



KATRADIS MARINE ROPES INDUSTRY S.A.

USER'S MANUAL

Synthetic Mooring Ropes

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This manual is intended to accompany the **Synthetic Mooring Ropes** - manufactured by KATRADIS SA, used in mooring operations and provide information and guidance regarding their proper usage, installation, safety issues, inspection & discard criteria.

Synthetic mooring ropes cover a wide range of materials and constructions and can be generally categorized as Polyolefin, Polyester, Mixed Polyolefin/Polyester and Nylon. More specifically:

Polyolefin (Polypropylene PP / Polyethylene PE)

KATRADIS SA has been producing for many years the special NIKA-Steel® monofilament fibers, a "melt mixture" of first quality virgin raw materials (Polypropylene, Polyethylene and UV stabilizers). Ropes made of NIKA-Steel® are floating, very durable and outlast the common polypropylene ropes.

Polyester

These ropes are made of polyester multifilament fibers and exhibit a lot of advantages such as very high abrasion resistance, flexibility and capability of maintaining breaking strength even at high temperatures. Polyester ropes are non-floating.

Mixed Polyolefin/Polyester

Consisting of NIKA-Steel® and polyester fibers twisted on the outer surface of rope yarns, these ropes combine the high strength and long service life. The proportions of each material can vary and provide floating or non-floating properties.

Nylon

Nylon ropes are used mostly because of their elasticity and shock-load absorbing properties for the shipping industry. This is why they are used mostly for mooring tails, but can be also used as main mooring lines. Nylon ropes (non-floating) tend to lose approx. 15% of their breaking strength in wet conditions, but this effect is recovered when dried.

All the above rope types can be manufactured in 3/8/12/24/32/64-strand construction.

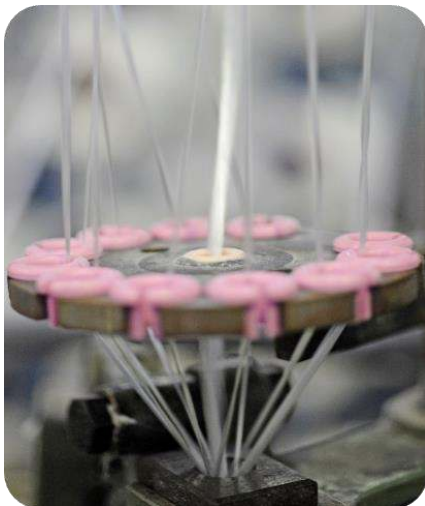
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Brief description of manufacturing process

The manufacturing process follows ISO 9001:2015 quality system and includes the following basic production steps:

- The twisting level where the yarns are twisted in twisting machines
- The stranding level includes the construction of the strands in special one-for-one stranding machines.
- The braiding of the rope is completed in the braiding level in Herzog's braiding machines.
- In case of jacketed construction, the core rope is overbraided with polyester jacket in special 32-str braiding machine.
- The rope coil is weighed, and specimens are prepared for breaking load testing
- After all quality control tests have been satisfactorily finalized, the coil is placed on a rotating base, unlay and measure the required length (for the slack on deck final length). Then the special chafe protection is inserted for each eye splice section and the eye splice is formed (with minimum 5-tucks fabrication per splice). Then follows the marking and packaging to give a complete final product which is taken away for storage and/or transport.



Manufacturing rope yarns



Braiding of Synthetic ropes

Description of quality control arrangement

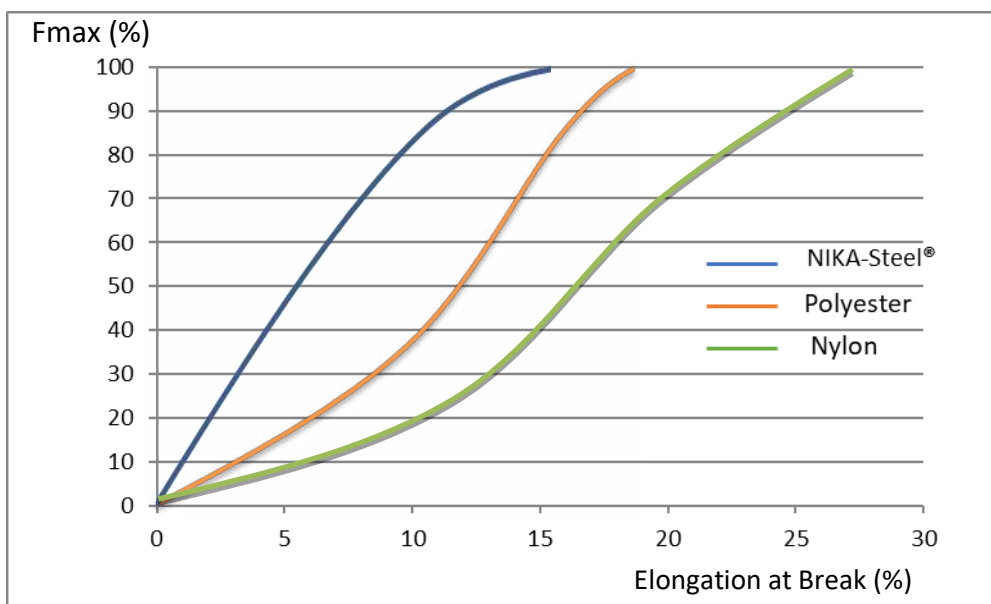
The product quality control involves the following steps/procedures:

- Tenacity testing of the **yarns**.
- Yarn-To-Yarn abrasion test of the **yarns**
- UV resistance tests of the **yarns**
- Breaking strength testing of the rope yarns (**twisted yarns**)
- Breaking testing of rope specimens as per batch order.



