International Association of Marine Aids to Navigation and Lighthouse Authorities

**AISM** Association of Internationale de Signalisation Maritime **IALA**

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# On

# Synthetic Mooring Lines

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# Document Revisions

Revisions to the IALA Document are to be noted in the table prior to the issue of a revised document.

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| July 2005 | Entire document reformatted | Reformatted to reflect IALA Documentation Hierarchy. |
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# Guidelines on Synthetic Mooring Lines

## 1 INTRODUCTION

Synthetic rope moorings are being used by the offshore oil industry to replace chain and wire rope mooring lines, primarily in very deep-water situations. At very deep sites the weight of chain cables would present buoyancy problems for the moored vessel or handling problems for the servicing vessel to lay or lift the moorings.

Aids to Navigation Authorities such as the French and USA services have a number of composite synthetic rope/chain moorings in use. The Trinity House Lighthouse Service has some experience with trial moorings, the Finnish Service use rope to moor spar buoys and The Netherlands Service has made extensive trials with cord moorings.

These Guidelines are based on information provided to the IALA Engineering Committee by the Lighthouse Services of the United States, Canada, the United Kingdom, the Netherlands and Finland.

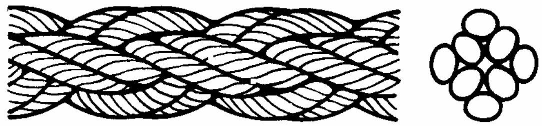
## 2 ROPE CONSTRUCTION

A great variety of ropes are now available with many different fibre types as well as types of construction. The use of natural fibre ropes for load carrying applications has almost disappeared. Natural fibre ropes have low strength, will have a short life when compared with synthetic fibres and are no longer cheaper than their synthetic counterparts.

Traditional three-strand rope construction has also largely been superseded by plaited or braided constructions where high strength and long life are the primary requirements.

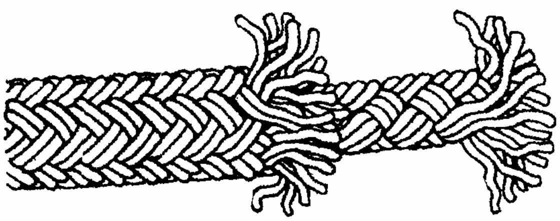
3-strand Constructions:

This is the oldest and simplest rope construction, consisting of 3 twisted strands laid together. 3 strand ropes are hard wearing and easily spliced.



Multiplait constructions:

Multiplait rope consists of 8 strands plaited in pairs, each pair passing over one pair and under the next. It is easily spliced and the twisted strands offer good resistance to abrasion.



Braided Constructions:

This illustration shows a rope with a braided core encased in a braided jacket, 3 strand cores are also used. Variations in jacket and core construction allow ropes to be designed for specific working situations. The highest strengths are possible in this construction but splicing is complex.

# 3 TYPES OF FIBRE

Modern rope materials utilise the following fibre groups:

- Nylon : This provides high strength, elastic rope with good shock absorbing qualities. Some ultimate strength is lost due to water absorption if the rope is permanently immersed in water.
- Polyester : this is widely used to construct high strength, low stretch ropes with good wear resistance and long life.
- Polypropylene : this has been used for cheap, general purpose rope, however recent developments in fibre manufacture and rope construction have resulted in moderate performance ropes, which are considerably cheaper than nylon or polyester.
- Advanced Fibres : these include Aramid fibres (trade name Kevlar) and high modulus polyethylene (Spectra and Dynema) which have very high strengths associated with very low stretch. However, these are very expensive products being approximately three times the cost of nylon or polyester. Rope identification can be difficult as different manufacturers may use trade names for fibre type rather than generic names.

# 4 MIXED CONSTRUCTION

Large ropes, such as those used for ship mooring may be constructed from a mix of fibres to achieve particular performance parameters.

# 5 ROPE BUOY MOORINGS

The primary advantage of rope moorings is their light weight and elasticity when compared with normal chain moorings. Modern ropes can easily match the strength of steel chain and experience has shown that a similar or better working life than chain can be achieved if chafe is carefully avoided.

The conventional chain mooring utilises energy absorption of the chain catenary to absorb much of the wind and wave energy acting on the buoy and prevent this being transferred to the sinker or anchor. The elasticity of the rope performs a similar function and choosing a suitable combination of fibre type and rope construction can optimise this energy absorption.

Chafe and cutting are the greatest dangers to a rope mooring. It is easily demonstrated that a sharp knife will rapidly cut through a piece of rope and any sharp edges presented by rocks, sea shells or the servicing ships own capstan can rapidly cause permanent damage to the surface of the rope. Allowing the rope to slip on the drum of a capstan or pulling it through an unsuitable fairlead may not only result in abrasive damage but also in localised heating such that the surface fibres of the rope may melt, resulting in significant weakening.

Rope does not suffer abrasive damage from sand particles in suspension in the water as do the bearing points of chain links resulting in rapid chain wear.

# 6 MOORING DESIGN

The mooring must be designed so that the rope is never in contact with the buoy body or tail tube and is never in contact with the sea bed (although this may not be a problem in areas with soft, muddy bottoms).

These criteria can be achieved in a normal buoy mooring by utilising a ground chain that absorbs the wear on the sea bed to which a rope “riser” is attached. The rope “riser” component of the mooring is of such a length that even at the lowest tides the rope is never chaffing on the sea bed. The rope may be attached directly to the buoy if the mooring eye is in a suitable position such that the rope will always be clear of the buoy. In other cases a short length of chain (or bridle in the case of two mooring eyes) may be used to absorb any chafe.

Cutting by trawl wires may also be a hazard in some areas where commercial fishing takes place. It may be possible to utilise chain in the part of the mooring that may be subject to abrasion from trawl wires.

