INTERNATIONAL MARITIME ORGANIZATION

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MARITIME SAFETY COMMITTEE
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Agenda item 23

MSC 84/INF.6
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ANY OTHER BUSINESS

Nautical Institute – Operational Guidance for Mooring

Submitted by ICS, BIMCO, IAPH, IHMA, IMPA and IFSMA

SUMMARY	
Executive summary:	The sponsors advise the Committee of the publication of the Nautical Institute "The Mariner's Guide to Mooring"
Strategic direction:	5.2
High-level action:	5.2.1
Planned output:	-
Action to be taken:	Paragraph 4
Related documents:	None

1 The need for industry guidance on mooring equipment has been a subject of debate in several IMO committees, notably at MSC 79, NAV 49 and DE 48. In response to this debate the co-sponsors of this paper undertook to progress the matter and supported the Nautical Institute in the preparation of a new book entitled "The Mariner's Guide to Mooring". In addition to the requirement identified in IMO debate the Nautical Institute was also responding to a growing demand for practical guidance.

2 Ports had been concerned about an increasing number of accidents, and surveys had demonstrated inconsistency and hazardous practices in mooring operations (NAV 49/6). Similarly a number of major accidents involving damage, pollution, injury and death had been investigated by Maritime Authorities with the same conclusions as above. Evidence from the Nautical Institute's Confidential Marine Accident Reporting Scheme MARS also contains cases, which underscore the difficulties which can arise on board when a mooring operation gets out of control.

3 The safety and preservation of ships' crews is clearly one area, which needs to be addressed, but mooring is a co-operative effort between the ship's crew, the pilot, tugs and shore gangs. It is the integrity of the whole mooring operation, which needs to be considered and this has been reflected in the comprehensive new publication "The Mariner's Guide to Mooring" which is now drawn to the attention of the Committee.

Action requested of the Committee

4 The Committee is invited to note the summary information given at annex.

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ANNEX

AN OUTLINE OF THE CONTENTS OF "THE MARINER'S GUIDE TO MOORING"

Chapter 1 – The forces acting on a ship

This chapter describes the static and dynamic forces that can act on a ship when it is berthing, unberthing or tied up alongside. The text outlines some simple methods for approximating the forces but these do not indicate the possible yawing moments that the forces of the wind and current can produce. Consequently, the chapter also includes graphs of the results of model tests conducted for the oil industry to provide a means for estimating the environmental forces and yawing moments acting on the moorings of a tanker in any strength of wind or current from any direction.

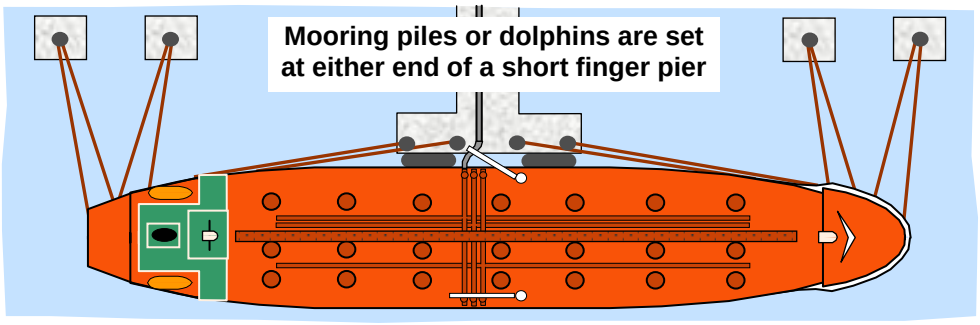
The graphs are the basis for the oil industry's methods for calculating the *steady* force acting on a moored tanker, though they also show how a ship would react to these forces if it were unrestrained by the moorings and free to drift and yaw. Pilots and masters handling ships in confined waters need to understand an unfettered ship's response to the environmental forces acting on it and how its behaviour is subsequently altered as a result of its initial reactions. Although the graphs specifically relate to tankers, they give a good indication of the general behavioural characteristics that can be applied to any ship.

OCIMF is currently the only organisation to provide a set of environmental criteria to be used when determining the minimum strength of a ship's moorings suitable for worldwide trading. Operators of ships other than tankers berthing on oil terminals may decide on a different set of criteria that are more appropriate for their own ships and trading patterns.