Table 1. Synthetic ropes constituent yarns technical information

Property	Nylon	Polyester	NIKA-Steel®
Density	1,14 kg/dm ³	1,38 kg/dm ³	0,92 kg/dm ³
Tenacity	> 9gr/den	> 9gr/den	8gr/den
Elongation (at break)	25%-30%	18%	15%-18%
Melting point	218 °C	265 °C	165 °C
UV resistance	Excellent	Excellent	Excellent



ON-BOARD INSTALLATION

Hardware / deck preparation

- **Check for sharp edges or rust on flanges, winch drums, bitts and general in every hardware equipment on deck that the rope comes in contact with.** Generally, rust will act as “knife” for the mooring line and result in severe rope damage and breaking load reduction, even for a new rope.

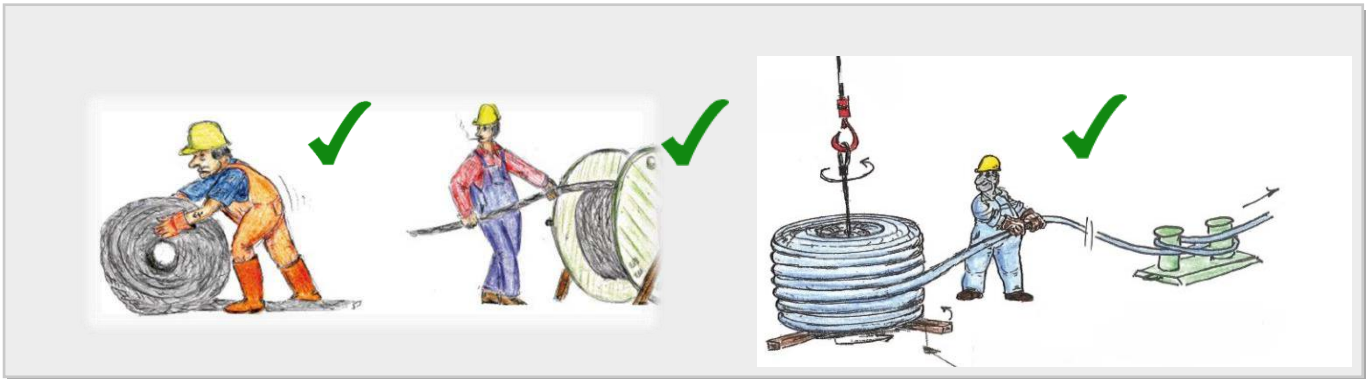


- **Take special care in chocks, as these contact points are crucial during the mooring operation.**



Installation on a winch

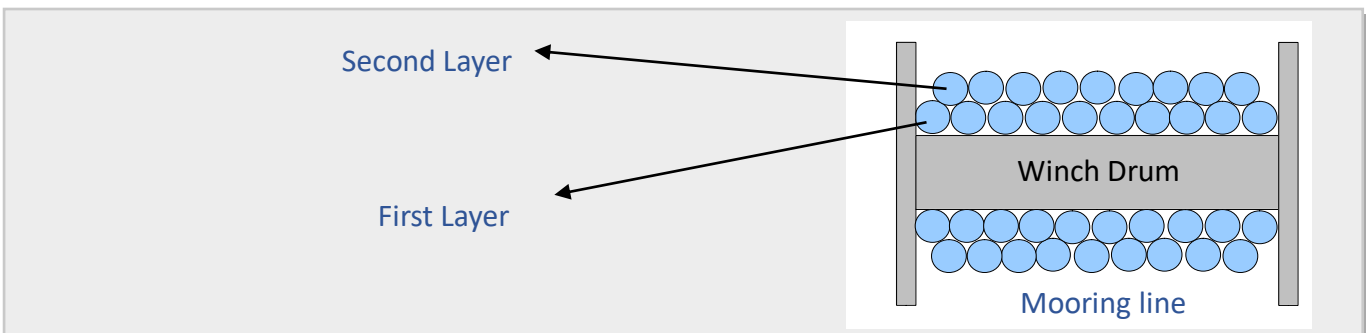
- Uncoiling the rope from the delivery package must be done carefully and gradually.
- **When uncoiling the rope from a reel or a coil, the winding and unwinding must be performed with care to avoid twisting**



- **Be careful of the twist that may be introduced to the rope while winding it on the winch.** Studies have proved that loss of strength amounts to 7% per turn per meter.

Mooring rope that has suffered several twists, which cause considerable strength reduction. The handling of braided ropes should be with care to avoid twists as much as possible.

- **Winding of the ropes must be carried out tightly & evenly at clockwise direction, so that no spaces are created between the wraps.**

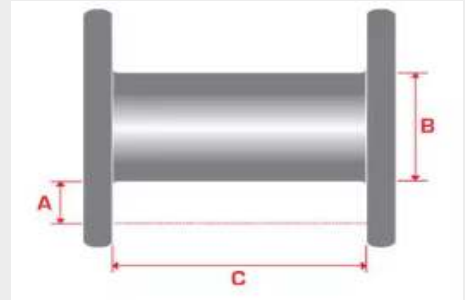


Drum Capacity calculation

The following formula has been developed to determine drum capacity under normal tension and uniform winding conditions.

$$L = \frac{A \times C \times (A + B) \times \pi}{2 \times (d \times d)}$$

L = Length of rope (meters)
 A = Desired depth of winding (cm)
 The depth of the flange is normally reduced by 40 to 50 mm to allow ground clearance for the rope
 B = Diameter of Barrel (cm)
 C = Width between flanges (cm)
 d = diameter of the rope (mm)
 $\pi = 3,14$



- In cases of split mooring winch drums, the drum separator should have rounded edges where the rope passes through.



