum consists of a tension section and a separate storage section divided by a notched flange. Properly deployed, the winch operates with one layer of line only on the tension section

maintaining a constant and effective holding power.
- The main **disadvantage** of split drums is the increased operational difficulty when making a line fast. Care must be taken when transferring the line from storage to tension section.
- Operation of a split drum with more than one layer will decrease the brake holding capacity and thereby the effectiveness of the mooring system.



- The condition of wire lines deteriorates when they are squashed by overlying tight turns.

- A 'split drum' winch avoids such damage by separating the tension section of the barrel, which should only have a single layer of turns on it, from the storage section that holds the rest of the line in several layers.

- The rated brake holding capacity for these winches is always be quoted for only a single layer on the tension drum.

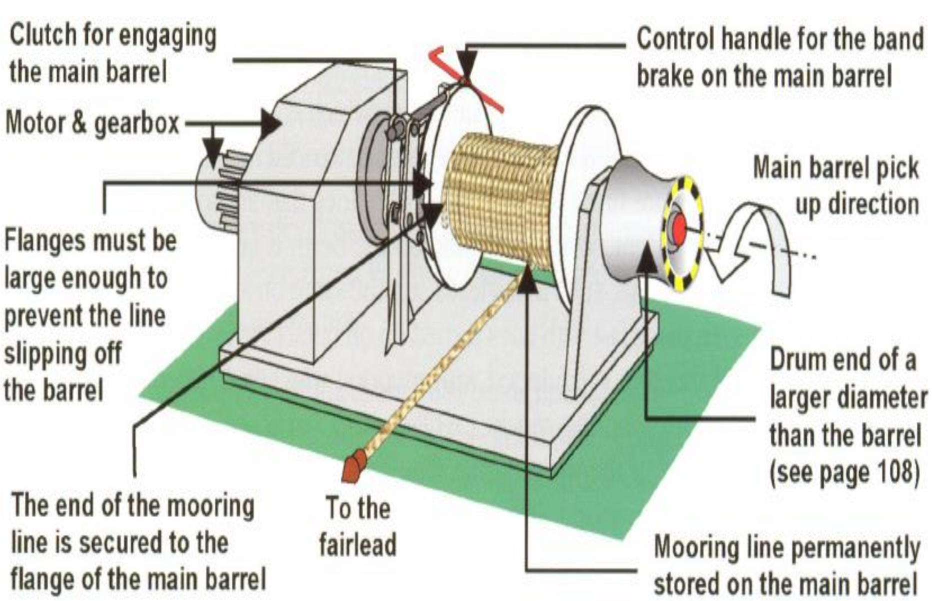
- Operation with additional layers on the tension drum would decrease the brake holding capacity.

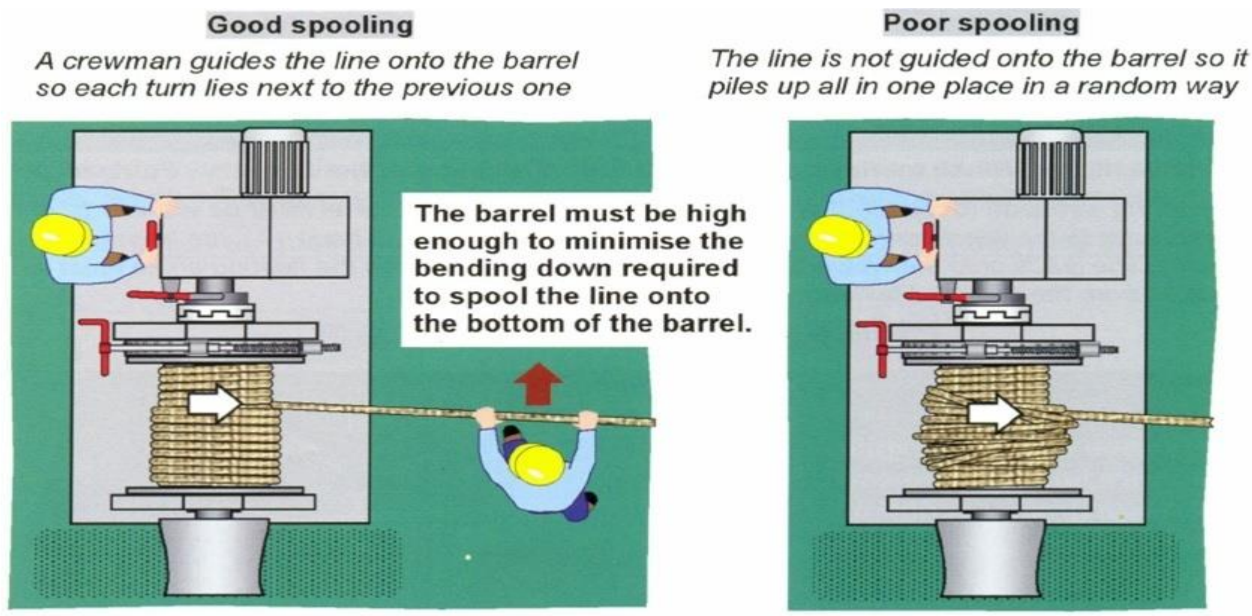
Theoretical reduction in holding capacity for more than one layer assuming a rated holding capacity of 55 tons.

No. Of Layer	Theoretical holding capacity	% Rated Holding Capacity
1st Layer	55 tones	100%
2nd Layer	48 tones	89%
3rd Layer	44 tones	82%
4th Layer	40 tones	75%
5th Layer	37 tones	69%

UNDIVIDED MOORING WINCH:

- The shaft driving the drum end passes through the hollow shaft of the main barrel with the mooring line stored on it. A clutch engages the shaft with the main barrel.
- The brake holding capacity for undivided drum winches will always be quoted for a specific number of layers. In order to minimize 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.
- When the mooring line is heaved tight, the band brake is applied to the main barrel, which is then disengaged from the shaft. The brake only works in one direction, though line can be picked up from either the top or the underside of the barrel.





Poor spooling may lead to the following problems:
- rope may not all fit onto the barrel and the pile up of turns can collapse.
- rope can slip down between the gaps between underlying previously poorly spooled turns and become trapped.

6.1.2 RENDER AND HEAVE RATIO OF MOORING WINCH:

RENDER is the amount of force needed to turn a winch which is set to heave, to pull the line, when power is applied; <u>the render value of a winch is always constant</u>.

When the winch is working to heave in a line attached to a load, HEAVE refers to the maximum load weight which that level of render power going into the winch can safely handle.

For a standard winch: RENDER force of 35 tons needed to turn a winch and give it a HEAVE power of 22 tons. The “Render-to-Heave” ratio is generally between 1.17 and 2.30, depending on winch type.

REMEMBER that a winch brake’s holding power is always greater than its heaving power, so if the brake starts to slip, it will be impossible for the winch to heave in, unless the load is reduced.

- A winch holding power is also affected by its render value: for example, if a winch RENDER value is 36 tons and its break holding power is 65 tons ◊ total holding power is 100 tons.

- But if this winch is using a mooring line with MBL of 108 tons, and allowing 20% reduction in strength, then its breaking load is reduced to 86 tons. This line would be then in danger of parting when used with that winch.

6.1.3 WINCH BRAKE

- The brake is the heart of the mooring system, since the brake secures the drum and thus the mooring line at the shipboard end. A further important function of the brake is to act as a safety device in case the line load becomes excessive.

- It does this by rendering and allowing the line to shed its load before it breaks.

- Ideally, a brake should hold and render within a very small range. Rendering should shed only enough load to bring the line tension back to a safe level.

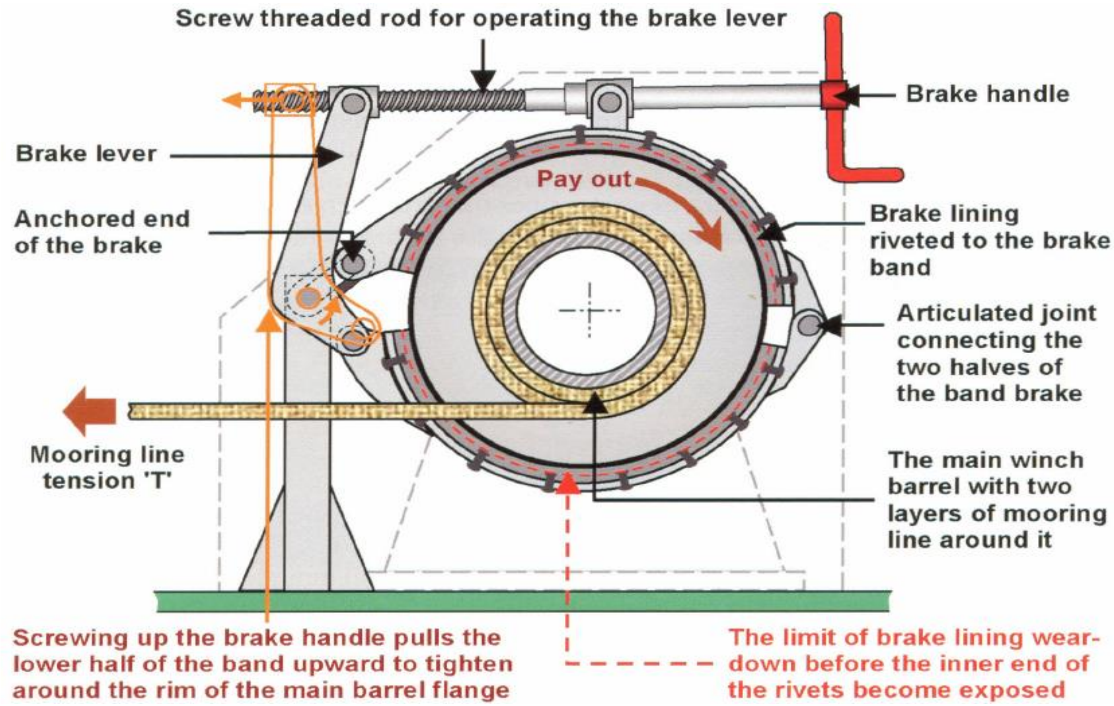
- Unfortunately, the widely used band brake with screw application is only marginally satisfactory in fulfilling these requirements and its operation requires special care.

- The brake holding power is based on the final mooring calculations which are function of the ship's particulars.

- However, the holding power of winch brakes will always be designed to exceed the "render" value of the winch.

There are two main types of brake system used on board: BAND and DISC brake type.

BAND TYPE



- The brake linings are secured to the two halves of the steel brake band by brass rivets and so the linings must be replaced before they have worn down to expose the inner ends of the rivets.

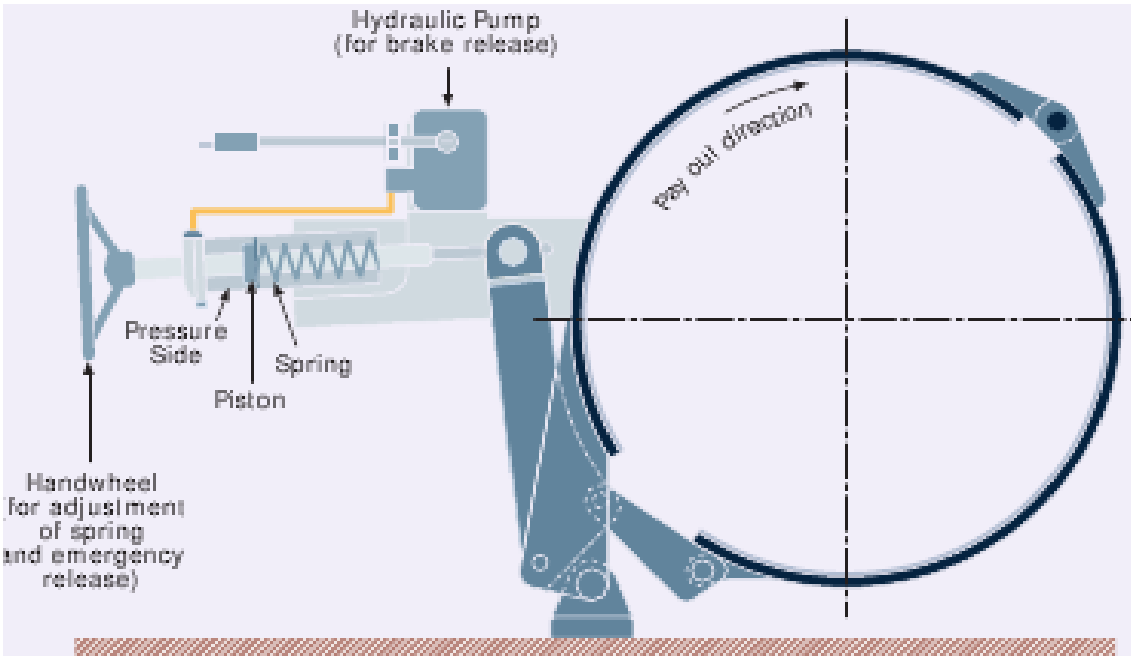
- Band brake lining must be properly fitted (all bolts or rivets in place).

- Sufficiently thick, although thickness of the brake liner is not always a good indicator for brake lining efficiency, as new lining can also be inefficient through exposure to heat / damp conditions, presence of oil on drum surface, inferior quality or corrosion of the drum surface, etc.

- Band brake lining must not be unraveled, deformed, squeezed or over-compressed.
- Band brake lining surface must be free of oil, grease, abrasive material.
- Check that the band brake lining does not contain asbestos.
- Handle band brake lining with gloves as the rough texture or reinforcement wires might cause hand injuries.
- The physical condition of the winch gearing and brake linings have significant effects on holding load capacity.
- Oil, moisture or heavy rust on the brake linings or brake drum can reduce holding load capacity up to 75%. Many operators run the winch with the brake set slightly to burn off or wear off the oil or moisture.
- However, care must be taken to ensure that excess wear is not caused by this practice when using composite brake linings. Excessive winch speed can also reduce brake holding capacity by the build-up of heat in the composite brake lining.

DISC TYPE BRAKE:

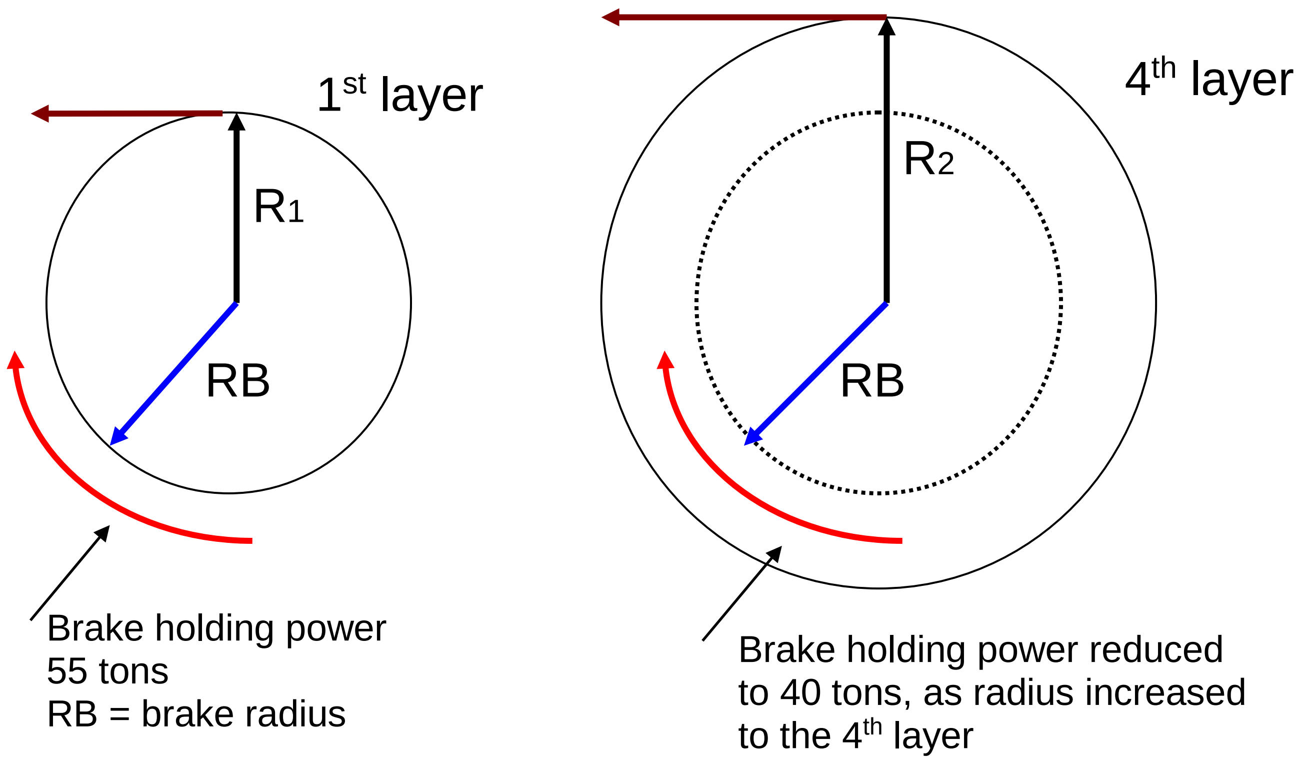
- Disc brakes are widely used for input brakes but only few manufacturers offer it as alternative to band brakes.
- Input Brakes: Some hydraulic winches and most electric winches are provided with spring-applied brakes at the drive motor. They are automatically applied by springs when the control lever is in neutral and automatically released when the control lever is in the heave or rendering position (when the motor is powered).