Chapter 2 – Ships' mooring line patterns

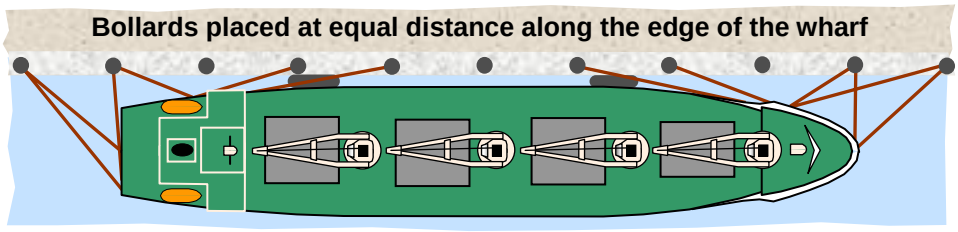
This chapter starts with a brief look at the various ways that ships are moored, especially with regard to how mooring considerations for ships that are tied up with long breast and spring lines differs from those for ships held alongside by head and stern lines.

A tanker moored alongside an oil terminal



The tanker is held alongside by long breast lines running out from the bow and the stern to bollards on the dolphins whilst springs hold the ship in the correct fore and aft position.

A dry cargo ship moored alongside a cargo wharf

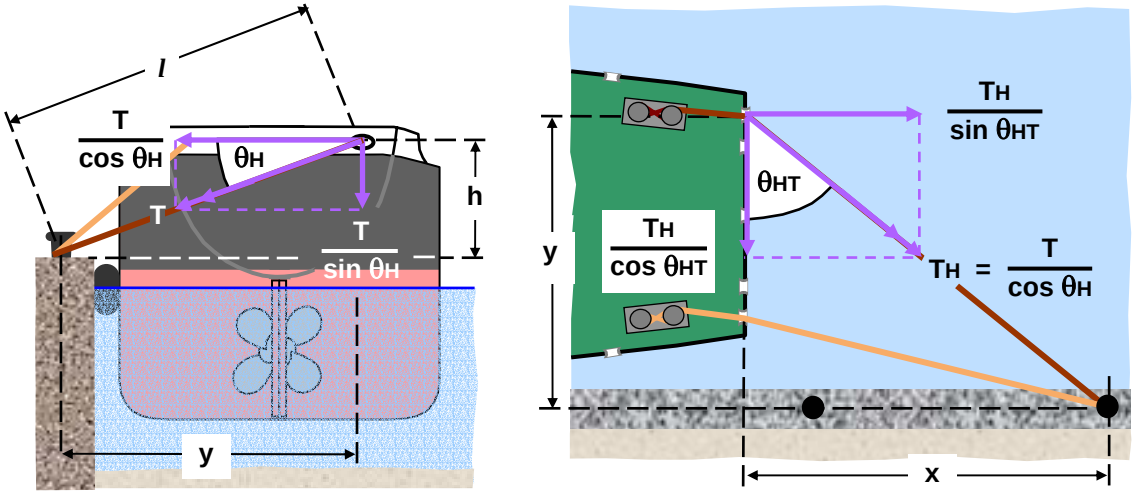


The head and stern lines must hold the ship alongside the wharf, as the short horizontal distance between the ship's side and the bollards puts limits on the scope for effective breast lines.

The three dimensional geometry of a ship's mooring pattern must be taken into account when determining the line tensions produced by the conditions at the absolute mooring limits. This is relatively easy for the forces acting on spring lines, which can be led close to fore and aft in either mooring pattern shown on the previous page. It is also quite easy to estimate the tension in the tanker's breast lines as these all are of very similar lengths and lead within about 10° of athwartships. However, it is more difficult to determine the tensions in head and stern lines due to an offshore force, particularly as the lead angles differ so much between lines run from the offshore sides of the ship to those leading from the inshore side.