These metal surfaces that come in contact with mooring lines must be rounded and not sharp.



- On the tension drum, the rope must have at least 4 to 5 wraps to avoid slippage. Also, the tension drum is operated with only one layer of mooring line.



- On an undivided drum, outer layers of mooring line tend to embed into lower layers when under tension which can damage the mooring line. The split drum winch has been designed as a solution to this problem and is preferred by most operators.
- **OCIMF recommends that the primary brake should be set to hold 60% of the ship design MBL on the first layer.** The brake holding capacity for this type of winch is always quoted for the first layer on the tension drum. If more than one layer is wound onto the drum, then significant loss of brake holding power will result. For undivided drums, it is recommended to ask the winch manufacturer for guidance on maintaining the value for brake rendering.

(MBLSD) Ship Design Minimum Breaking Load: The MBL of a new, dry mooring line for which a ship's mooring system is designed. The MBLSD meets standard environmental criteria restraint requirements.

(LDBF) Line Design Break Force: The minimum break force at which a new, dry, spliced mooring line will break when tested acc. to CI1500B:2015. This value is declared by the manufacturer on each mooring line certificate.

LDBF = 100% - 105% of MBLSD

MOORING OPERATION



Mooring operation is one of the most critical and hazardous tasks carried out on vessels. Mooring arrangements differ from port to port and careful re-planning of the mooring operation is essential.

Deck crew has to consider various safety precautions and understand working principles of deck machinery and systems. When it comes to mooring operations, additional precautions need to be taken to ensure crew members' safety.

- ✓ **As the ship nears the port the mooring winches are tried out, the breaks are tested, the mooring ropes are checked and positioned.**
- ✓ **Mooring lines must be as symmetrical as possible about the midship line of the vessel.**
- ✓ **Two or more lines leading in the same direction should always be of the same material (also tensile strength, elongation etc.) and construction.**
- ✓ **MIXED MOORING MUST BE AVOIDED.**

Rope Protection

- ⚠ Use protective chafe gear.** KATRADIS SA has developed high quality protection sleeves against external abrasion conditions (to be used in areas such as chocks, bitts, etc.). Using chafe protection will substantially extend the service life of your mooring line.

Protection for the main body of the mooring line



NIKA®-Guard Protector

Flat Polyester webbing pad used for the protection of ropes against abrasive surfaces (chocks, bitts etc.). The Velcro scratch tape, firmly stitched on the sleeve guard, is used for quick & easy installation and removal.



NIKA®-Guard UltraDouble

It is manufactured using a combination of High Tenacity polyester and UHMWPE webs in a double-layer sleeve construction. The polyester layer of the webbing sleeve is fixed on the outer side while the UHMWPE layer protects the rope from the inside.

Protection for the rope's eye



Polyester Eye splice Protector

Special braided cover designed for extra protection of the eye splices, made from specially twisted polyester fibers.