- Winches should never be left in gear with the mooring winch band brake on. Hydraulic or electric drives can suffer severe damage should the brake render.

- Mooring drums should always be left disconnected from the winch drive whenever the mooring line is tensioned and the band brake is fully applied.

- A winch's brake holding power depends on how many layers of line are on its drum, with *its holding power decreasing as layers of line increase on the drum.*



With 4(four) layers of line around mooring line drum, the winch's brake holding power has been reduced from 55 tons to 40 tons.

WINCH BRAKE HOLDING CAPACITY:

- The primary brake should be set to hold 60% of the mooring line's MBL. Since brakes may deteriorate in service, it is recommended that new equipment be designed to hold 80% of the line's MBL, but have the capability to be adjusted down to 60%.

- A band brake holding capacity of 80% MBL with the rope on the first layer is also required by Lloyds, DNV and ISO Standards. If a brake of an undivided drum is set to hold 80% MBL on the first layer, it will hold approximately 65% MBL on the third layer.

- Reeling lines onto a drum in the wrong direction can cut its brake holding power by up to 50%.

- Correct reeling direction should be clearly marked: 'heave in' and 'slack out'. Winches fitted with disc brakes do not have to be marked as they cannot be reeled in the wrong direction. Where a band brake is fitted to a winch it allows the line to be pulled directly against its fixed end.

WRONG USE OF BRAKE:

- A winch's brake should only be used for stopping and holding its drum. It is not intended for use in controlling the rate at which a line is paid out or taken in.

- If a line has to be slacked down then the winch should be put in gear, the brake released, and then the line walked back as it comes off the drum.

- A line should never be slacked down just by releasing the brake alone as this means there is a lack of control on the line, and it is therefore not completely safe.

- For example, if there are two mooring lines running in the same direction and sharing the load, then suddenly transferring all of that load to one of the lines, which could happen if winches are not under control, might cause it to part.

Windlass – a machinery that restraints and manipulates the anchor chain on a ship, allowing the anchor to be heaved and lowered. A notched wheel engages the drums.

<u>6.1.4 Warping drum</u>: <u>warping</u> means to haul or heave.
Warping drums are shaped rotating barrels used to haul a line by taking turns around the rotating drum and then manually pulling on the line to create sufficient friction for it to grip on the drum.

- The number of turns on the drum remains the same as the line is hauled in and 'tailed off' the drum by the crewman who is pulling the line.

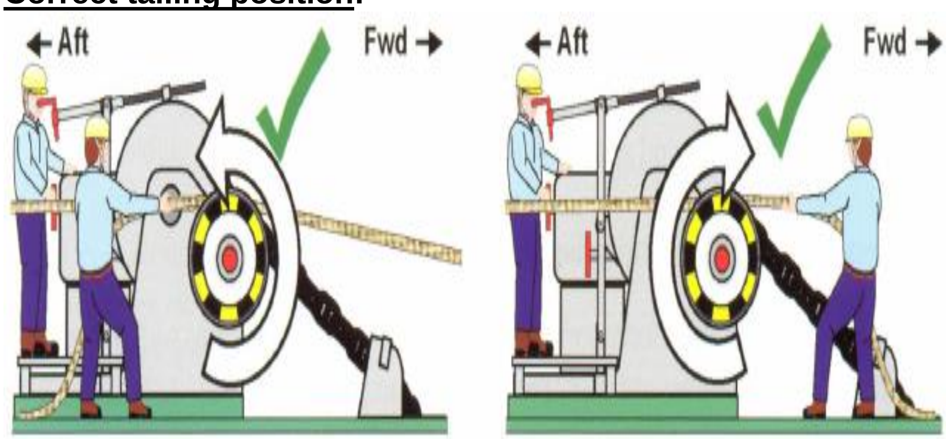
- There are warping drums or rotating barrels which are spool shaped, mounted on a horizontal axle and frequently fitted to a winch or windlass. They are used to ease the handling of large/heavy mooring wires/lines which are secured on bitts once they are heaved tight.

- They can also be used when shifting the vessel by means of its mooring lines along the berth. The spool shaped drum prevents lines from slipping off the drum, especially when the lines or drums are wet.

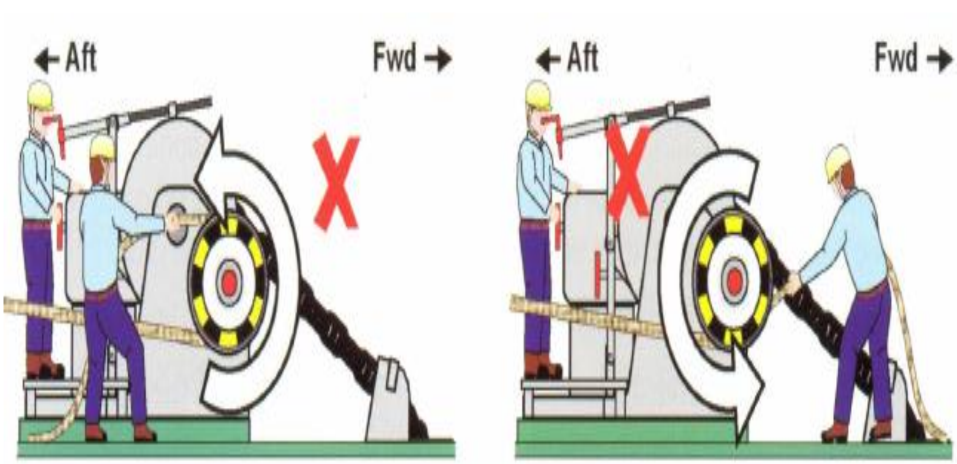
- The **Whelps** should be free of excessive wear / abrasion, corrosion, sharp edges / grooves. In order to improve the grip of the mooring ropes on the drum end, steel strips (whelps) are welded onto the rounded surface of the drum end of the winch.

- Mooring lines should never be secured to the drum ends, as are not designed for holding the load of the mooring ropes.

Correct tailing position:



Incorrect tailing position:



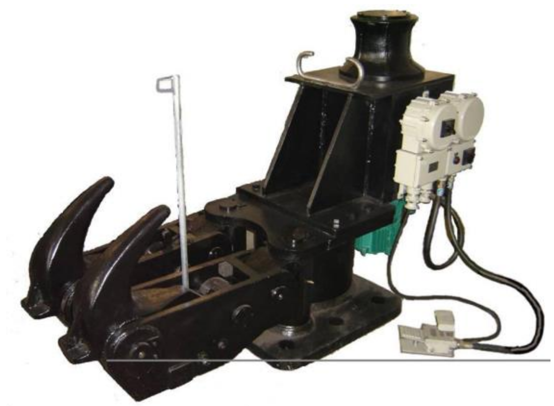
<u>6.2 Fender</u> - Fender is a device used to protect the hull of Ships, barges, tugs, etc, when alongside, as well as to protect the berth integrity from any damage . Fenders are made from a rubber or plastic hull filled with air or foam. (Normally fenders can absorb an impact speed of about 15 cm/sec, depending on the vessel's size, hull shape and UKC).

<u>6.3 Bollard</u> – is a short vertical post used on a quay for mooring a vessel. A bollard is a short wooden, iron or stone post which has a larger diameter near the top to prevent mooring lines from coming out, as well as typical shape and angle

- Bollards are used to make fast the ship along the berth, designed to withstand a considerable force and can accommodate at least one or two ships to moor their lines, depending on their SWL.

Attention to be paid to SWL of the bollards and vessel's bits!

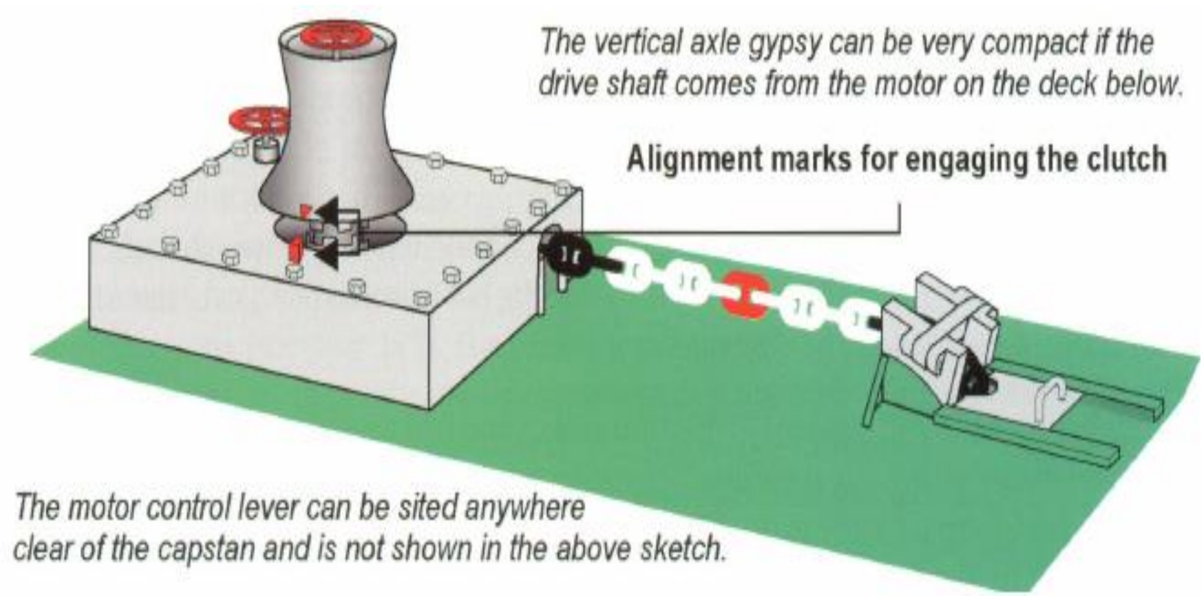
6.4 Quick release mooring hooks – specialized mooring equipment used on shore or on board, which have a strain gauge pin that measures precisely the amount of strain on each rope. The strain can also be set to be pre-tensioned before the mooring lines are cast on. Can let go line in emergency.The load pins detect any deviation from the defined values and indicate an alarm to adjust the forces as per desired criteria. Mostly used on oil and gas jetties.



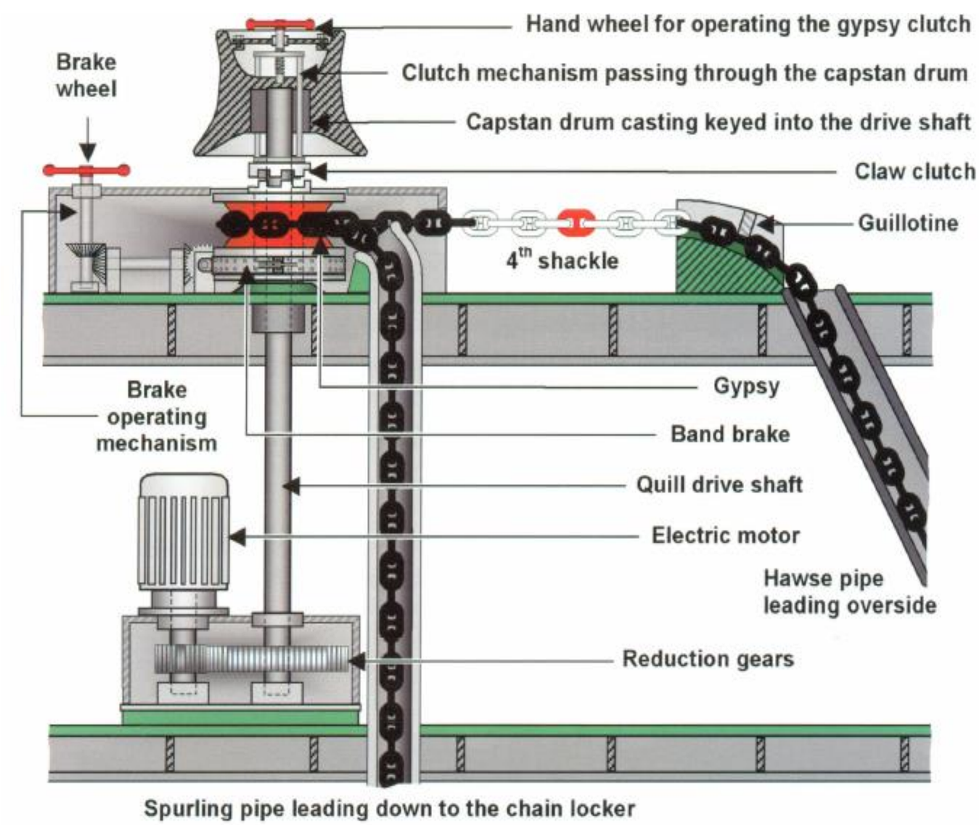
6.5 Cleats – a device for securing rope, designed with two horns wherein the rope is knotted around in a figure of eight; are mostly used on board small vessels, barges, yachts, etc.

6.6 Capstan–a vertical-ax rotating machinery developed for use on sailing ships to apply force to ropes, cables and hawsers, the principle is similar to that of the windlass which has a horizontal axle. Modern capstans are powered electrically, hydraulically, pneumatically or via internal combustion engine. Is a vertical warping drum, frequently installed on decks where free space is limited. It can be combined with a gypsy that allows operation of the anchors. Capstans can accommodate any mooring rope lead in the horizontal plane as long as there are no obstructions in between the capstan and the overboard fairlead.

Anchor cable handling gypsy combined with a capstan for working mooring lines: Gypsy (A), Spurling Pipe (B), Swivels (C), Band Brake Linkage (D), Band Brake (E), Protection Guard (F)

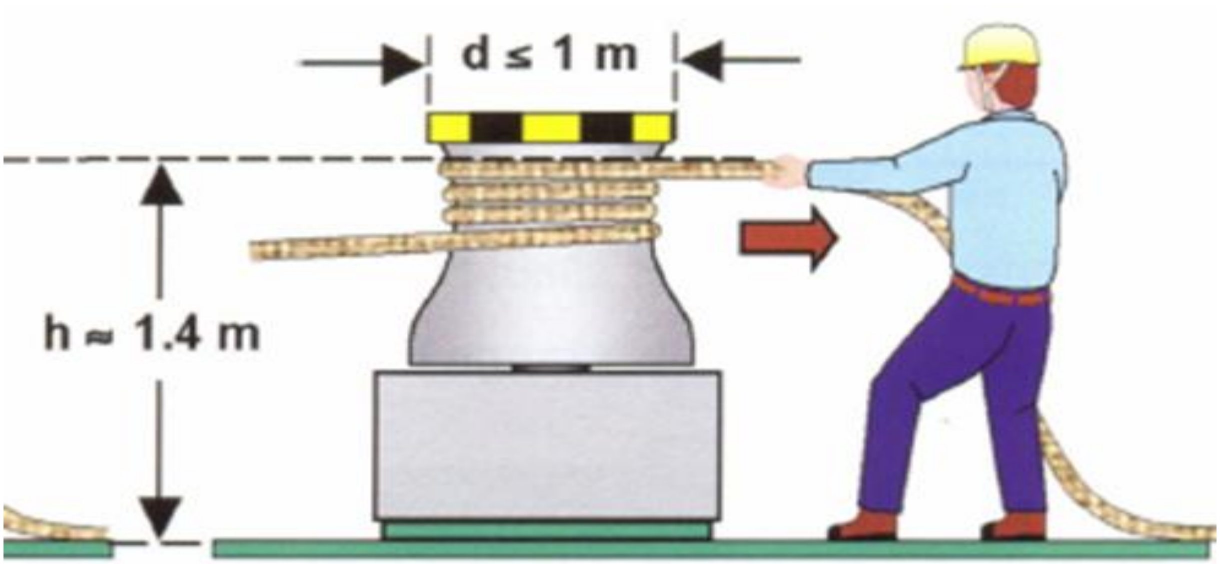


The vertical axle gypsy can be very compact if the drive shaft comes from the motor on the deck below.
Alignment marks for engaging the clutch
The motor control lever can be sited anywhere clear of the capstan and is not shown in the above sketch.