The horizontal components of the tension 'T' in an offshore side stern line

The horizontal component of tension 'T' | **The athwartships pull of tension 'T'**



l = *actual* length of the mooring line from the ship's side fairlead to the quayside bollard
h = height of the ship's side fairlead above (or below) the level of the quayside
x = horizontal fore and aft distance from the ship's side fairlead to the quayside bollard
y = horizontal athwartships distance from the ship's side fairlead to the quayside bollard
— = offshore stern line, — = inshore stern line

Lead angle to horizontal 'θ_H' = $\sin^{-1}\frac{h}{l}$ **Horizontal athwartships lead angle 'θ_{Ht}' = $\tan^{-1}\frac{x}{y}$**

Horizontal component 'T_H' = $T\cos\theta_H$ **Pull against an offshore force = $T\cos\theta_H\cos\theta_{HT}$**

If a stern line of a ship alongside a general purpose quay typically leads 30° to the horizontal and 55° to the athwartships axis, then the contributing force that the line makes in opposing movement off the berth is given as:-

The line's pull against an offshore force = $T\cos 30°\cos 55° = 0.50\,T$

*I.e. The effective athwartships pull is equal to **50%** of the line tension created by the offshore force. (The inshore stern line will be even less effective at opposing athwartships movement.) This can be compared with the effectiveness of a breast line of a tanker alongside an oil jetty that 25° to the horizontal and 10° to the athwartships axis,*

The line's pull against an offshore force = $T\cos 25°\cos 10° = 0.89\,T$

*I.e., The effective athwartships pull is equal to **89%** of the line tension created by the offshore force.*

The chapter then considers the factors to take into account when deciding on the strength and number of lines to use when the ship's moorings are subjected to the designed maximum static force. No line should be put under more than 50% of its minimum breaking load, *when new*, to allow for snatch loads and wear in the lines. The text explains why it is usually better to use fewer stronger lines rather than a greater number of weaker ones, whilst considering the limits to how far this approach can be taken.

Chapter 2 continues by considering in more detail the following different aspects of a ship's mooring arrangement:

- The height of the quay, relative to the height of the ship's mooring deck, and the problems that can arise when the ship's deck is below the level of the quay.

- The spacing of mooring bollards along the quay, the implications in the mooring patterns of adjacent ships sharing bollards and the various types of bollards in common use.

- The design of quayside fendering for different purposes and, in particular, how lines held tight against the fenders by mooring winches interact with the compression of the fenders.

- The properties of the different types of fibre and wire mooring lines, such as:

    1 The strength and stretch characteristics of different materials for a given line diameter.
    2 The durability versus cost of the different types of fibre rope.
    3 The ease of handling of different types of rope for a given strength.
    4 The ease at which the crew can repair damaged lines onboard.

- Sharing the load between the lines as equitably as possible for different mooring patterns and the problems in achieving this when the lines are made fast on sets of bitts.

- The advantages and disadvantages of using bights as opposed to single mooring lines.

The chapter finishes with an outline of mooring patterns used when ships are double berthed.

Chapter 3 – Mooring equipment and fittings for a ship securing lines on bitts

This chapter considers the number, strength and siting of mooring fittings for a ship on which lines are heaved tight on capstans or winch drum ends and then stoppered off whilst they are made fast on sets of bitts. The lines cannot be secured tight by this method, as tension is lost when lines are transferred to the bitts, so there is scope for some ship movement on the berth. However, many smaller ships are tied up in this way so the chapter considers the following:

- The distribution of overside fairleads (or 'chocks') and bitts and how it affects the range of mooring options available to the crew.

- How the force on a fairlead or set of bitts depends on its height above deck and the way a mooring line is led around the fitting.

- The need for adequate reinforcement of the deck structure under a fitting.

- The different ways of turning up a line on a set of bitts and how these affect its strength.

- The different ways of applying stoppers to fibre and wire lines.

- Towing fittings, including emergency towing arrangements for tankers, and how the crew should handle a towline from a tug.

Mooring and towing fittings should be at least 25% stronger than the maximum force that they can be subjected to by the lines they serve, so that a line will part before pulling the fitting off the deck. The IMO gives guidelines for minimum fitting strengths in MSC/Circ.1175 that are derived from a table of nominal breaking loads of mooring lines based on a ship's equipment number. Chapter 3 illustrates with examples why these guidelines need to be revised to take account of the following:

- The equipment number was devised as a measure of the forces acting on a ship at anchor, so it only accounts for fore and aft forces, as ships at anchor head into the wind or current.