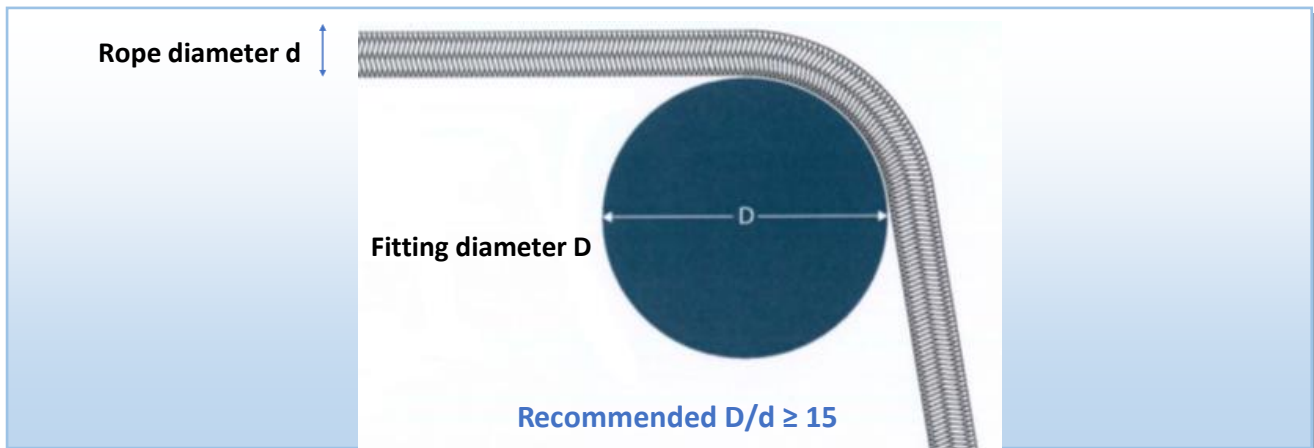


NIKA®-Eye splice Protector

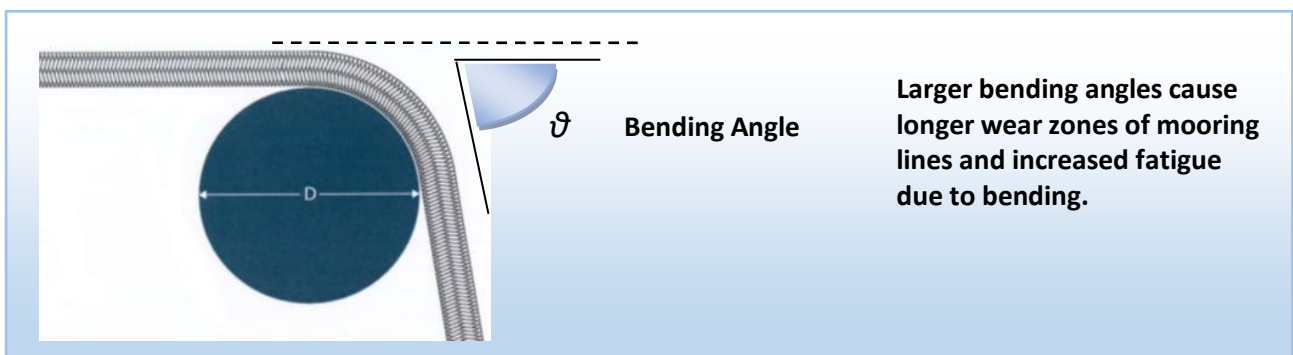
UHMWPE braided sleeve cover highly efficient against abrasion and wear. It's low coefficient of friction makes it ideal for the eye protection in demanding operations.

Minimum safety usage factors

- ⚠ The maximum Working Load Limit (WLL) of synthetic mooring lines must not exceed 50% of the ship design MBL (MBLsd).
- ⚠ The SWL of the bits and other deck hardware should be equal or greater than the MBLsd of the employed mooring line.
- ⚠ Any bending of mooring lines will instantaneously reduce its breaking strength. Repeated bending will reduce the service life of the line. The D/d ratio (D: diameter of bend, d: diameter of mooring line) should be as large as possible to maximize mooring line strength and working life.

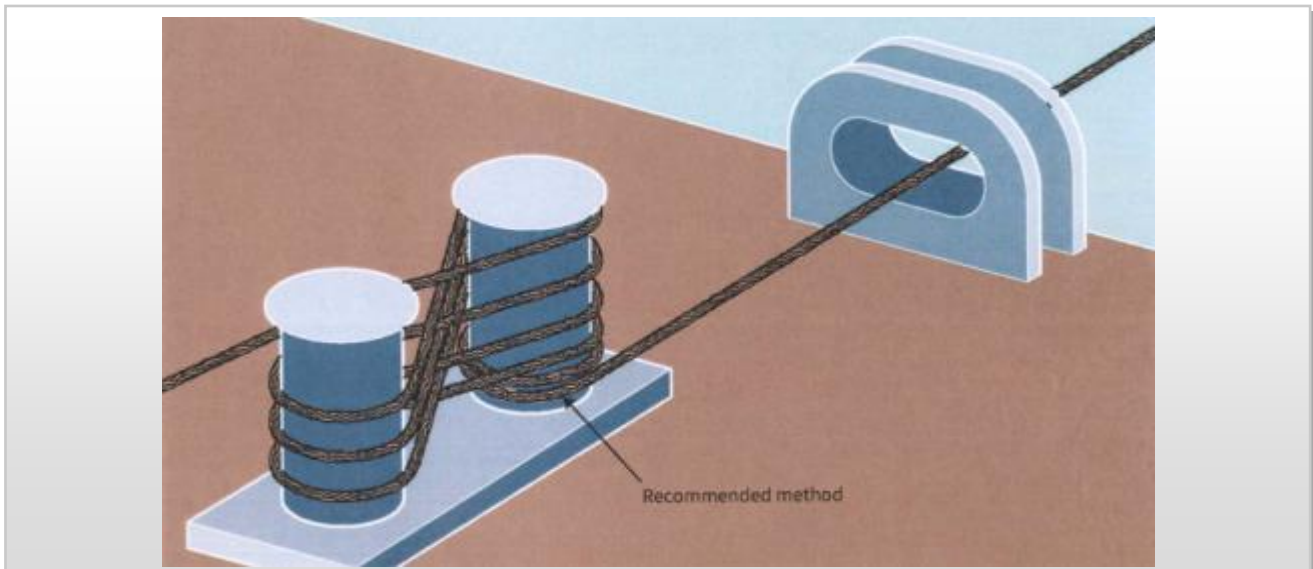


- ⚠ The diameter D of bits, pedestal fairleads, etc. that meet mooring lines should be at least 15 times larger than the diameter of the line.
- ⚠ Mooring line arrangements often require redirection from winches and bending of lines around pedestal rollers. Users should keep in mind that high bending angles can cause compression of the inside strands and yarns and also extensive wear when the line is under loading and unloading conditions.