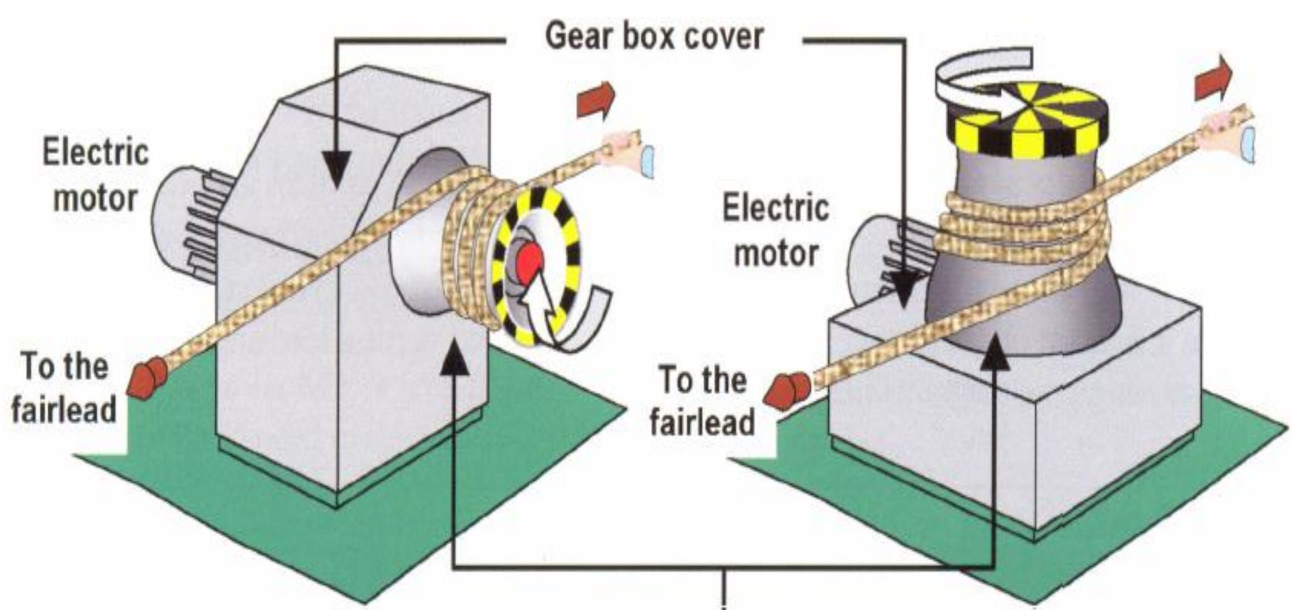


Hand wheel for operating the gypsy clutch
Brake wheel
Clutch mechanism passing through the capstan drum
Capstan drum casting keyed into the drive shaft
Claw clutch
Guillotine
4th shackle
Gypsy
Brake operating mechanism
Band brake
Quill drive shaft
Electric motor
Hawse pipe leading overside
Reduction gears
Spurling pipe leading down to the chain locker

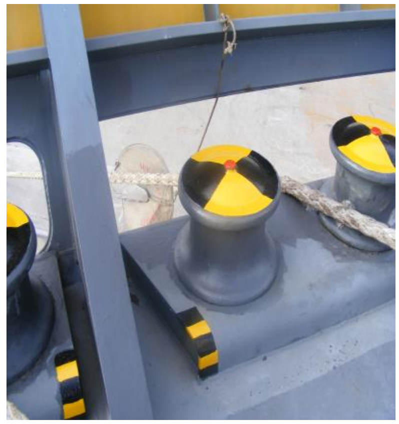
Correct tailing position:



Difference between Drum-end and Capstan:



6.7 Fairlead – is a device to guide a line, rope or cable around, out of the way or to stop it from moving laterally.

6.8 Bitts – are cylindrical objects made of steel, located on deck, used to secure a rope on board vessels. Usually arranged in pairs, can be mounted on a separate footing.


6.9 Chock- is a hole or ring attached to the hull for guiding a line.

6.10 HOW TO USE CHAIN / ROPE STOPPER:

- The most common loose fitting is a stopper, which is required to temporarily hold the load of a line while the line is in the process of being belayed on a bollard.

- Only a properly sized 'carpenter's' stopper can approach the line's strength. Standard fibre stoppers for fibre ropes, as well as chain stoppers for wire ropes, are covered by the BSRA Shipbuilding.

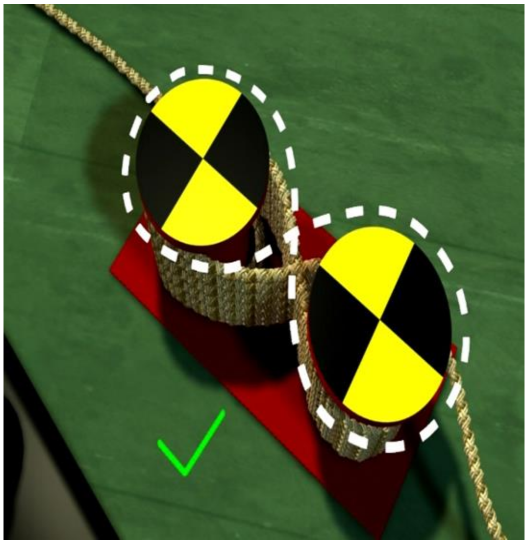
- The fibre stoppers are of three-strand polyester rope and may be used on any synthetic or natural fibre mooring rope.

- Stopping off a line is a dangerous operation. High loads in the line must be avoided, since the stoppers have less strength than the mooring line. Only a properly sized 'carpenter's' stopper can approach the line's strength. Standard fibre stoppers for fibre ropes, as well as chain stoppers for wire ropes, are covered by the BSRA Shipbuilding Standard No. SIS 23. Three different sizes are listed for each type, including all details and the SWL.

- On modern ships today, mooring lines are permanently stored on the winch drum.

Any additional lines - to deal with environmental conditions or to meet a shore request - are made fast on the ship's bitts. (These ropes would be tensioned on the winch drum end and transferred to the bitts using a chain or rope stopper).

- Ropes tensioned by means of the drum end should always be properly belayed on the bitts as soon as possible.



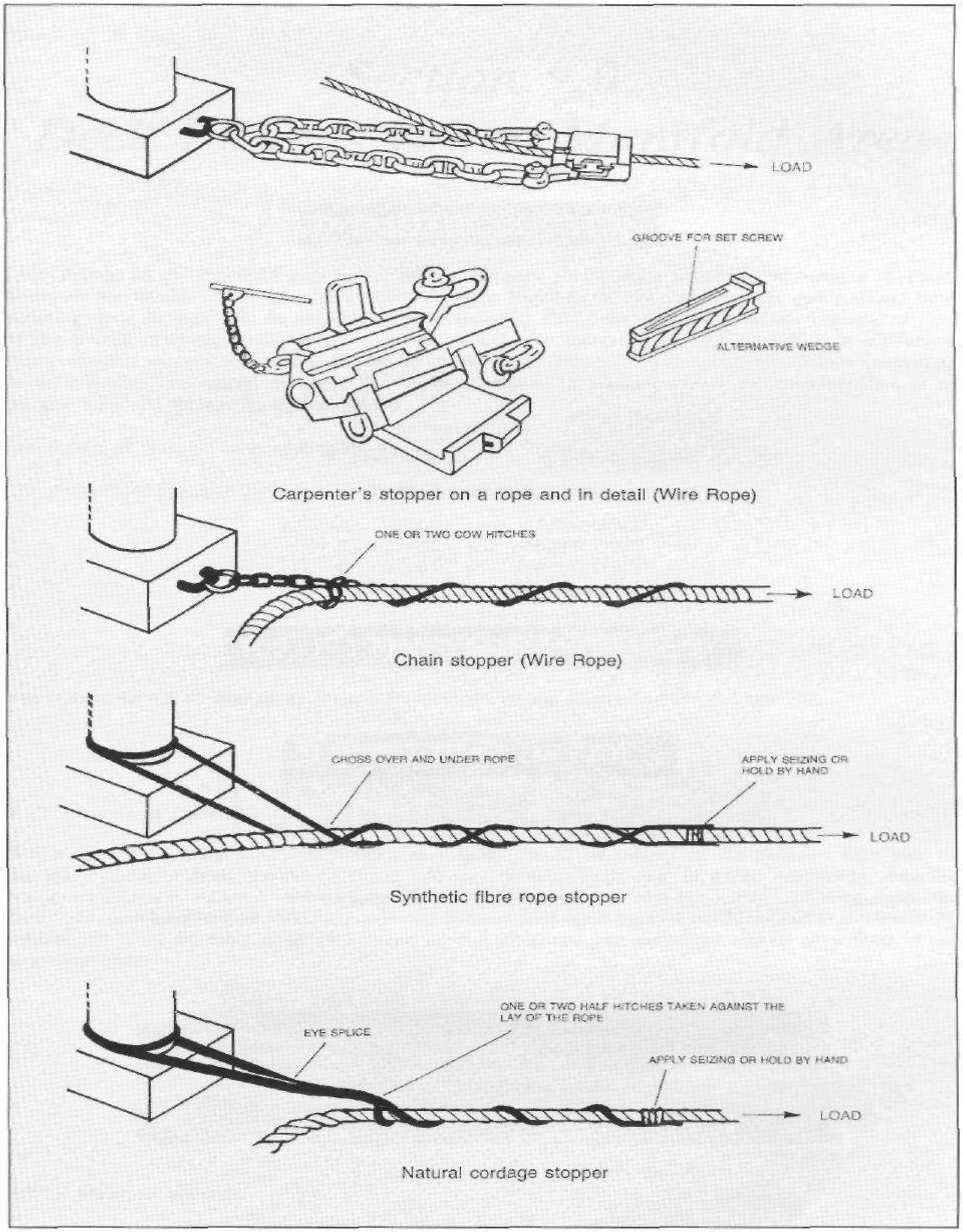


FIGURE 8.5: STOPPERS

MAKING FAST A LINE TO BITTS

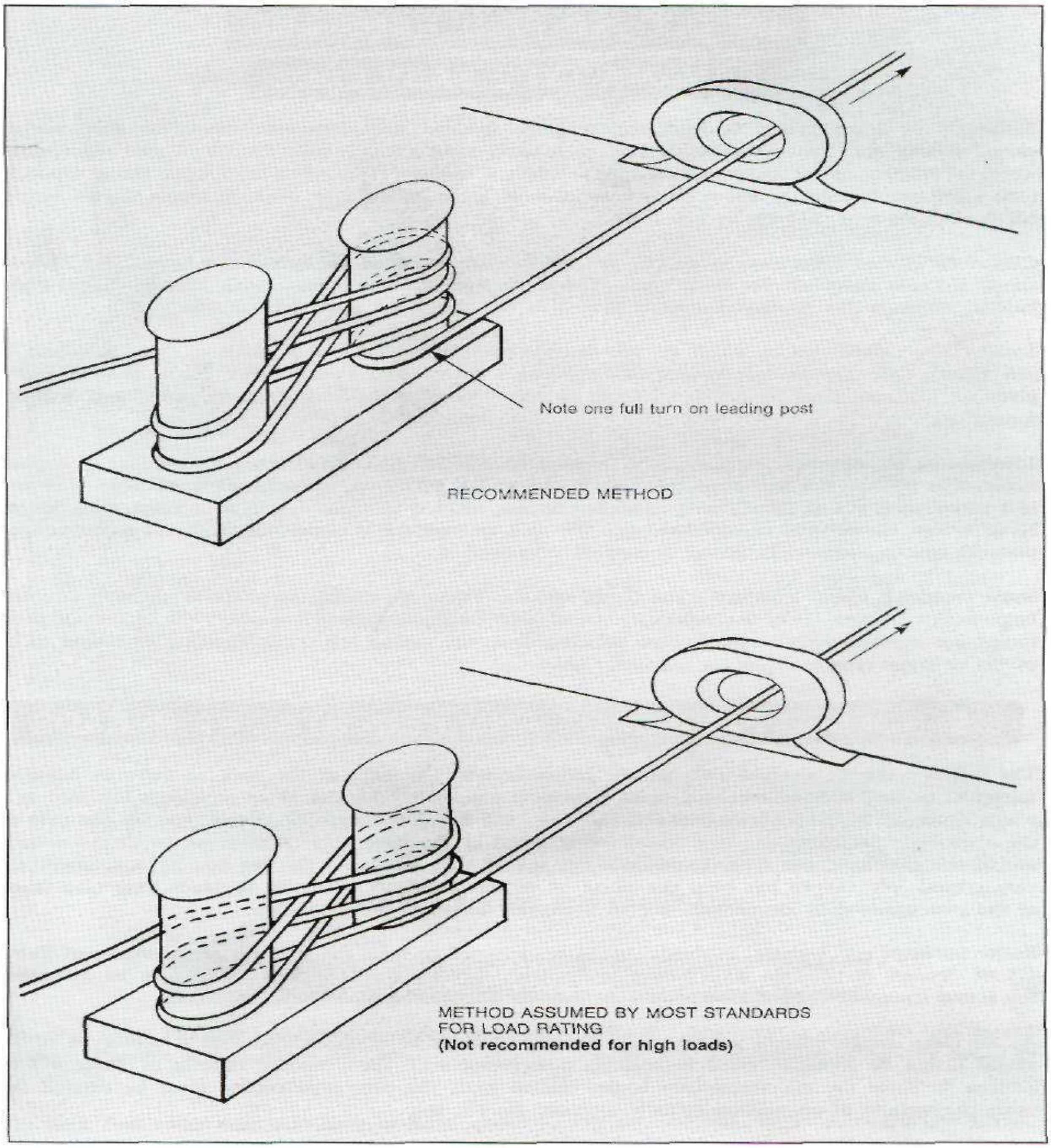
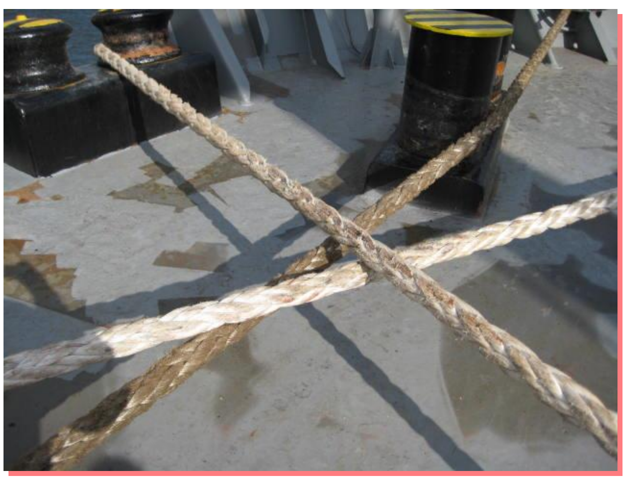


FIGURE 8.1: METHODS OF BELAYING A BOLLARD

NEGATIVE EXAMPLES OF MOORING ARRANGEMENTS ON BOARD:



Chapter 7 – SAFE MOORING PRACTICE AND GUIDELINE

7.1 SMS INSTRUCTIONS FOR SAFE MOORING:

1.1 Planning - The key element for safe and successful mooring operation is planning. Planning shall take into account not only the mooring layout of the vessel and the berth but the prevailing and expected weather conditions, tide, currents and any other factors affecting the moorings of the vessel.