- Even if the equipment number were a fair guide to athwartships forces acting on a ship, it fails to account for the effectiveness of the lines' lead angles in different mooring patterns.

The chapter concludes by comparing drum ends with capstans and outlining the characteristics of their motor and drive arrangements.

Chapter 4 – Mooring equipment for a ship with dedicated mooring winches

Chapter 4 starts with an illustrated description of a mooring winch and its components, then considers the various aspects concerned with handling mooring lines on dedicated winches with particular regard to the following:

- The hauling ability of a winch, how this is determined by the motor torque, the diameter of the winch drum and the number of layers of line on the drum.

- The width of the winch drum with regard to the length and diameter of line to be stored on it and how these impose limits on how close to the fairlead that the winch can be sited in for the line to fleet satisfactorily onto the drum.

- The problems that can arise when fleeting a long pick up onto the drum, particularly if the line is under tension.

- The advantages and disadvantages of a split drum winch as compared with an undivided barrel.

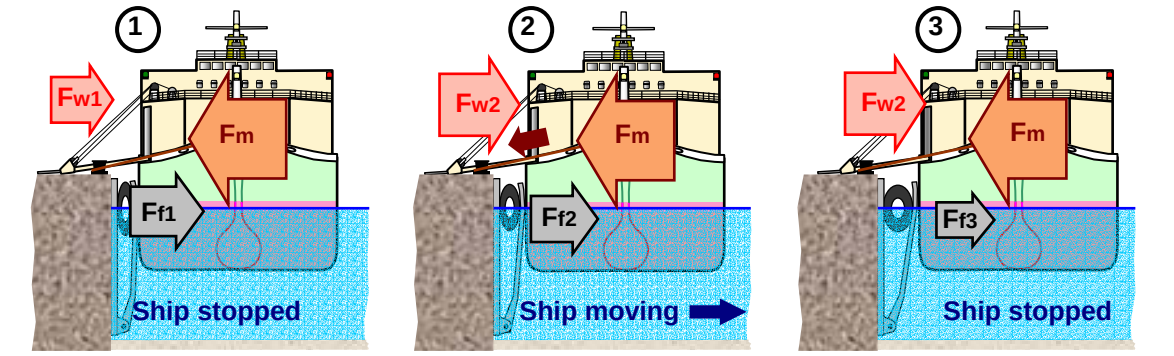
- The holding capacity of winch brakes, how this is also affected by the number of layers of line on the drum and how the brakes should be set so that they will render before tension in the line exceeds 60% of its breaking load.

- Multiple barrel winches and how these can be used to provide suitable mooring patterns with the minimum number of winch units.

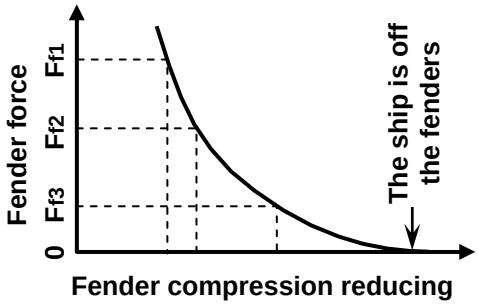
The chapter ends by considering auto (or self) tensioning control, why it should *not* be used on lines working against each other (i.e., the spring lines) and how its performance depends on:

- The difference between the payout and pickup tensions that programmed into the control system (i.e., the 'deadband').
- The stretch characteristics of the mooring lines.
- The compression characteristics of the quayside fenders, as shown in the diagram below.