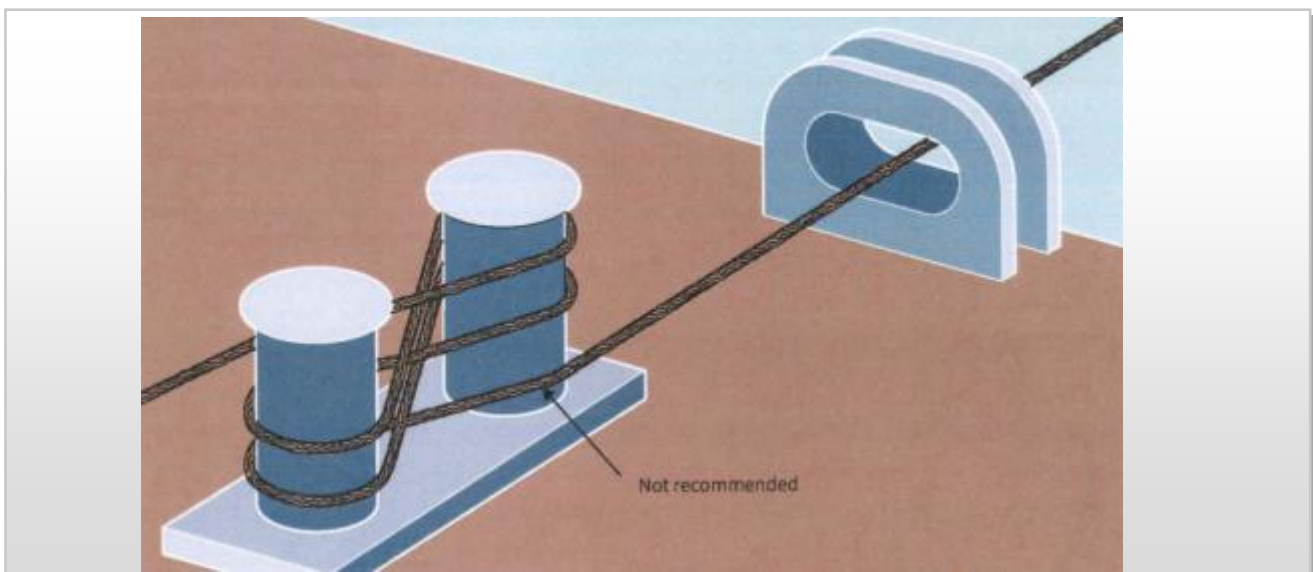
Securing Mooring Lines in figure 8 arrangement

It is recommended by MEG4 that when securing mooring lines to double post mooring bitts, two turns should be placed around the first post before beginning to belay figure of eights.



Recommended method of turning up a mooring line on bitts (two full turns around leading post)

If the two full turns of the mooring line around the first post are missing, a higher stress is induced in each post creating a tendency for the bitts to be pulled together. This method is not recommended and is illustrated below:



Incorrect figure of eight method for attaching a mooring line on mooring bitts

Safety issues

The underlying factors

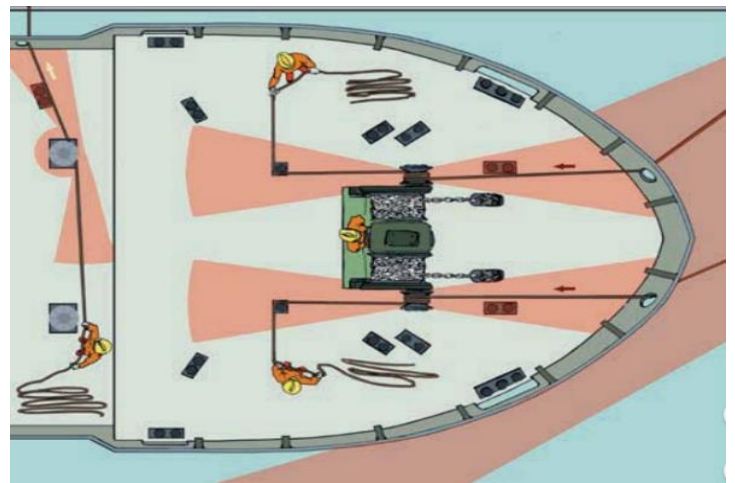


⚠ ALWAYS CONSIDER the high risk areas regarding snap-back effect of mooring ropes, as indicatively shown in the drawing below, when the line is under tension.

NOTE: MEG4 Guidelines suggest that a snap-back area should not be marked on deck because such an approach gives a false sense of safety for the crew outside the marked areas. It is suggested that during mooring operations, all crew and personnel should become aware of the snap-back dangers and not be in close proximity of the tensioned mooring lines.



It is impossible to work the lines without the crew standing in such a large and high-risk snap-back area.



The crew can work the lines without standing in high-risk snap-back zone.

⚠ Any work that must be performed near to a mooring line under tension must be performed as quick as possible, but NOT HASTY, and with extreme caution.

- ⚠ **Never let two ropes rub one another when they are under tension. There can be excessive heat build-up that will damage the fibers locally and impose a weak point in the line.**
- ⚠ **Directing more than one mooring line through fairleads, chocks etc. is a bad mooring practice because of local compression and abrasion, which can severely affect the performance of the lines.**

Mooring lines that come in contact with each other create high-risk working conditions.