1.1.1 Before arrival at a port, all necessary mooring equipment shall be made ready for use and all mooring machinery shall be inspected and proved to be in good condition. The inspection shall be carried out by the Chief Officer.

1.1.2 The Officer in charge of the mooring operation before arrival at the berth shall carryout mooring equipment safety checks and reports his findings to the bridge. A log book entry is to be made of these checks. Any deficiency reported to be advised immediately to the pilot. He shall also hold a briefing with the mooring party and make them aware of the mooring arrangement and the hazards involved.

1.2 Communication

1.2. The Master shall discuss the mooring arrangement and plan with the pilot before coming alongside and this information to be entered on the "Master Pilot Information Exchange" . The mooring plan shall take into account the layout of the berth, prevailing and expected weather conditions, tides, currents and traffic movements. The information shall be relayed to the person in charge of mooring parties.

1.2.2 Person's carrying out adjustments to the lines shall first take permission from the OOW. OOW shall carefully assess the affect of adjusting the lines on the position of the vessel before giving permission. Moorings are to be adjusted in such a way that vessel does not move position or comes off the fenders or berth. Adjustments shall also ensure that severe loads are not placed on individual lines.

1.3 Safe Practice

1.3.1 Mooring Operations onboard present significant risks to the crew. All personnel engaged in these operations shall be trained to ensure they are competent and aware of the hazards involved. Risk Assessment shall be carried out prior all mooring operations.

1.3.2 All personnel involved with mooring operations shall wear Personal Protective Equipment, including safety helmets, safety shoes, and gloves. Safety goggles are to be worn during anchoring.

1.3.3 The responsible officer of mooring operations shall wear following safety gear so that he can easily be distinguished from the other crew members during the mooring operation:

a) Helmet (Red) and / or High Visibility Safety Vest , and

b) Whistle

LNG vessels: All three safety gear listed above shall be donned by responsible officer.

1.3.4 All mooring areas shall be free of obstructions and litter and well illuminated at night. The decks shall be painted with anti skid paint. Mooring winches shall never be left running unattended. The person in charge of mooring operation shall give clear instructions to the winch operator. Mooring equipment shall be operated by competent persons. The personnel shall never stand in the rope bights and when moorings are under strain they shall stand clear of the "snap back zones".

1.3.5 Additional gas/fire detection and extinguishing systems shall be confirmed to be available for monitoring any enclosed spaces containing mooring equipment power supplies.

1.3.6 The maximum number of turns on a smooth mooring drum or warping end shall not exceed 4(four).

1.3.7 Moorings are to be adjusted by putting the winch into gear, opening the brake and walking back the line. On no account the moorings shall be slackened off by releasing the brake only.

1.3.8 The person in charge of the mooring party shall ensure that the mooring crew is kept well clear of the tugs lines when under load. When the tug is made fast or let go the person in charge shall ensure that operation is carried out in a controlled manner keeping in close contact with the bridge and the tug.

1.3.9 All personnel involved with mooring operations shall consult the relevant industry guidelines and publications available onboard, e.g. "Effective Mooring", COWSP, ISGOTT and OCIMF publication "Mooring Equipment Guidelines".

1.4 Protection of Power Supply

The electric switch board (Power-supply) to mooring equipment shall be sufficiently and adequately protected against water spray, water leaks or leaks of other kind. An electric insulating mat or appropriate wooden grating shall be placed under electric switch board as an additional measure to protect against electrocution.

1.5 Minimum Manning

1.5.1 For safety of operations, following minimum personnel shall man each mooring stations:

a) Mooring/ Unmooring at berth, Pier, Buoy, STS, SBM: 3 crew and Deck Officer
b) Making fast and letting go of Tug: 3 Crew and Deck Officer
c) Anchoring and heaving up anchor: 2 Crew and Deck Officer
d) Laying up and storing of ropes/wires on deck: 3 Crew

1.5.2 Vessel fitted with all mooring ropes/wires on winches (self stow winches) a minimum of 2 deck crew and one officer shall be minimum requirement.

<u>**7.2 SMS INSTRUCTIONS FOR WINCH / WINDLASS OPERATION**</u>:

1. Operations and Handling

The responsible Deck Officer and the operators of the machines shall operate the windlass and mooring winch in accordance safety guidance as per SMS ZZ-S-P-09.60.00 "Safe Mooring Practices and Guidelines" and following operational instructions:

1.1 Preparations for Operations

a) Make sure that the mooring line is wound on the drum in such a direction that when the drum rotates in the forward direction, the winch is wound up. Band brakes are designed for the line to pull directly against the fixed end of the brake band. 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.

b) Make sure that the each clutch of a windlass and a mooring winch is in the "DISENGAGE" position, and that the operating handles of each control stand are in the neutral position.

c) Remove the canvas cover of the windlass and the mooring winch to be used, release the lashing of the anchor, anchor chain, and hawser.

d) Make sure that all the bearings and gears of the mooring winch are efficiently applied with grease.

e) Check that the hydraulic line is properly lined up for its operation.

If a control device (e.g., switch or lever) to change over the operation of a windlass and a mooring winch is provided, the proper operation mode shall be selected.

f) Check the amount of oil in the oil tank.

Where a head tank is installed, confirm that the amount of oil in the piping is sufficient to check to see, by operating the hand pump, that the oil over-flows from the head tank through a sight glass.

g) Check the temperature of the hydraulic oil. If it is higher or lower than the normal condition, allow the cooling sea water to pass or shut the passage of the cooling water line as appropriate.

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

1.2 Starting

a) Start the necessary hydraulic pump. While driving the pump for few seconds, check to see that there is no abnormality with its operation, including the rotational direction; if no trouble is found, continue the operation.

If the required number of hydraulic pumps for driving the windlass is different from that for the mooring winch, a proper number of pumps shall be started for the operation in hand. In cold climates, start normal operation after properly warming the pumps.

b) Make sure that there is no oil leakage from the hydraulic pipe lines.

c) Make sure that the remote control equipment normally operates by maneuvering the operating handles of each control stand.

d) Make sure that brakes and the clutches of the windlass and the mooring winch to be used normally operate.

e) Pay attention to the temperature of the hydraulic oil. Adjust the opening of the cooling water valve of the oil cooler as needed.

f) Make sure that the emergency stop equipment normally operates.

g) Before starting any hydraulic deck machinery, ensure that the all drain plugs are in closed position.

1.3 Precautions during Operations

a) The operators of each handle shall operate the clutches, brakes, and handles in accordance with the instruction and command by the responsible Deck Officer.

b) Before operating the windlass or mooring winch, "engage" the clutch and insert the clutch pin, with the brake "off." In the event of a mooring line under excessive tension, in particular, release the brake after taking off the play between the drum clutch and shaft clutch in the hauling direction.

c) Operate the handles gently. A quick operation will cause a surge pressure, adversely affecting the machines; great care is necessary.

d) During operation, pay attention to the noise generated from the hydraulic machinery. If a noise is generated, immediately stop the machine, locate the cause, and take corrective actions.

e) When operating a winch or windlass, ensure that the operator understands the controls and is in visual or radio contact with the officer or person in charge for instructions.

1.4 Marking on the Winch and Windlass

The winch and windlass shall be marked boldly with following details:

a) Heaving and slacking direction of winch/windlass operating lever.
b) Brake rendering capacity.
c) Lowering and hoisting direction of winch drum.
d) Date when brake was tested last. (Tankers & Gas Carriers)
e) Date of rope change end to end or replacement

The working area adjacent to mooring equipments shall be painted with non-skid paint.

1.5 Others

- Master is to ensure that adequate numbers of experienced personnel are available to handle the mooring operations safely and effectively. (Reference: ZZ-S-P-09.60.00 " Safe Mooring Practices and Guidelines").

- Master shall not hesitate to use extra moorings if prevalent weather so demands. He shall request tug assistance in good time if deemed necessary.

- Mooring practices shall be reviewed as part of Risk Assessment procedures and during onboard safety and sanitary committee meetings periodically.

- The onboard training for the safe mooring operations shall also be reviewed at the same time.

2. Stopping Operations

a) Bring the operating handle to the neutral position, and apply the stopper.

b) Apply the brake.

c) Disengage the clutch.

d) Stop the hydraulic pump.

e) Check the pump for oil leakage, loosening of bolts. If any, immediately repair for next operation.

The Chief Officer shall instruct and check the following in order to avoid difficulty in anchoring in the case of blackout:

a) Disengaging of the clutch after the brake band is used on the windlass.

b) Giving of adequate clearance to chain stoppers so that these can be manually managed.

3. Precaution Whilst At Berth

The safety of the ship does not finish once the ship is finally moored but continues all the time she is alongside.

a) The tide timings and range shall be calculated and informed to OOW.

b) The weather forecast, warning from port etc shall be monitored.

c) During watch keeping, OOW shall pay attention to unpredicted change in weather conditions.

d) Mooring lines shall be regularly tended whilst the ship is moored at a jetty and when other vessels are passing close to the jetty and/or mooring unmooring of other vessels ahead or astern of own vessel.

e) Check traffic movement with agent and pay special attention during the passing of other vessels.

f) Frequently obtain weather information for local agent or other means. Take additional ropes or wires, as necessary. If considered unsafe, ask for tugs to be stand by. If required cast off and shift to sea, well in advance of onset of bad weather.

g) It should be noted that the heaving power of the winch 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. Use main engine, bow thruster or tug assistance to keep the ship alongside, as required.

h) Brakes should be tightened at frequent intervals even if there is no signs of slipping, allowing for change of freeboard due to cargo operations and/or tides.

i) Do not surge synthetic 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.

Chapter 8 – COMMUNICATION AND SIGNALS

8.1. EFFECTIVE COMMUNICATION:

Company procedures should ensure that a high level of communication discipline is exercised at all time. Communication covers all means:

- verbal
- written
- hand signals / body language
- radio / telephone
- sound powered system

- Verbal communication must be precise, simple and unambiguous, to avoid confusion and error;

- Use standard terminology, clear, short and concise.

- Use of the word “OVER” at the end of speaking (message) and “OUT” when finally completing the entire communication..

- Repeat the message (feedback)

- Execute the instruction given on the message and report that the instruction has been complied with.

<u>VHF or Walkie-Talkie is a one way communication system unlike the regular telephone. Personnel should understand the need for, and use of, correct radio procedure:</u>

- avoid un-necessary use of radio-communication;

- test the equipment before required to be used;

- working channels should be established and should not interfere with other operations;

- establish how each station / crew-member is identified;

- commands should be repeated and not only acknowledged (not only by “roger” or by clicking transmitter button);

- do not use offensive language or private matters in radio communication.

- human element and cultural issues must be considered.

- too much information can result in overload: use only relevant information.

- do not engage in long / detailed messages: the receiver of a spoken radio message (especially with numerical content) will lose the track of the message after about 15-20 seconds.

Some words in English language have different meanings, depending on the context in which they appear. Misunderstandings frequently occur and can cause accidents!

- Attention for the use of “may”, “might”, “should” and “could”.

- Possible problems using word “can”, which describes the possibility or the capability of doing something.

May

Do Not Say:	“May divers enter the water?”
Say:	“QUESTION. Do divers have permission to enter the water?” [Or “...is it safe for divers to enter the water?”]
Do Not Say:	“Divers may enter the water.”
Say:	“ANSWER. Divers have permission to enter the water.” [Or “…it is safe for divers to enter the water]

Might

Do Not Say:	“Divers might enter the water”
Say:	“INTENTION. Divers will enter the water”

Should

Do Not Say:	“You should use the ten tonne crane”
Say:	“ADVICE. Use the ten tonne crane.”

Could

Do Not Say:	“You could be using the wrong shackle”

Examples of items to be reported and confirmed:

- distances (value and any changes – constant, increasing or decreasing), CPAs to different fixed or moving objects, clearance of passing, overlapping distances, parallel / lateral distances, etc.
- any situations and conditions which are not visible / observable from the Bridge – moving / fixed objects, obstructions in the water or at the surface, equipment malfunction, etc.
- any other item should be required from the Bridge.
- any other information to the Bridge that Officer in charge of mooring station considers is necessary for the safety of maneuver.
- proper sequence of reporting should be kept so as not to interfere with important orders given by the bridge team, and to achieve this,

the following **guidelines** are set forth:

- normally only the mooring team leader shall be allowed to communicate with the Bridge team; if the team members at the mooring stations have their VHFs switched on, they should only use it for receiving, unless otherwise instructed.
- crewmembers should be aware of the squelch feedback when handheld VHFs transceivers are in a close vicinity and that it can block or distort incoming/outgoing messages.
- team leaders should not interrupt any transmission going on in the used channel/frequency, they should wait until transmission is over.
- team leaders must acknowledge receipt of message and repeat it for the sender to countercheck whether received correctly
- when instructions are not made clear to the team leaders they shall ask the bridge to re-transmit the message.

- When the information requested is not immediately available, say:
  "STAND BY" …followed by the time interval within which the information is available.

- When the information requested cannot be obtained, say:
  "NO INFORMATION"

- " How do you read (me)?"
- "I read you…

  bad / one – signal strength ONE (barely perceptible)
  poor / two – signal strength TWO (weak)

fair / three – signal strength THREE (fairly good)
good / four – signal strength FOUR (good)
excellent / five – signal strength FIVE (very good)

- When it is advisable to remain on a VHF channel, say:
  "*Standby* on VHF channel… / frequency …"

- When it is accepted to remain on the VHF channel, say:
  "*Standing by* on VHF channel … / frequency…"

- When it is advisable to change to another channel, say:
  "*Advise (you) change* to VHF channel … / freq…."
  "*Advise (you) try* to VHF channel … / frequency …."

- When the changing of a VHF channel is accepted, say:
  "*changing to* VHF channel … / frequency …"

- The use of "Mistake … Correction"

When a mistake or incorrect information has been give, say:

"MISTAKE …" followed by the word:
"CORRECTION…" plus the corrected part of the message

Example: I am sending the spring line forward - *mistake*.
Correction, I am sending the breast line forward.

- The use of "Say Again"

If any part of the message is not properly heard or has not been clearly understood , say:
"Say Again (Please)"

Answer "**No**" can be accompanied by "**Negative**"
Answer "**YES**" can be accompanied by "**Affirmative**"

- Numbers are to be spoken in separate digits:
  "One-five-zero" for 150.
  "Two decimal five" or "Two point five" for 2.5.

STANDARD TERMINOLOGY:

Is / are the propeller(s) clear?
Yes, the propeller(s) is / are clear
No, the propeller(s) is / are not clear
Keep the propeller(s) clear

Are fenders on the berth?
Yes, fenders are on the berth
No, fenders are not on the berth
Have fenders ready forward and aft.

We will berth port side / starboard side alongside

We will moor - to buoy(s) (ahead and astern)
- alongside
- to dolphins

Send out
- The head / breast / stern line
- The … spring(s) forward / aft

Have the heaving lines ready forward and aft
Send the heaving / head / stern / breast line(s) ashore

The lines men will use shackles / lashings for securing the mooring

Use
- The center lead / panama lead
- The bow lead
- The port quarter / starboard quarter lead

Heave on the... line(s) /... spring(s)
Have the heaving lines ready forward and aft
Pick up the slack on the … line(s) / … springs
Heave Away
Stop Heaving
Slack Away/Check the…lines(s) / …spring(s)
Hold on the …line(s) /… springs(s)
Heave in easy
Heave alongside

Keep the … line(s) /… spring(s) tight
Report the forward / aft distance to …
    The forward / aft distance to… is … meters
We have to move … meters ahead / astern
We are in position
Make fast forward and aft
Finished with maneuvering stations

Stand by engine(s)
Are you ready to get underway?
    Yes we are ready (to get underway)
    No, we are not ready (yet) (to get underway)
    We will be ready to get underway in … minutes
Standby for letting go
Single up the … lines and …springs forward and aft
Slack away / hold on / heave on the
- head / stern line
- breast line
- forward /aft spring

Let go
- The head / stern line
- The breast line
- The forward /aft spring line
- all (forward / aft)

Let go the towing line(s)
Standby bow anchor(s)
Finished with maneuvering stations

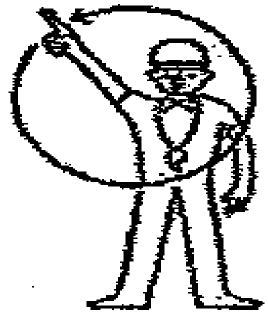
8.2 HAND SIGNALS:

- There is a range of different hand-signals used internationally, often standardized by countries or by companies, however it is unlikely that they will be standardized globally into one system.