The effect of the fender force on a ship with auto-tensioning mooring winches



Fw = Offshore wind force, Ff = Offshore fender force, Fm = Mooring line tensions



1 - Ship held alongside by the set line tensions, so:-
$F_m = F_{w1} + F_{f1}$

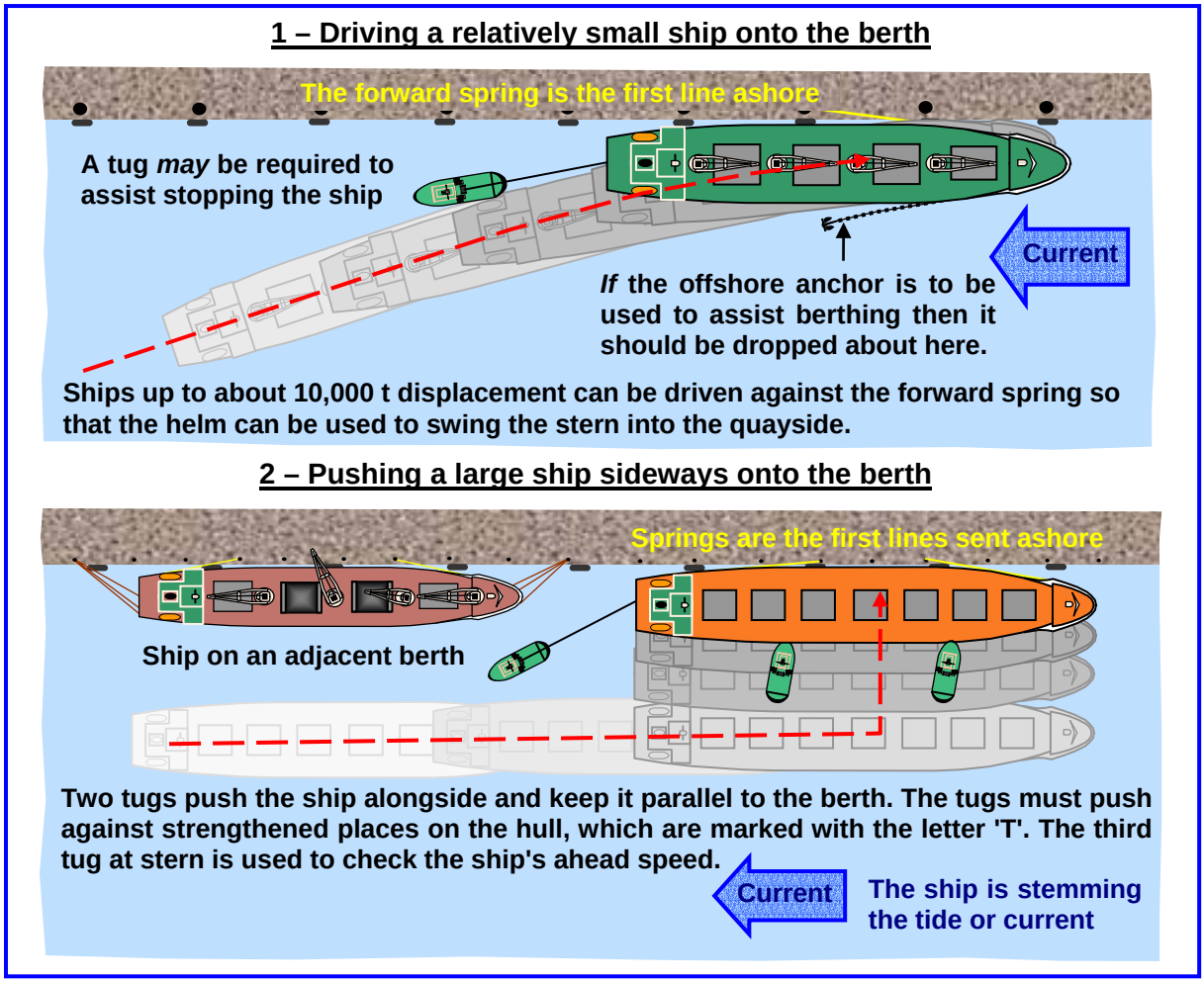
2 - Wind force increases, mooring lines pay out, the ship moves out and the fenders start to extend.
$F_m < F_{w2} + F_{f2}$

3 - Decrease in fender force equals increase in wind force, lines are held and the ship stops moving.
$F_m = F_{w2} + F_{f3}$