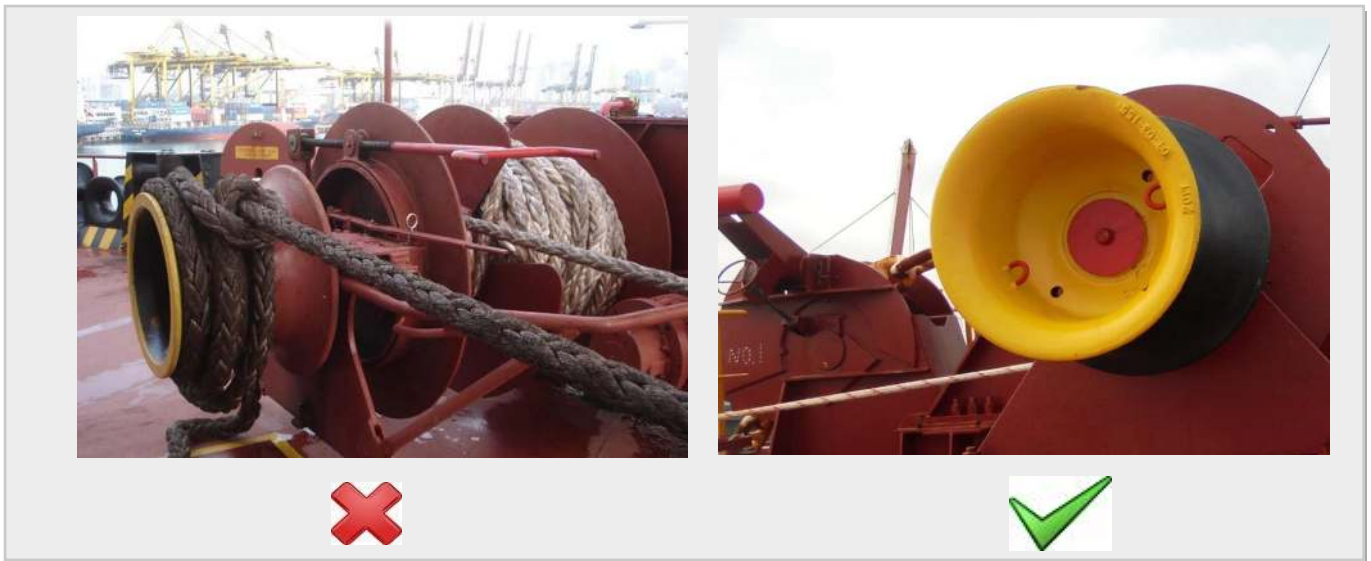


- ⚠ **All mooring lines must be equally tensioned, otherwise the most tensioned line will be exposed to overloading.**

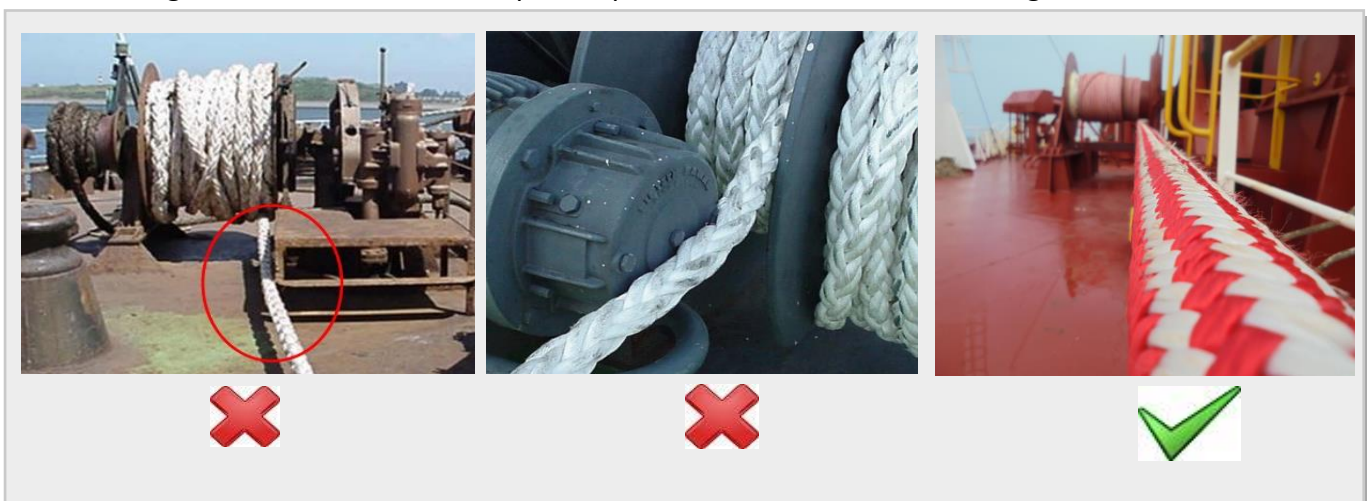
This line is highly tensioned compared to the rest mooring lines.



- ⚠ **AVOID keeping mooring lines on drum ends.** Lines must be kept in storage drums with appropriate wraps.



- ⚠ **MAKE SURE that there are no obstacles on the mooring line's directions.** Parts of the vessel's construction that come in contact with mooring lines must be removed as they can cause rope damages that could lead to unexpected premature failure of the mooring line.



- ⚠ **Under no circumstances the rope should contain oil/grease material, as it may cause chemical contamination and foreign particle adhesion (which will create abrasive conditions).**

⚠ Induced Twisting:

As already mentioned, the handling of braided ropes should be with care to avoid twists as much as possible - twisting of ropes causes a strength reduction up to 7% per twist per meter. Below there is an example of rope that has suffered several twists.

Mooring rope suffering a large number of twists.

Under no circumstances the mooring ropes should work with induced twists, because it highly affects their performance.



BEST ACTION: Spread the twisted length of the rope along the deck and align in order to straighten the rope.

After removing the twists that may have been induced, wind it carefully back to the winch.