- Therefore it is important that those involved in mooring operations know exactly which system of signals is to be used and that they are familiar with each hand-signal used.

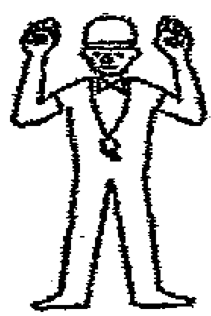
- Whatever hand-signals are used, should be displayed – posters, laminated copies, etc. – visible and easy accessible to all crew-members.

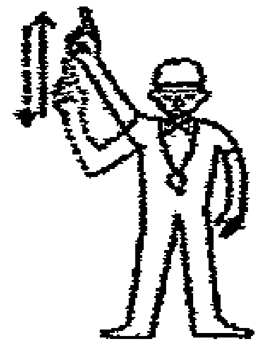
HEAVE IN / HOIST / START



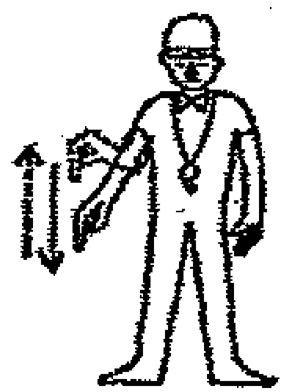
HEAVE IN SLOWLY, WITH CAUTION

HOLD ON / STOP

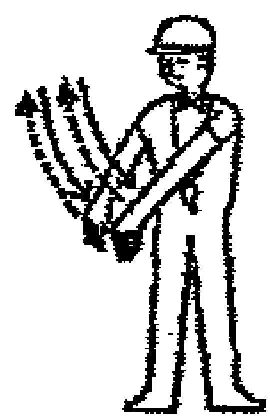




UP

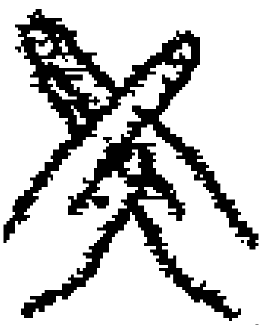


DOWN

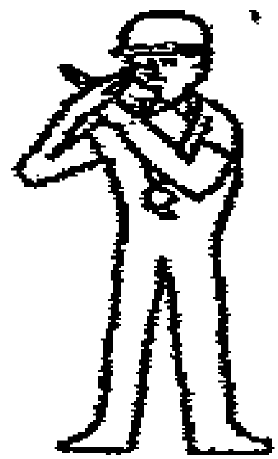


STRETCH / SLACK

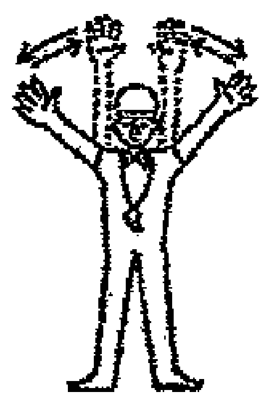
LET GO / RELEASE



CLOSE / STOP / HOLD ON



FINISHED



Hand Signals used in Boston (East Boston Marine Terminal)

1. An outstretched arm with hand open and flat being waved downward means "slack off."

2. A sharp upward movement of the arm with the hand cupped towards the signaler means "let go" or "cast off."

3. Crossed arms in front of the body means "make fast" or "is made fast."

4. A circular movement of the hand above the head means "heave away."

5. Both hands raised above the shoulders, with open hands facing forward means "stop."

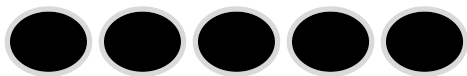
6. A raised hand with the fist being clenched and unclenched means "heave or hoist slowly" (inching).

Please also refer to <u>Appendix 9</u>: Annex 21.1 Code of Safe Practices – Coded Signs to be used

8.3 WHISTLE SIGNALS:

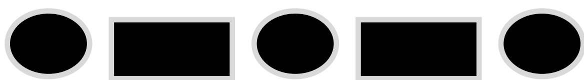
●	Attention!	Workers ***pay attention*** to the order.
● ●	Heave IN	The operator or driver starts to do as indicated.
● ● ●	Slack	The operator or driver starts to do as indicated.
▬	Stop!	The operator or driver ***stops*** the operation.

Whistle Signals



Danger!
Cancelation!
Emergency!

This is used when the signalman feels danger, fails to make a correct order, cancels his order, and / or for emergency stops.



Finished operation!

Emergency!
Accident!

The occurrence of an accident! Crew members shall rush to the scene at once. (This signal can be used by a person on duty for security reasons)

安全第一
全船統一作業号令
N.Y.K.LINE
日本郵船株式会社
意味
呼子笛 信号(主)
手先 信号(副)
•捲け •揚げ •前進
ピッ ピッ
人さし指をのばし 輪を描くこと
•停止
ピー
ホールドオン
止め，閉め，
•下げ•のばせ•後進
手のひらを下に向け 水平より下方へ動かす
•注目 •待て
片手首をまげ指先を 上にし手のひらを示す
•OK. (了解)
拇指と人さし指で環を 作る
•終了. 開け
両手のひらを左右に ひらく
•取消し •危険 •非常事態
方向
上へ
下へ
1. 呼子笛信号（主）と手先信号（副）は可能な限り併用すること。
2. 指揮者の呼子笛信号に作業者は同種信号で応答してから行動すること。
3. この信号の他，実状に応じて他の意味の信号を追加することは差支えない。
特に手先信号は出来るだけ腕一杯に動かし可能な限り両手を使用すること。
4. 呼子笛信号は船内共同作業の指揮者の号令，受令者のアンサーバック，非常事態の
時以外は使用しないこと。又OKの手先信号はラテン系外国人には使用しないこと。
みどりの笛で安全作業

Chapter 9 – TESTING, INSPECTION AND MAINTENANCE OF MOORING EQUIPMENT

- Before arrival at a port, all necessary mooring equipment shall be made ready for use and all mooring machinery shall be inspected and proved to be in good condition. The inspection shall be carried out by the Chief Officer.
- The Officer in charge of the mooring operation before arrival at the berth shall carryout mooring equipment safety checks and reports his findings to the Bridge. A log book entry is to be made of these checks. Any deficiency reported to be advised immediately to the pilot. He shall also hold a briefing with the mooring party and make them aware of the mooring arrangement and the hazards involved.
- The responsible person for maintenance shall, with the approval of the Master, submit documents to the Vessel Manager in the case where the responsible person for maintenance submits a report, proposal, request, or requisition to, or requests instructions from the Company.
- Each officer shall carry out maintenance of various facilities, machinery and equipment under his charge, following orders from the responsible person for maintenance, and shall be responsible to the department head or the responsible person for maintenance.
- With reference to maintenance of machinery, equipments, etc, *Maker's manuals & instructions* shall be understood thoroughly prior taking up the task.

9.1 INSPECTION AND MAINTENANCE OF DECK FITTINGS:

Mooring equipment that has suffered severe wastage will not perform to the certified standard. This also applies to the steel to which the equipment is welded. The image shows mooring bitts that are badly wasted. The deck is in equally bad condition and there is a danger of the bitts being torn from the deck.

Many national, shipyard and vendor standards for mooring fittings exist. In almost all cases these standards lack complete information on the true strength of the fittings. Even where back-up calculations are provided, questions still arise. For complete evaluation of existing standards, extensive stress analysis would be required for each fitting and component.

Any fitting of undocumented or incomplete strength characteristics should be verified for compliance with the recommended strength criteria by detailed calculations and prototype testing. Generally, reference is made to the widely-used International Standards (ISO), British Standards (BS) and Japanese Industrial Standards (JIS).

9.2. INSPECTION AND MAINTENANCE OF MOORING HAWSERS:

9.2.1 Inspection and Maintenance of Mooring Ropes

Identification of Hawser

All the mooring hawsers and tail-ropes, both spare and in use, shall be marked with identification number. The same number or mark shall be noted on the certificate of the rope for ready referencing.

Checking of Mooring Lines before use:

Before using a mooring line, check for symptoms of damage or deterioration every time. Synthetic lines shall be examined frequently while in service. Look carefully for signs of cut, wear and tear of strands. If any abnormality is found, execute check all parts of mooring line and judge whether it is necessary for reversal or replacement.

Periodic checks

All ropes must be inspected every three months to confirm the deterioration and included in the PMS. Hawsers shall be laid out to its ordinary length of use and checked for the following aspects:

- External abrasion and fusion
- Eye condition
- Cuts
- Internal abrasion (Eight rope only)
- Hockling (Eight rope only)
- Tight strands (Nylon eight rope only)
- Broken core (Double braided only)

Evaluation Procedure

Upon the completion of inspection, records must be updated in the "Quarterly Hawser, Tail rope Inspection Record."(SMS).The following remarks shall be made based on the condition observed.

Good : Nothing abnormal found.
Fair : There is some abnormality but the condition is still good.
Poor : If the condition is below acceptable standard.

Quarterly Hawser, Tail rope inspection record — Figure

Vessel name: NYK Seagodess — Date:

Drum No.	Supplied date	Turned over date	External aberration and fusion	Eye condition	Cuts	Internal aberration (Eight)	Hockle (Eight)	Clogged up (Nylon Eight)	Broken core (Doubler)	Remark
1	10th sep 00	-	Good	Fair	Good	Good	Good			
2	10th sep 00	-	Good	Fair	Good	Good	Good			
3	10th sep 00	-	Good	Fair	Good	Good	Good			
4	10th sep 00	-	Fair	Good	Good	Good	Good			
5	23rd Apr 98	Nov. 02	Good	Good	Fair	Good	Good			
6	23rd Apr 98	Nov. 02	Good	Poor	Good	Good	Good			
7	23rd Apr 98	Nov. 02	Good	Fair	Fair	Good	Good			
8	23rd Apr 98	Nov. 02	Good	Good	Fair	Good	Good			
9	23rd Apr 98	Nov. 02	Fair	Good	Fair	Good	Good			
10	23rd Apr 98	Nov. 02	Fair	Good	Fair	Good	Good			
11	5th May 95	Aug. 00	Fair	Good	Fair	Good	Good			
12	5th May 95	Aug. 00	Fair	Fair	Good	Good	Good			
13	5th May 95	Aug. 00	Fair	Fair	Good	Good	Good			
14	5th May 95	Aug. 00	Fair	Fair	Good	Good	Good			
15	10th sep 00	-	Good	Fair	Good	Good	Good			
16	10th sep 00	-	Fair	Fair	Good	Good	Good			
Spare	11th Nov 02									
Spare	11th Nov 02									
Spare	11th Nov 02									

Criteria for Changing End to End (Reversal) and Replacement

All hawsers on board must be changed end to end every 18 months. However, before discarding a rope, the following two criterions shall be taken into account.

Hours of Use

- Hawser: All mooring hawsers shall be discarded after 5 years (on wood chip carrier after 04 years) from the date taken in use or even earlier if visible deterioration of hawsers is observed
- Tail rope: Ropes shall be replaced every 18 months.

Visible Condition (Reference: SMS)

The ropes shall be discarded if the following conditions are observed:

- External abrasion and fusion: If the diameter worn down more than 5% by external abrasion and fusion

- Eye condition: If significant abrasion or fusion has occurred to the eye.

- Cuts
- If 25% of the area of one or more strands are broken by cuts. Applicable to Eight Strand rope only. (As seen below)

Example 1: Eight rope
1/4 cut

Example 1: Eight rope
1/2 cut

- If 10% of the entire cover strands are broken by cuts. Applicable to Double braid only.

- Internal abrasion (Eight Strand rope only) If the Internal abrasion has progressed to the extent that some yarns are worn out.

- Hockling (Eight Strand rope only)

- Tight strands (Nylon Eight Strand rope only) In case it is hard to insert a spike between strands of a Nylon eight rope, it is a sign to discard the rope as tight strands greatly reduce the structure's strength of the Nylon eight strand rope.

- Broken core (Double braided only) Hawser bends freely at the specific point. The core of a double braided rope may break under high load without resulting in immediate rope failure. Under load, the rope will have a smaller diameter at the point of core break.

Visible Condition Reference Tables

The wear and tear level of the outside layer of yarn

Judging standard: Any case equivalent to the level 2 should be judged as meeting the standard for reversal or replacement.

LEVEL 5

The outside layer of yarns is not broken. There is not wear and tear at all.

LEVEL 4

The outside layer of yarns rubs, and there is a wear and tear.

LEVEL 3

About ten yarns are broken

LEVEL 2

The yarns of the 1/4 to 1/2 strand equivalent are broken.

LEVEL 1

The yarns of the 1/2 strand equivalent are broken.

- It is recommended that, in the absence of any other information, mooring ropes are replaced when their residual strength reaches 75% of the original MBL.

- This reduction can be ascertained either by destructive testing or by visual examination.
- Tails should be retired when their residual strength reaches 60% of the original MBL.

- The amount of strength loss due to abrasion / flexing relates to the percentage of yarns broken in the rope's cross section. (For high modulus synthetic fibre mooring lines, the proportional loss in strength is greater than the percentage of the damage).

In order to preserve the usage life of ropes, ensure they are protected from the elements and not subjected to unnecessary chaffing.

Do not store ropes on wet decks. Ensure they are stowed off the deck and if possible away from precipitation and direct sunlight. If baskets or other storage devices are not available then ropes should be coiled down on pallets.

Ropes correctly stowed off deck

Ropes badly stored on wet deck

***Guidelines for Handling and Inspection* of *Fibre Ropes*:**

a. **HANDLING**

Following are some recommendations for the care and handling of fibre ropes:

• New fibre rope of right-hand lay construction should be uncoiled from the centre of the coil in a counter-clockwise direction. When re-coiling it, the rope should be coiled in a clockwise direction. If it is a left-hand lay rope, the opposite would apply. If the rope is on a reel, the reel should be placed on a spindle or a rod to allow the reel to revolve freely. The rope should not be removed from over the end of the reel or while the reel is lying on its side.
• The ropes should be flaked down with as large a flake as possible to avoid kinking the ropes when storing them.
• Excessive build-up of turns in rope or loss of turns should be avoided. Excessive twist should be worked out of the rope by hand before loading.
• A capstan or winch drum rotating clockwise will add turns to a right-hand laid rope and one turning counter-clockwise will remove turns. To avoid this, the rope should frequently be turned end for end on winch drums.
• Ropes should not be dragged over sharp or rough edges, or along the ground, as they could pick up abrasive particles.
• Chafing at chocks and fairleads and on edges of dolphins and piers should be avoided where possible. All metal fittings should be smooth, and ropes protected against chafing by the use of anti-chafe devices such as leather jackets. Winch drums should be as smooth and free of rust as possible. Chocks and fairleads should be in a similar condition. If chocks are of the roller type, they should be free running.