The decision on the size of rope to be used will depend on the load imparted by the buoy, due to wind/wave action and water velocity and the strength necessary to lift the sinker (or anchor). The method to be used to handle the rope may also influence the size of rope chosen.

# 7 ROPE TERMINATIONS

## *7.1 Thimbles*

The use of fibre rope rather than wire rope for towing and mooring ships and oil rigs has lead to the development of thimbles which allow ropes carrying very high loads to be shackled to chain or mooring eyes without damaging the rope fibres.

These thimbles completely enclose the rope leaving no unprotected rope surface to chafe against the joining shackle. They may be fabricated from steel tube, made in cast iron, or moulded from high strength plastic. Movement of the rope within the thimble can be further prevented by filling the thimble with a flexible resin system (usually polyurethane), however opinions differ as to the need for this process.

## *7.2 Splices*

The modern rope constructions, i.e. braided and plaited constructions, both allow high strength splices to be made when the rope has been installed around the thimble. It should be noted that detailed splicing information **must** be obtained from the rope manufacturer and that these instructions have to be followed precisely in order to retain the majority of the rope strength at the splice. Special tools will be needed for splicing braided rope and training of those making the splices in any modern rope construction will be necessary.

# 8 HYBRID ROPE/CHAIN MOORINGS

One of the most successful applications of rope has been for the “riser” component of deep-water buoy moorings. The lighter weight of the rope component will allow a service standard buoy to be used at stations where the weight of an all chain mooring would sink the standard buoy or the lighter weight of the rope mooring may allow a smaller buoy to be used when compared with the size of buoy that would be required to support the chain mooring (providing daymark size and focal plane height are adequate).

The buoy size is related to the size of the servicing craft and the reduction in buoy size may enable the use of a smaller servicing vessel.

The design of the buoy being used must be carefully examined to ensure that the riding performance of the buoy is adequate if the rope mooring is used. Some buoy designs rely on chain weight to achieve positive stability.

# 9 TENSION LEG MOORINGS

Rope moorings are particularly suitable for tensioned mooring configurations such as spar buoys and resilient beacons, where the mooring goes directly from the buoy to the sinker and tension in the mooring line holds the buoy upright. The rope being in tension is not in danger of chafing on the seabed or on the buoy. This configuration has the advantage of maintaining the buoy precisely on station (i.e. there is no “swinging circle” as there is with a conventional mooring) but is only practical in areas with little tidal range or current. However, the mooring sinker or anchor will need to be considerably larger than that associated with a conventional catenary mooring.

# 10 FAST WATER MOORINGS

The United States Coast Guard has used rope moorings for buoys in fast flowing rivers. Here the particular advantage is the light weight of the mooring which helps reduce the tendency of the buoy to be submerged as the current drag on the buoy lifts more mooring off the river bed.

# 11 HANDLING ROPE MOORINGS

## *11.1 Deployment*

When compared with chain, rope is light and easy to manually handle. The components for quite large moorings can be moved about onshore or on deck by hand. Moorings can be deployed by flaking the rope on deck (or in a flaking box, large version of line throwing gun rope box). The buoy is placed in the water, the sinker and ground chain simply pushed overboard (or released by cutting lashings) and the rope will follow into the water.

## *11.2 Recovery*

If the mooring is to be lifted for removal or inspection then two areas need special attention:

- Any fairlead that the rope runs over must be of sufficient diameter for the rope used, be of the roller type and present no sharp edges
- The winch or capstan must be designed for handling rope and must not allow the rope to slip on the winch drum when under load.

Conventional capstans as used for tensioning mooring warps etc., may be capable of recovering a rope mooring however their tendency to allow the rope to slip on the capstan drum will result in considerable heat being generated at the rope/drum interface which will result in serious damage to the rope. Successful techniques have been developed using large spooling winches where the rope is wound onto a large rotating drum. This technique is limited by the length of rope and hence the number of moorings that can be carried on the drum at any one time.

The preferred method, where a large number of rope moorings are to be handled, is to use a specialised rope hauling winch. These can be installed at the vessel’s deck edge so that the rope can lead directly to the winch without a fairlead being required. The winch consists of an arrangement of large rubber wheels, which grip the rope without causing damage to the surface fibres. The rope usually only passes over a segment of hauling wheel rather than being wrapped around a drum and can thus be placed in, or removed from, the hauling winch as may be necessary. This type of winch placed on the deck edge also has the advantage that there is no rope under load passing across the vessel's deck, which may present a serious hazard, should the rope break.

The deep water mooring design used by the French authority ensures that the ground chain is sufficiently long so that as the rope part of the mooring is retrieved the tension in the rope will only be the weight of the ground chain being lifted. The weight of the sinker will not be felt until all the rope has been recovered and the vessel is lifting the chain part of the mooring.

# 12 SAFETY

It must be noted that the energy stored in the more elastic types of rope when under tension may be considerable and suitable precautions must be taken to ensure that no personnel will be in any area that may be swept by the end of a broken rope.

# 13 ELASTIC MOORINGS

Rope moorings will absorb some of the buoy's energy due to the elasticity of the rope and prevent this energy being transferred to the sinker. Fully elastic moorings have been developed where all of the buoys' motion is absorbed by an elastic cord which forms part of the mooring cable. The Canadian Coast Guard are trialing such a system where the mooring cord is of a composite braided construction which limits the extension of the elastic cord and slows the elastic recovery of the cord to prevent any "whiplash" effect should a break occur. Such moorings have been successfully used as part of tension leg moorings securing pontoons in marinas subject to wave action and wash from passing vessels.

The Netherlands authority is using elastic cord cables to moor relatively small buoys in areas subject to wave action. The elastic moorings allow the use of a short cable and hence a limited swinging circle.