ROPE CARE AND MAINTENANCE

- ⚠ **Unless otherwise recommended, on an annual basis reverse your mooring line end-for-end: bring the rear part of the rope in front and vice versa so that the wear is distributed and get a longer service life.**
- ⚠ **Avoid making knots at all costs because this can reduce the line's strength by up to 50%. Also, end-to-end splices will cause significant strength loss up to 20%. Best practice is to make eye splices instead.**
- ⚠ **Keep the ropes clean:** wash them with tap water on a regular basis (the time frame is to be decided upon operators' experience) to remove any dirt or sea salt. Such particles will act as “razors” and damage the fibers when dry.

Spread the mooring line on the deck and after the tap water scouring let it dry normally.

Nylon ropes must be carefully dried as their strength starts to decrease in wet conditions.



- ⚠ **Conduct regular inspections on the rope and the hardware** (see more on the inspection practices).
- ⚠ **For better abrasion performance we recommend the use of the special NIKA-Lube lubricant. It is polyurethane based and appropriate for application on mooring ropes (for more information please contact KATRADIS SA).**

Determination of NORMAL / EXTREME Operating Conditions

Generally, mooring lines operate in various weather conditions, types of ports (sheltered or exposed – open sea), mooring arrangements and loading conditions. Such factors highly affect the service life of mooring lines and should be taken into consideration when evaluating their condition and performance.

Below, there is a table for determining the normal or extreme operating conditions of mooring ropes.

NORMAL OPERATING CONDITIONS	Operating temperatures up to 50°C
	Mooring at sheltered port
	Low wind forces (1-4 beaufort)
	Typical mooring layout
	Absence of swell
EXTREME OPERATING CONDITIONS	Operating temperatures exceeding 50°C
	Mooring at exposed terminal
	Ship-to-Ship operations
	High wind forces (over 5 beaufort)
	Presence of swell
	SPM, CBM or Multi Buoy Mooring layout



Typical mooring at sheltered berth

INSPECTION PRACTICES AND RETIREMENT CRITERIA



- ⚠ The rope should be inspected after each operation. A trained person from the crew, assigned by the master or by the company, must be charged with the visual inspections and rope repairs. A diary log must be kept where as much information as possible must be recorded (mooring line history, hours of mooring operations, temperature exposure data etc.).**
- ⚠ Also keep in mind that in order to have an indication of the remaining/current breaking strength of a line, the originally received coil should have an extra length of about 10 to 12 meters. This way, a breaking test in a specimen could be performed without limiting/affecting the line's length. For this extra length, the purchaser should make this notification during the order placement and always consult KATRADIS SA regarding the recommended mooring line testing.**
- ⚠ It is recommended that mooring lines and tails that have reached the 75% of the ship design MBL (respectively) must be replaced.**

The visual inspection must check the following (also useful guidance for complete inspection can be found in the User's Checklist Inspection).

For unjacketed ropes:

- **One strand of the rope is pulled out.** If it is possible, try and work it back to the rope (if the strand is in good condition and there no significant wear), and look out for the cause (possibly some snagging on deck equipment). **RETIRE THE ROPE? NO**



- **Rope strand that has parted (probably due to working under extreme loading conditions):** this damage can cause dramatic load reduction and the rope must be repaired. **CUT AND RESPLICE*** if remaining length is sufficient for mooring operations **OR RETIRE**



(*RESPLICE: forming a new rope eye after cutting the undesired length of the rope. The term does not refer to an end for end splicing of two rope lengths.)

- **The rope's diameter is inconsistent.** Possibly due to shock loading there are broken internal strands/rope yarns.

REPAIR THE ROPE (CUT AND RESPLICE if remaining length is sufficient for mooring operations)
OR RETIRE



- **The rope has extensive wear and/or reduced volume.** The percent of the volume decreased means greater decrease in line's strength.
CUT AND RESPLICE if remaining length is sufficient for mooring operations) OR RETIRE



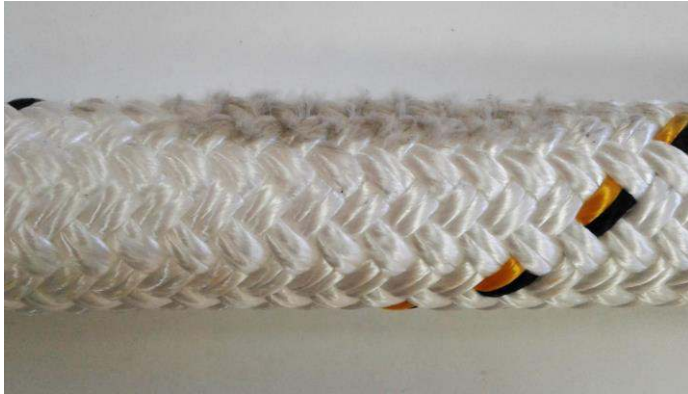
- **The rope's surface is discolored.** Most probable cause is chemical contamination (oil/grease residues from deck or other chemicals). The rope should be cleaned thoroughly with plenty of water because foreign particles will adhere the rope's surface and create abrasive conditions.
RETIRE THE ROPE? NO