• Ropes should not be exposed unnecessarily to sunlight.
• Fibre ropes should not be exposed to heat. They should never be dried by placing them near heaters.
• Contamination of ropes by chemicals or fumes, especially by acids and alkalis, should be avoided. If contamination is suspected, ropes should be hosed down and washed to avoid damage.
• Sharp bends on a rope should be avoided. Wire lines and synthetic ropes should not be placed on the same bollard or mooring hook.
• Extreme care should be exercised when easing out synthetic ropes from around bitts, cleats or other holding devices, to avoid sudden slipping of the line. Factors contributing to slipping are the low coefficient of friction between synthetic ropes and steel and the large elongation of synthetic ropes under load. Nylon and polypropylene are particularly prone to slipping.
• Due to the high stretch of synthetic ropes, large amounts of energy can be stored in a line under load. Sudden failure of the rope can then result in a potentially dangerous snapping back of the line.
• Mooring ropes should never be knotted. Knots weaken a rope considerably, even after they are removed.
• A left-hand rope should not be coupled to a right-hand rope.

b. **INSPECTION**:

Fibre ropes lose strength and deteriorate through normal use and must eventually be replaced. Weak points and potential areas of failure can be detected and the line repaired or retired before it parts in service. For inspection, the rope should be laid out and the inspector should run the rope between his hands, examining about a foot length at a time. As he proceeds, he should rotate the rope and open the strands or spread the yarns to expose the strand interior surfaces and fibres.

c. **REPLACEMENT**:

The following guidelines will aid in determining when a fibre rope should be replaced:

• *Fibre deterioration.* The rope should be retired if the fibre is breaking up or if powdered fibre is present.
• *Damage due to external wear.* For this purpose, an unused rope sample may be helpful for comparison. If strand crowns are worn down considerably, the rope should be retired. If a significant number of outer yarns are also severed, the rope should no longer be used as a mooring line.
• *Local abrasion.* Heavy chafing or fusion of surface fibres are indications of severe abrasion. If these sections are localized, they can be removed and the rope spliced in accordance with the manufacturer's recommendations.

9.2.2 Inspection and Maintenance of Mooring Wires:

Standard Evaluation and Inspection: The wires shall be inspected at the intervals and guidelines as stated below

- Mooring wires every 3 months
- Other wires & wire slings- every 3 months

The wires must be cut-off or replaced, if the wire comes under any of following conditions. ("Cut-off" means removing the part which has the following conditions up to the end of the wire.)

Regular application of good quality wire rope grease will fulfill the purpose of corrosion prevention, weather protection and lubrication.

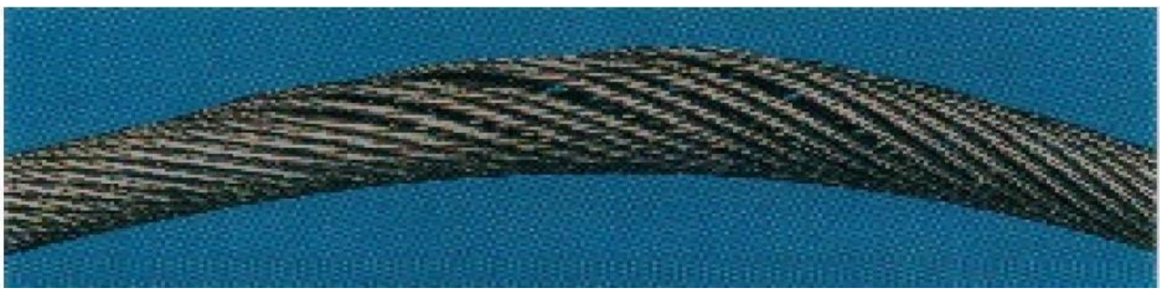
The wire on board shall be lubricated periodically. During maintenance following shall be followed.

- The rusty parts on the wire shall be removed by wire brush or sand paper / emery paper.
- The wire shall never be allowed to dry. The wire shall be greased up using adequate grease as per vessel lubricating chart.
- The un-accessible part of the wire such as wire under the sheave, anchoring point etc, shall be paid careful attention while greasing.

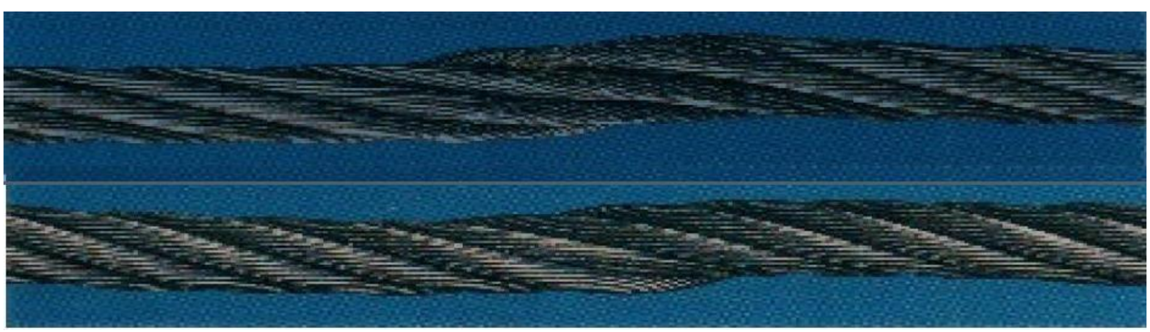
Deterioration of Shape of Wire
- Collapse of shape
- Collapsed Strand
- Protrude of core
- Cave in/protrude of core

Flattening Out and Bending

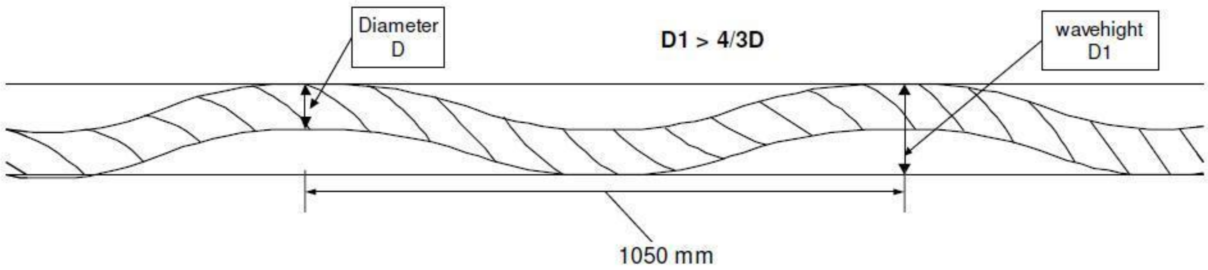
- If wire rope has flattened out to the extent that minimum diameter of rope is less than 2/3 of maximum diameter of wire.
- If wire has developed permanent bent.



Kink
If wire has developed a prominent kink as illustrated below



Undulation
If Wave-height of undulation becomes more than 4/3D, within the length of 25xD of wire rope. Following illustration is showing 42mm diameter wire.



Abrasion / Corrosion

If abrasion or corrosion of wire is as follows:

- Reduction of diameter becomes more than 7% of its original diameter
- Pockmark is existed on the wire face.
- Strands are loosed due to hard corrosion

Cuts

The wire shall be replaced if strands of wire exceed the condition as detailed below:

- 10% of strand is cut in one ply (Lay).
- 20% of strands in 5 plys.

Example
Ex. 6X37 wire
Total number of Face layer; 222 strands
10%=222X0.1=22 strands
OR
i.5%=222X0.05=11 strands

Condition of Wire-Rope

The following terminology shall be used to describe the condition of wire:

- Good: nothing abnormal
- Fair: there is some abnormal condition but have not reached to the condition as per above mentioned conditions.
- Poor: reached to above mentioned conditions.

(*a*) Crosslay (*b*) Equal lay

DEFINITIONS

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

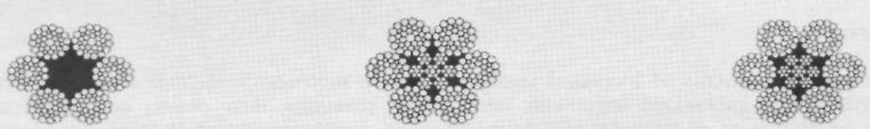
Crosslay or Equal Lay—terms describing the lay of the wires used to make up the strands. (See (*a*) + (*b*) above)

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

Ordinary Lay or Lang's Lay—terms applying to the lay of the strands when making up the rope. (See (*c*) + (*d*) below)

(*c*) *Lefthand* *Righthand*
Ordinary Lay

(*d*) *Lefthand* *Righthand*
Lang's Lay



(*e*) 6 × 36 WS
(1 + 7 + (7 + 7) + 14)
+ Fibre core

(*f*) 6 × 36 WS
(1 + 7 + (7 + 7) + 14)
+ Steel core

(*g*) 6 × 41 WS
(1 + 8 + (8 + 8) + 16)
+ Steel core

This applies to the number of wires in each strand

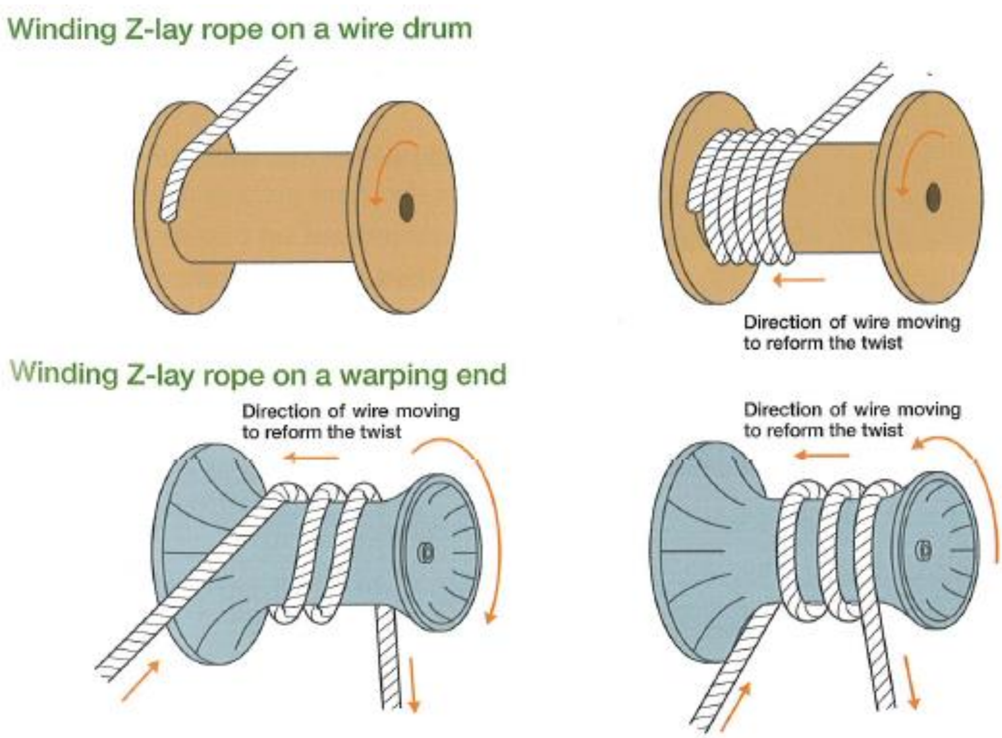
1 = centre
7 = next layer
7 + 7 = layer with mixed wire diameters
14 = outer layer

FIGURE 6.1: WIRE LINE CONSTRUCTIONS

Winding on a wire drum

Tension on a wire rope will make it twist in its natural direction. This tendency should be used when stowing on a drum in order to maintain the evenness on it. The first layer serves as the base and guides the following layers to wind on correctly.

The winding direction on a mooring which is decided by the mechanism of its break system.



Criteria of prohibition of using and replacement

Wire ropes gradually reduce in strength whilst in use. The same location is likely to be damaged by the drum or heave and they need to be partially cut or turned end for end.

Although it is difficult to set a standard guide to replacement of wires, according to fractures wires, excessive wear, deformation or rot, a rule of thumb is said to be as follows:

- Broken wires

  Referring to the following table, decide whether usable or not, according to the situation of broken wire, i.e., whether concentrated or distributed among all strands of the rope.

Kind of wire rope (No. of strand x No. of yarn)	Distributed broken wires in one pitch	Concentrated broken wires in one strand
6x19	12 wires	5 wires
6x24	15 wires	6 wires
6x37	23 wires	9 wires

- Wear Down

  When wear down is easily observed visually, you should not use it.

  If the measured value of the diameter has reduced to below 93% of the nominal one, it should not be put to use again.

  Measure the diameter from 3 directions at a portion where the diameter has reduced; and the diameter is represented by their arithmetical average.

- Deformation

  Wire ropes which have shown such symptoms as follows should be taken out of use.

wire rope which has kinked

wire rope whose core has protruded

wire rope whose strands have loosen and been raised

Prohibition of use of unsuitable wire ropes by safety regulations for cranes, etc.

- Wire ropes whose yarns have been broken to 10% of the total number within a pitch.
- Wire ropes whose diameter has reduced by 7% or more of nominal one.
- Wire ropes which are conspicuously deformed or corroded.

- Others
  - Date of replacement of wires being used for cranes, mooring lines, lifeboats and so on shall be recorded and inspect periodically, so as to find abnormality in early stage.
  - Greasing prolongs the wire ropes life by up to 2 to 3 times compared with no grease.
  - The most important things to prevent kinking is to find signs of kinks and prevent them.
  - It is rather belated to notice the internal corrosion in the portion of a wire rope where serving is applied. At portions where waterproof covering is provided, corrosion develops more quickly than one may think, when they run out of grease. (The same care should be required for turnbuckles which are provided with waterproof covering.)

Wire ropes sometimes part instantaneously. But in many cases, wire ropes spring back while some of the strands parting and unlayed.

The safe use of wire ropes is qualified by the following criteria:

1. Nature and number of broken wires – usually external surface, but can be also non-visible fracture. The wire should be discarded if:
- 2 or more valleys breaks are found in one lay length;
- number of visible broken wires in a rope is > 4 over a length of 6D, or 8 over a length of 30D (D = nominal diameter).

2. Broken wires at the termination – are indicative of high stresses at this position and can be caused by incorrect fittings of the terminations.

3. Localised grouping of wire breaks – where broken wires are very close together, constituting a localised grouping, the rope should be discarded.

4. The rate of increase of wire breaks – if the primary cause of deterioration is fatigue, the number of breaks will increase over time; careful periodic examination and recording is required.

5. Fracture of strands – if a complete strand fracture occurs, the rope should be discarded immediately.

6. Reduction of diameter resulting from core deterioration – can be caused by internal wear, wire indentation, friction between strands (in case of bending), or fracture of a steel core.

7. External wear – abrasion of the outer strands of the rope due to rubbing contact under load with fittings (chocks and fairleads).

8. Decreased elasticity – is difficult to detect visually, but usually is associated with reduction in diameter, elongation of the rope, fine brown powder between the strands and increased stiffness.

9. External and internal corrosion – internal is more difficult to detect, but can be recognized if is a reduction in diameter, or loss of clearance between strands is observed.

10. Deformation – visible distortion of the rope from normal shape, resulting in uneven stress distribution in the rope:

- basket or lantern deformation (birdcage), is a difference in length between core and outer layer of strands;
- core or strand protrusion / distortion;
- wire protrusion: certain wires or group rise up in loops form;
- local increase in diameter, due to deformation of the core;
- kinks or tightened loops: deformation created by a loop in a rope that has been tightened without allowing for rotation about its axes.

11. Damage due to heat or electric arcing – externally recognized by the colors produced in the rope.

Regular inspections are necessary to assess the condition of the wire and to perform remedial action in case of damage.

Following are some guidelines for inspection:

• The wire diameter should be checked. A marked decrease in wire diameter is a sign that the line should be removed from service. Reasons for the decrease could be core deterioration, internal wear and wire failure, or internal corrosion.

• The wires of the outer layer should be inspected for wear and breaks. If lubrication has been good and operating conditions such that the inside wires are intact, the reserve strength of the inside wires will be maintained. In this case, only a strength reduction corresponding to the broken outer layer wires need be deducted from the rope strength.

- Wires should be checked for abrasion. If the outside wires show a considerable loss of metallic area, the line should be removed from service.

- Individual wires on the strand crowns should be inspected for fatigue breaks (squared-off ends perpendicular to the broken wire). If these wire breaks occur at the strand crowns, the residual wire line strength may be estimated by counting the number of breaks in the length of one lay and subtracting these from the number of wire strands in the line in order to determine the number of remaining unbroken strands.

(A wire lay is the distance parallel to the longitudinal axis of the rope in which a strand makes a complete turn about the axis of the line).

- Look for fatigue breaks at or near the valley positions of the strands. If one fatigue break of this type is noted, the line should be removed from service, since further deterioration of this type will doubtlessly have taken place where it cannot be easily detected.

- Remove the wire up to and including the kinked or cut sections.

- An inspection should be made for corrosion and the line should be retired from service if corrosion has penetrated below the surface of the wires.