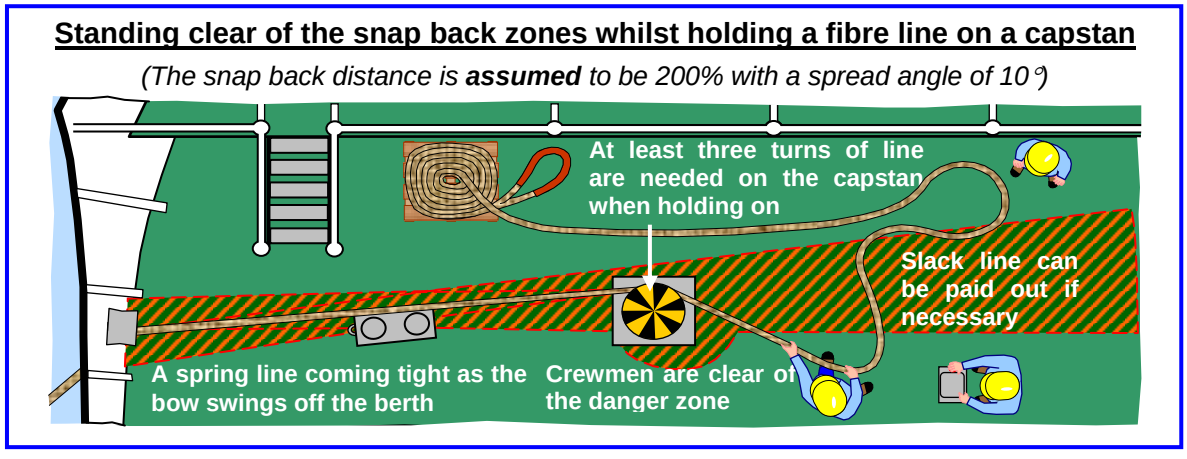
An increase in the offshore wind force is matched by a decrease in the fenders' compressive force.

Chapter 5 – Routine mooring operations from berthing to unberthing

This chapter starts by outlining how a ship's manoeuvrability and size influence which of the methods shown below is better suited for berthing the ship.



The text describes the various steps to be taken by the ship's crew from preparing the mooring stations to securing the ship alongside, explaining how and when lines should be run ashore, hauled in, held and then finally made fast. Particular attention is paid to the hazards that arise during the operation, including the risk from the 'snap back' of a line parting under load. The areas of deck exposed to snap back depend on how the line leads from the winch or capstan to the fairlead at the ship's side and are illustrated by diagrams such as the one shown below.



Chapter 5 continues by outlining the duties of the deck watch in port with regard to:

- Adjusting the moorings as the height of the ship relative to the quay changes with the tide or the ship's draft and, in particular, how to slack off tight lines made fast on bitts.

- Running extra lines if an increasing offshore force is overloading the moorings.

- The action to take if lines start to part.

- The problems that can arise with the moorings and gangway if the ship is below the quay.

The chapter then describes how to: shift a ship along the quay by its mooring lines, turn a ship around on the berth with the moorings and, finally, the procedures for letting go on departure.

Chapter 6 – Anchoring and anchoring equipment

The first part of this chapter covers a ship's anchoring equipment requirements, as determined by the ship's equipment number and the IACS rules stated in the following two documents:

The unified rule '*UR-A- Requirements concerning Mooring, Anchoring and Towing*' and '*Recommendation No.10 of 'IACS Rec. 84/Corr. 2004/Rev.2 2005'*.

In particular, the text describes in detail:

- The different anchor types, how they perform and the anchor weight requirements.

- The anchor cable, how it is marked and the strength and length requirements.

- Windlasses, vertical axis cable lifters, chain stoppers and the performance requirements.

- Chain lockers including the requirements for the bitter end.

- Stowing the cable securely for putting out to sea.

The chapter then describes the conventional method of anchoring to a single anchor, including an explanation as why shortcomings in this method can arise when it is used on large ships. An alternative method of letting go the anchor on a turn is described as a way of overcoming this problem. The chapter continues by describing the different ways of mooring with two anchors and ends with suggestions for how to use the anchor in an emergency to prevent the ship from running aground and how an anchor may be recovered when the windlass is stalled.

Appendices

The following topics are dealt with by the appendices at the end of the book:

- Personal safety, including suitable protective clothing.
- An outline of the procedure for berthing a tanker on a single point mooring.
- Brief descriptions of quay based mooring winches and the vacuum system.
- A brief guide to accommodation ladders and gangways.
- An outline of care and maintenance of mooring lines and equipment.

The book includes a considerable number of diagrams illustrating the points made by the adjacent text.

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