Guidelines for Handling and Inspection* of *Wire Mooring Lines:

a. **HANDLING**

Prevent kinking of lines; when unreeling, the reel should be mounted on a spindle and the line pulled directly off the reel, not over the end. If a loop forms, it should be thrown out immediately, before any load is placed on the line.

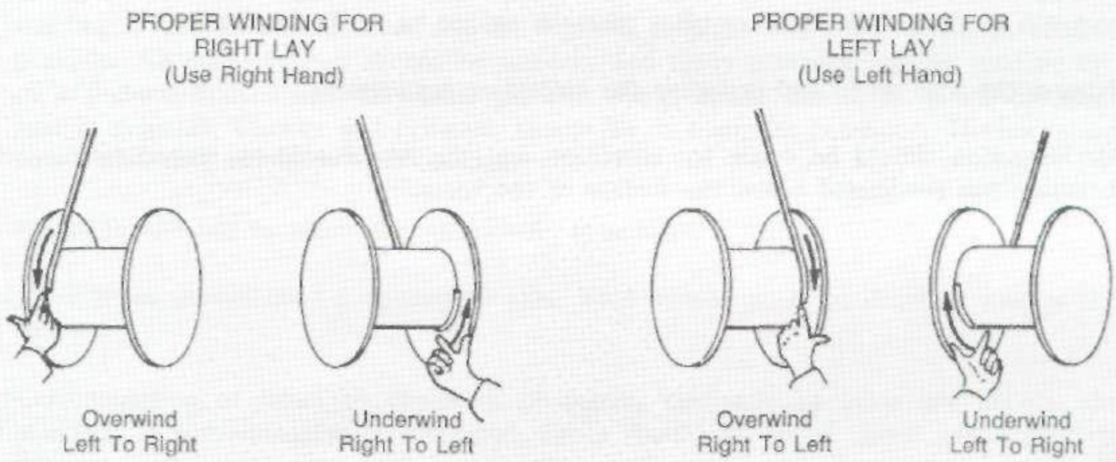
The coiling of the first layer of a line on a plain winch drum, depending on the lay of the line, should be in the direction shown in Figure below.

Wire lines should be lubricated periodically. Proper lubrication reduces the abrasive effect of individual wires sliding against one another and helps to prevent corrosion. Wire lines are lubricated during manufacture, but this initial treatment is lost during use, particularly in marine applications. Ideally, the line should be lubricated every two or three months.

Several patent varieties of wire line oil are available and the lubricant may be brushed on or a box lubricator used. Mooring line manufacturer's recommendations should be followed.

- The ends of a wire should be periodically reversed in order to evenly distribute the wear.

- When points of wear develop on wire lines, the wire up to and including the worn sections should be cut off and removed.



This rule will help to determine the correct lay (left or right) of rope to use on a given drum. The right hand represents right lay rope and the left hand represents left lay rope. The index finger and thumb are extended with the other fingers being closed into a fist. The fist represents the drum, the index finger is the rope coming onto the drum, and the thumb points to the side at which the rope is to be fastened. For overwind the palm is down and for underwind the palm is up.

FIGURE B1: WINDING LEFT AND RIGHT LAY ROPES ON THE WINCH DRUM

b. **INSPECTION**:

Since wire lines deteriorate in service, regular inspection is necessary to assess damage to the wire and to perform remedial action.

Following are some guidelines for inspection:

• The wire diameter should be checked. A marked decrease in wire diameter is a sign that the line should be removed from service. Reasons for the decrease could be core deterioration, internal wear and wire failure, or internal corrosion.
• The wires of the outer layer should be inspected for wear and breaks. If lubrication has been good and operating conditions such that the inside wires are intact, the reserve strength of the inside wires will be maintained. In this case, only a strength reduction corresponding to the broken outer layer wires need be deducted from the rope strength.
• Wires should be checked for abrasion. If the outside wires show a considerable loss of metallic area, the line should be removed from service.

• Individual wires on the strand crowns should be inspected for fatigue breaks. These are characterized by squared-off ends perpendicular to the broken wire. If these wire breaks occur at the strand crowns, the residual wire line strength may be estimated by counting the number of breaks in the length of one lay and subtracting these from the number of wire strands in the line in order to determine the number of remaining unbroken strands. A wire lay is the distance parallel to the longitudinal axis of the rope in which a strand makes a complete turn about the axis of the line. One wire lay has been selected as the length for which to note the breaks because the loss due to a broken wire is effective for approximately this distance.
• Look for fatigue breaks at or near the valley positions of the strands. If one fatigue break of this type is noted, the line should be removed from service, since further deterioration of this type will doubtlessly have taken place where it cannot be easily detected.
• Remove the wire up to and including the kinked or cut sections.
• An inspection should be made for corrosion and the line should be retired from service if corrosion has penetrated below the surface of the wires.

9.3 INSPECTION AND MAINTENANCE OF LOOSE GEARS:

All the loose gears i.e. Shackles, Slings, Chain block, lifting strobes, Rings, Chains etc shall be visually inspected prior to its use.

Every six month, loose gear shall be inspected for general material defect such as cracks, distortion, corrosion and wear and tear that could affect safe working load and overall strength of the material.

During every docking survey, slings, chain blocks shall be tested for SWL by competent workshop.

Sling Wire, Shackles, Chain Block etc
Tie wraps / Cable cleats / Plastic cable bands should be put on root area of eye when finish periodical inspection. The criteria of color of Tie wraps / Cable cleats / Plastic cable bands is as per company criteria.

9.4 TEST, INSPECTION AND MAINTENANCE OF MOORING WINCH AND WINDLASS:

- Check all grease nipples on mooring equipment to ensure the nipples remain usable. It is a good idea to highlight these items in order to prevent them from being overlooked.
- Oil, moisture or heavy rust on the brake linings and the drums be checked as it reduces the brake holding capacity.
- The brake lining thickness should never be less than 9mm. Always check the wearing out state of the brake band, brake drum, and the hole and pin of the break link.

- Check the safety pin on winch clutch lever. Risk of causing the operational mistake of the winch due to the clutch lever not positioned appropriately. Safety pins should be kept with chains or wires connected to the lever.Apply the grease to the gears and bearing bushes of the windlass properly.



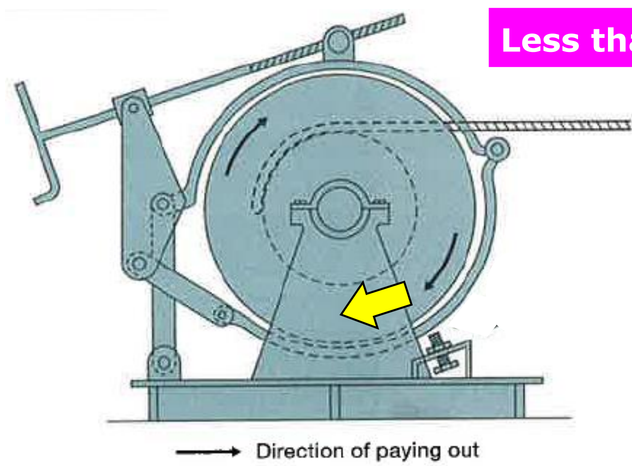

- Confirm that the working/operation area are not slippery and damaged

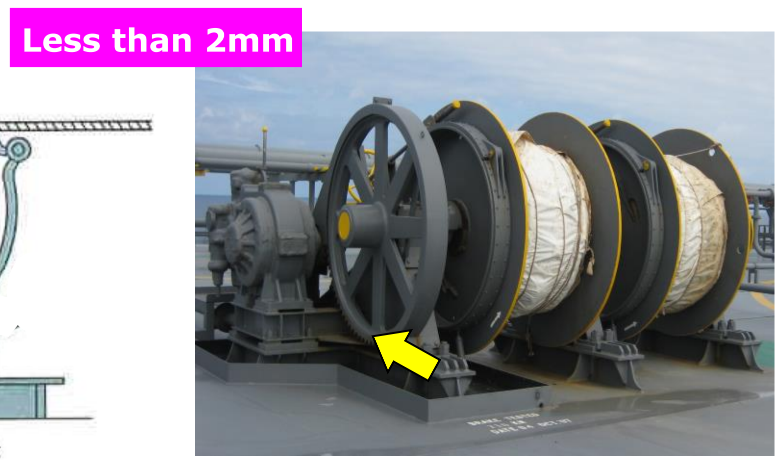
- Check the condition of Bollard, bitts and fair-leader and ensure that the fair-leader is working well
- Ensure that the strength, materials and shape of stoppers are appropriate
- Confirm that the mooring has a handling rope
- **Adjust the brake band support** appropriately. This is installed in the lower part of the brake to prevent abrasion or wearing out of the upper part of the brake band.

  Proper clearance between the brake band and the bolt should be less than 2mm. If the clearance is much wider, only upper brake band will work by own weight even loosing the brake.

<How to adjustment of brake band support>

1) Tighten Band brake to braking position.
2) Loosen lock nuts and support screws.
3) Tighten screws until they touch the band brake (clockwise).
4) Turn the screws back one turn (counter clockwise).
5) The clearance should now be 1-2mm, check.
6) Test opening function of brake. The band brake should be free from drum surface all way round.





In addition to brake testing, the following tests are recommended a/p ISO Standard 3730:

I. Rules concerning testing at manufacturer's works for the acceptance of the manufacturer and purchaser:

A. <u>Type testing</u> - One winch of each batch must be tested (This test may be replaced by a prototype test certificate if agreed by the manufacturer and purchaser), as follows:

(1) operation under load: alternately hauling and rendering at the rated load of the winch for 30 minutes continuously.

(2) holding test: to be tested by applying the holding load to a rope led off the drum, with no rotation of the drum.

(3) automatic brake system test: this test may be carried out on board ship if agreed between purchaser and manufacturer.

(4) throughout testing, the following should be checked:

(a) tightness against oil leakages

(b) temperature of bearings
(c) presence of abnormal noise
(d) power consumption
(e) speed of rotation of the drum.

B. Individual tests:

(1) operation under no load: running for 30 minutes, 15 minutes continuously in each direction, at light line speed.
(2) correct operation of brake system.
(3) throughout testing, the following should be checked:
(a) tightness against oil leakages
(b) temperature of bearings
(c) presence of abnormal noise
(d) power consumption
(e) speed of rotation of the drum.

II. On-board acceptance tests and inspections:

It is recommended that the Running Test to be carried out on board the ship using ship's power: The winch is to be run for ten minutes at light-line speed, five minutes continuously in each direction. Bearing temperature rises must be checked.

9.4.1 Testing and Maintenance of Winch Brakes – to be checked and replaced accordingly as per SMS / PMS and whenever required and / or necessary.

- Before testing a winch brake, the brake and the drum must be checked if are in a satisfactory condition. Any damage or failure should be rectified before any testing takes place.
- If the brake has not been in use for some time it should be applied slightly with the winch running in the pay out direction, thereby cleaning the brake drum surface and the brake lining.
- The main purpose of brake testing is to verify that the brake will render at a load less than the design rope's MBL. Some ships are supplied with a brake test kit.
- Each manufacturer will have his own test equipment and procedures which should be followed by the operator.
- Each winch brake should be tested individually and tests should be carried periodically, according to manufacturer’s recommendations, SMS, etc.
- In addition, individual winches should be tested after completion of any modification or repair involving the winch brakes, or upon any evidence of premature brake slippage or related malfunctions. Brakes should be tested to prove that they render at a load that is equivalent to 60% of the line's MBL.

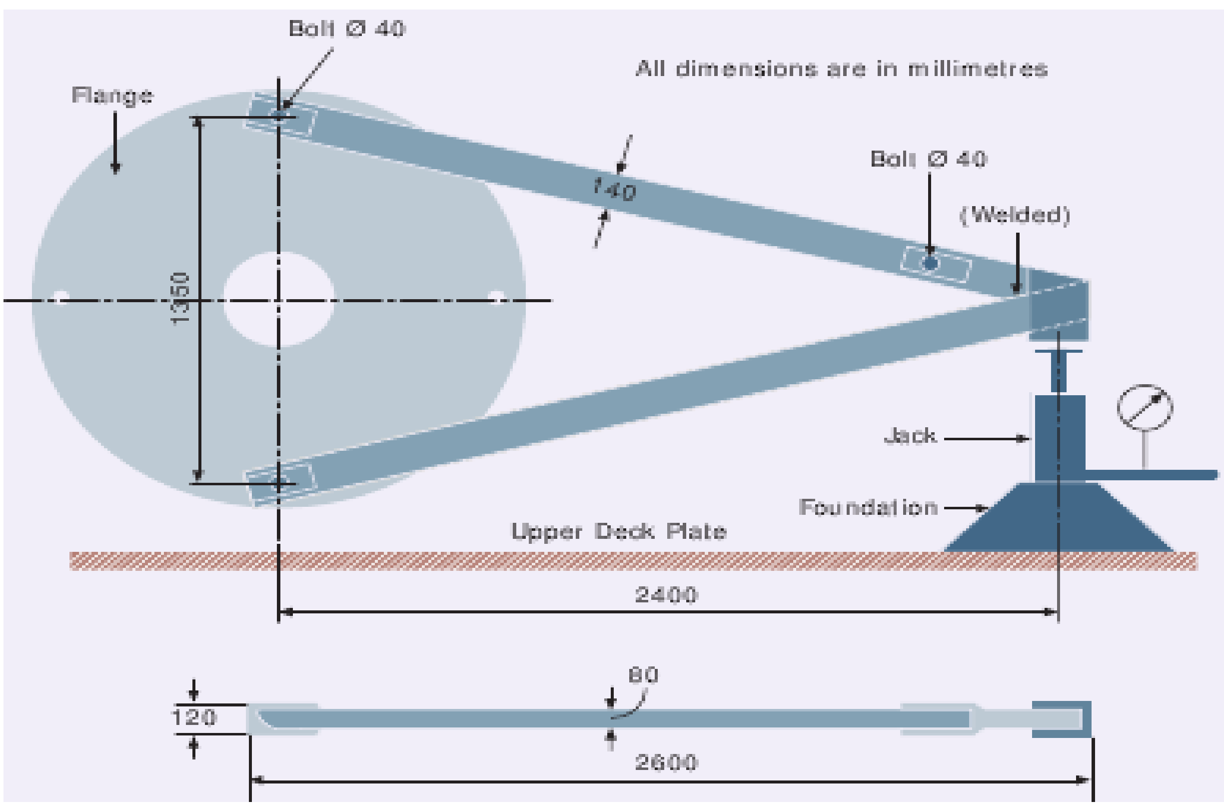
- A winch test specification is including specific work instructions for setting up the gear and breaks, preparation of the winch for testing, application of the test load, revision of torque wrench or hydraulic pressure readings, and recording of test results.

a) WINCH BRAKE TESTING EQUIPMENT:

- Lever, usually consisting of two pieces of bar, as shown on the sketch. The lever is secured to the drum of the winch by bolts from the test kit, and fitted through holes provided in the drum flange.
- Hydraulic jack with pressure gauge.

- Foundation to be placed under the hydraulic jack for the purpose of distributing the load into the deck structure.

- It is recommended that a complete set of test equipment is placed on board each ship, properly stowed in an appropriate location.



- The testing arms are bolted to the flange of the winch drum with the hydraulic jack pressed under the end of the arms at the designated location.

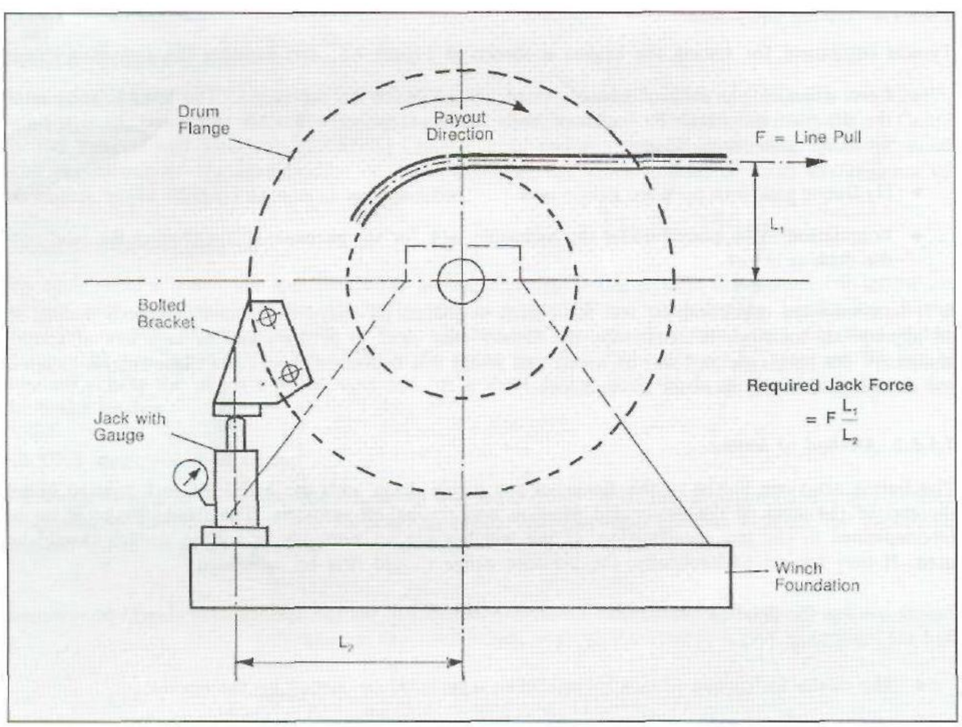
- The brake is set as recommended in the test specification.

- Before test the instructions should be reviewed: the value for torque wrench or pressure gauge fitted for setting the brakes and the hydraulic jack pressure at which the brake is designed to render.

- With winch prepared, testing gear secured and winch brakes set, pressure is applied to the hydraulic jack and the drum is observed.

At the first sign of drum movement, the hydraulic pressure applied to the jack is recorded and following actions taken:

- slippage occurs at less pressure, the brake should be tightened or repaired, then re-tested.
- recorded pressure corresponds to the design, jack should be released and test gear removed – test completed.
- slippage does not occur at the design pressure, the brake setting should be adjusted so the brake can render at the design load, then re-tested.



b) BRAKE HOLDING CAPACITY:

- The primary brake should be set to hold 60% of the mooring line's MBL. Since brakes may deteriorate in service, it is recommended that new equipment be designed to hold 80% of the line's MBL, but have the capability to be adjusted down to 60% of the line's MBL.

- A drum brake holding capacity of 80% MBL is also required by Lloyds, DNV and ISO Standard 3730 with the rope on the first layer. If a brake of an undivided drum is set to hold 80% MBL on the first layer, it will hold approximately 65% MBL on the third layer.

- The performance particulars for different size winches should correspond to values listed in the next table – these are in general agreement with ISO Standard 3730

Rated Winch Size	Rated Pull*	Rated Speed Min *	Light-Line Speed Min **	Design Rope Dia. (Wire Rope)	Minimum Breaking Strength of Rope	Stall Pull Max.	Brake Holding Force *		Minimum Dia. of Drum	Drum Capacity ***		Width of Tension Section ****
							Design Value New (80%)	In-Service Setting (60%)		Normal	High	
	See 7.5.1	See 7.5.2	See 7.5.3	ISO 3730	ISO 2408	See 7.5.4	See 7.4.6	See 7.4.6	See 6.2.4	See 7.5.4		See 7.2
(t)	kN (t)	m/min	m/min	mm	kN (t)	kN (t)	kN (t)	kN (t)	mm	m	m	mm
12	125 (12)	12	45	26	426 (43)	213 (21)	341 (35)	256 (26)	416	200	400	260
16	160 (16)	12	45	32	646 (66)	323 (33)	517 (53)	388 (40)	512	250	500	320
20	200 (20)	9.6	45	36	817 (83)	408 (41)	654 (67)	490 (50)	576	250	500	360
25	250 (25)	9.6	45	40	1010 (103)	505 (51)	808 (83)	606 (62)	640	250	500	400
32	320 (32)	7.8	45	44	1220 (124)	610 (62)	976 (100)	732 (75)	704	250	500	440
40	400 (40)	7.8	45	48	1450 (148)	725 (74)	1160 (119)	870 (89)	768	250	500	480

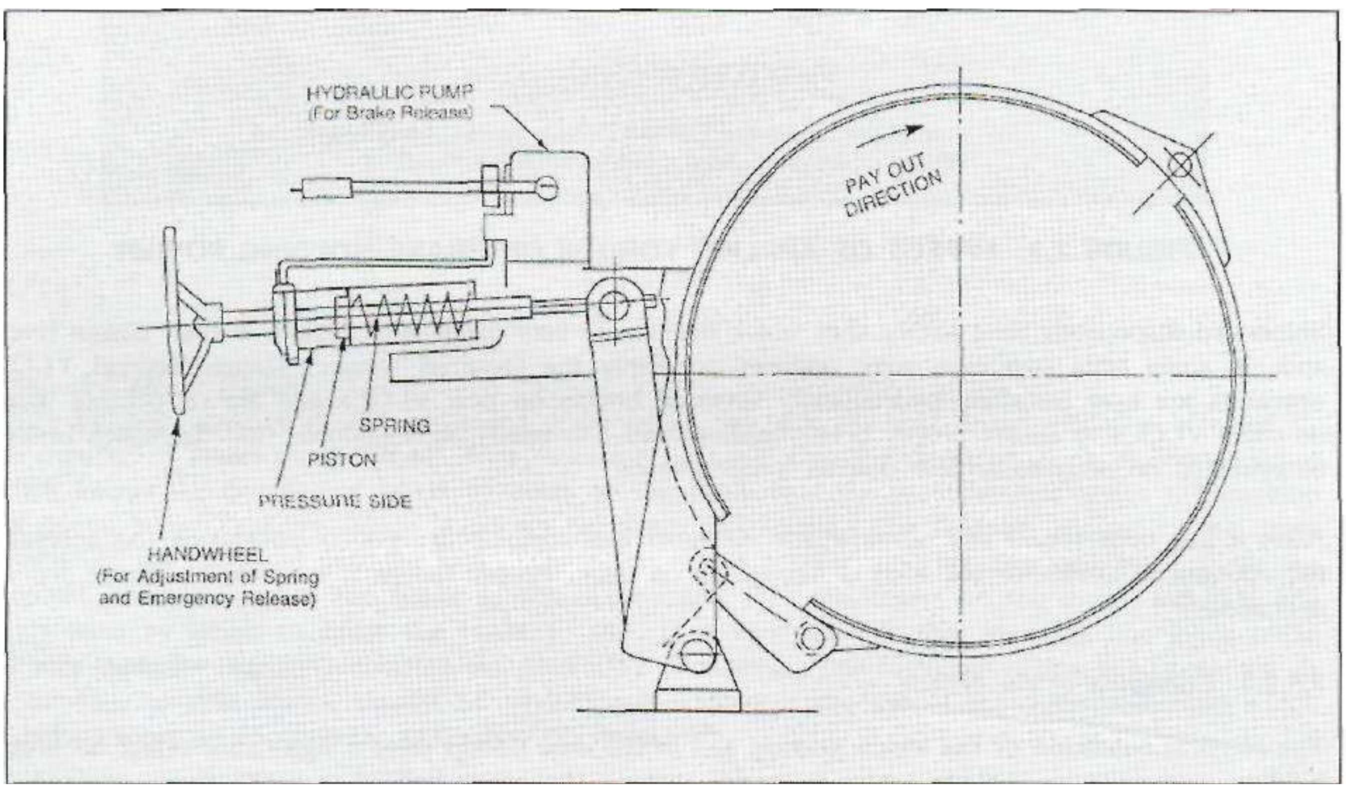
* With rope on first layer
** This is the desirable light line speed in the first layer and is in excess of the 0.5 m/s requirement of ISO Standard 3730. However, achievable light line speed depends on the winch drive as mentioned in 7.4 and 7.6.3, and should be clarified with the winch manufacturer.
*** For split drums, this applies to the storage part of the drum.
**** Applies to split drums only

Note: Performance data also applies to winches designed for fibre ropes, but drum dimensions must be increased to suit the larger diameter of the fibre lines

Table 7.1: Performance Specification for Mooring Winches

- Ideally, a brake should hold and render within a very small range, and once it renders, should shed only enough load to bring the line tension back to a safe level. Unfortunately, the widely used band brake with screw application is only marginally satisfactory in fulfilling these requirements and its operation requires special care.

- The physical condition of the winch gearing and brake shoe linings have a significant effect on brake holding load capacity. Oil, moisture or heavy rust on the brake linings or brake drum can reduce brake holding load capacity by up to 75%. Many operators run the winch with the brake set slightly to burn off or wear off the oil or moisture. (Care, however, must be taken to ensure that excess wear is not caused by this practice when using composite brake linings.) Excessive winch speed can also reduce brake holding capacity by the build-up of heat in the composite brake lining. Once a line load is applied to the drum, the brake band will stretch, reducing the load on the brake controls. For this reason, a conventional screw brake can be easily re-tightened when the mooring line is under high load, even if it was set hard originally. This means that there is no way to determine the proper hand-wheel torque required once the winch is subjected to a high line load. The danger exists that under worsening environmental conditions the brakes can be re-tightened to the point where the line may part before the brake slips. The problem can be solved by using spring applied brakes. The spring automatically compensates for the elongation of the brake band, thus assuring a constant holding capacity of the brake. It also prevents the brake from being over-tightened.



A schematic of a spring-applied band brake is shown in Fig above. In the case shown, the brake is released by a hydraulic hand pump. To apply the brake, a valve is opened to release the hydraulic pressure. Winches with hydraulic drives can utilize the main hydraulic pressure to release the brake. The hand-wheel is not used for routine operation: it serves to adjust the spring compression during calibration, and to release the brake in case of a hydraulic malfunction. The hand-wheel should be secured with a seal after each calibration to prevent tampering. Another advantage of the spring applied brake is its fail-safe feature.

c) WINCH PERFORMANCE TERMS:

- **Rated Pull** (Drum Load / Hauling Load) is the pull that the mooring line can develop at the rated speed on the first layer. The listed values should not be less than 22% and not more than 33% of the design line's minimum breaking strength.
This value assures adequate force to heave in against environmental forces. On the other hand, it is low enough to prevent line over-stressing in the stalled condition considering that the stall pull is generally higher than the rated pull for most drive types.

- Rated speed (Nominal Speed) is the speed that can be maintained with the rated load applied to the mooring line. The rated speed in combination with the rated pull determines the power requirement for the winch drive.
The recommended rated speed is higher for the smaller size winches because those are designed for smaller ships mooring faster than the large ships.

- **Light Line Speed** (No-load Speed or Slack Line Speed) is the speed of the winch with small load on the line. High speed is essential to pass a line quickly ashore or to bring the line fast back onboard.
- The slack line speeds achievable are different for different types of drives and this should also be considered when specifying performance and drive type for new equipment.
- During this phase the line is normally not on the first layer, and the actual line speed could be up to 50% higher.

- **Stall Heaving Capacity** (Stall Pull) is the pull the winch will exert when the control is in heave and the line is held stationary. A high stall heave capacity is desirable in high environmental loads.
- However, the stall pull should not be so high that there is any danger of line breakage and should not exceed 50% of the mooring line's MBL.

Following Stall Pull to Rated Pull ratios may be assumed:

Hydraulic	1.05
Electric	1.25
Steam-driven	1.50

- **Drum Capacity**: the drum should be capable of stowing the total line length, as specified in ISO Standard 3730.

- Two capacities, “**Normal**” and “**High**” are indicated.

- Winches with undivided drums could be more suitable for the ‘normal’ capacity since this would reduce the number of layers required.

- The total number of layers should not exceed 5 for normal capacity and 8 for high-capacity drums.

- For split drums there is no limitation on the number of layers on the storage section.

d) Summary of Recommendations regarding winch testing and performance:

Recommendations for ship designers:

• All winches should be controlled in the manual mode, including self-tensioning winches as presently designed.
• In selecting drive systems, the speed-pull relationship for various types must be considered.
• Minimum rated winch pull should be about 30% of the line's MBL.
• Minimum rated speed should be selected on the basis of ship size, from 0.13m/sec for large ships to 0.20m/sec for small ones.
• Minimum light line speed should be 0.75m/sec, if practicable for the chosen drive system.
• Maximum stall pull should be 50% of the mooring line's MBL.
• New winch brakes should be capable of holding 80% of the line's MBL, with provision for adjustment to 60% of the line's MBL.
• Winch drums should have a minimum diameter of 16 times the rope diameter.
• The tension section of a split drum should be wide enough for ten turns of line.
• Winch brakes should be of the fail-safe spring applied type.
• Disc brakes are a good alternative for winch drums.
• For optimum ease, security of operation and manpower reduction, single drum winches with full capacity 'fail-safe' input brakes should be considered.
• Winch brake testing provisions should be incorporated into the winch design.
• The strength of all structural winch components, including drum brakes and deck support, should be based on the line MBL. Special attention should be given to the connection of the brake band anchor point to the ship's structure.
• Winches should be clearly marked with the rope MBL for which they are designed.

Recommendations for ship operators:

• The instructions for the particular mooring winches should be followed carefully. Items of equipment which appear similar may require very different operation.

• Automatic tension mooring winches should only be used in the manual mode.
• Winch brakes should be tested annually and adjusted to hold 60% of the MBL of the mooring lines. After adjustment, a tag with proper setting values should be attached to the winch. On spring-applied brakes, the spring adjustment mechanism should be secured with a seal to prevent inadvertent tampering.
• Mooring lines must be spooled onto the drum in the correct direction, since band brakes are designed to work in one direction only.
• Winches that are provided with both a drum brake and an input brake should be operated with one brake only while the ship is moored. On multiple drum winches, this will always be the drum brake. On single drum winches, the instruction book should be consulted to determine which brake is the primary brake designed to hold 60% of the line's MBL. Where the drum brake is the primary brake, the clutch between drum and shaft should be disengaged while the ship is moored. This applies also to winches without input brakes.

9.5 MAINTENANCE OF FAIRLEADS AND PEDESTAL ROLLERS:

Rollers are to be properly maintained in good working condition and checked internally and externally. Check points are as follows;

How to check:	Periodical inspection
Check item:	Rotate smoothly?
Action to be taken:	Grease applies periodically.


Greasing up of roller shaft

9.6 BASIC STRENGTH PHILOSOPHY:

- Since a wire / synthetic rope or chain with a specific MBL is used as a link between ship and berth, it is desirable to relate the required strength of equipment and fittings to the strength of the associated lines / chains.

- For example, is possible to pass 2 lines through a single fairlead; if, in this case, the effects of the 2 lines are cumulative, the DBL must be increased to allow that.

- Winch brake rendering (slippage) in a mooring should not be used to reduce the DBL below normal values. Brake rendering at specific loads cannot be guaranteed, as brake settings are not precise; rather brake rendering is considered an additional safety mechanism.
- A load test should be performed on one fitting of each type.
- A manufacturer's test certificate is acceptable if the test was witnessed by an independent authority (such as Class).
- The load test should be applied with a rope of adequate strength to allow a line tension equal to the approved "test load".
- Alternative arrangements are acceptable if the test load is equivalent to the resultant load from a line application.

9.7 MARKING OF MOORINGS:

- Each fitting should be clearly marked by weld bead outline with its SWL expressed in tonnes, and should be located so that it's not obscured during operation.
- The marked SWL should correspond to the load in the associated line or chain (= MBL).
- Since the SWL does not provide information on safety factor, test load or geometry of line, the ship should be provided with all additional relevant information: *actual test load applied, geometry of load application, bitt strength when belayed by eye and higher up on the barrel, maximum size and MBL of line / chain, test certificates, drawings, etc.*
- Where twin lines may be deployed on a fitting, the SWL of each single line should be marked and the acceptability of more than one line should be indicated on the mooring layout plan.
- The mooring layout should be updated; the mooring lines should be arranged only as shown on the plan.
- All damaged / deformed equipment should be treated with suspicion regarding residual strength capabilities, and only utilized for lower loads, or not used until repaired / replaced.

Please refer also to:

Appendix 10 – The way of the eye-splice in the Cross Rope

Appendix 11 – On board maintenance of mooring lines (NYK Instructions)

Appendix 12 – Maintenance of Mooring Hawsers and Tail-ropes (SMS)

Appendix 13 – Windlass and Mooring Winches Maintenance (SMS)