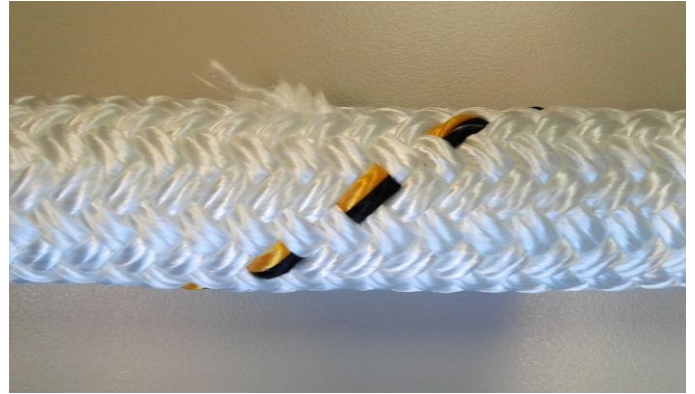
Jacket Damages:

In case of a worn jacket or a pulled strand, **local repair** in the jacket could be performed (as long as it is verified that the load bearing core is in good condition and hasn't suffered any damage - for details refer to Unjacketed rope inspection instructions). Examples of jacket damages are given below:

Abraded jacket



Cut jacket strands



Glazed (fused) strands on the jacket



Discoloration

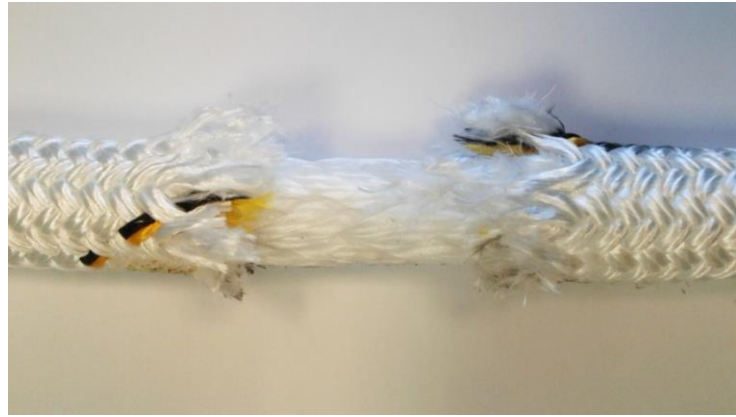


- ⚠ When the jacket is damaged, we recommend inspection of the inner strength member. If the inner strength member is damaged, then it may be necessary to downgrade the rope. The cause of the damage should be determined and if possible, removed.**

Depending on the extent of the damage either a small repair or an extensive repair is recommended (See below sections: Small repairs & Extensive repairs).

- ⚠ In case of a total jacket partition, the repairing should take place by KATRADIS SA (this includes removal of the parted jacket and overbraiding a new one as long as the core rope is in good condition). On-board, only a temporary repair can take place in this case.**

A temporary repair can take place: bring the two jacket parted sides as close as possible and use the Repair Kit (see below instructions: Extensive repairs).

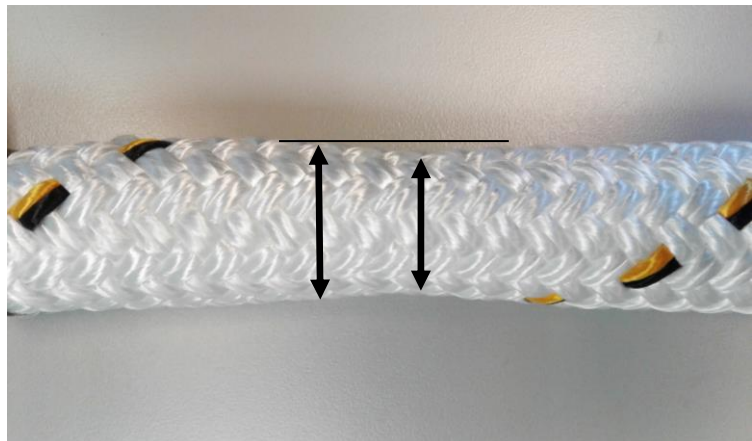


Broken internal strands:

A broken internal strand can be recognized from the diameter's reduction. Specifically, a 12% - 13% loss of the rope's diameter is expected when an internal strand has parted. Most likely the inside of the rope will become softer in the particular area.

BEST ACTION:

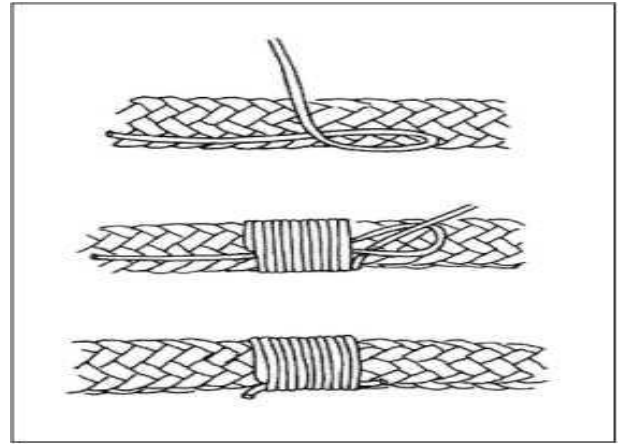
CUT AND RESPLICE IF ALLOWED
and if remaining length is sufficient
for mooring operations
OR RETIRE



Small repairs

The most durable method to make small repairs on the jacket braid requires the use of whipping twine and polyurethane glue.

Remove all the damaged yarns and coat the free yarn ends with the glue, in order to prevent further unraveling of the cover. Start whipping at least three centimeters away from the damage, as shown in the drawing. Lay a loop of twine across the rope, leaving a free tail after the damage zone of about ten centimeters. This tail has to be grasped later, so avoid covering it completely with whipping. With the working end of the twine, make multiple wraps around the rope from the tail end toward the apex of the loop, covering the loop until the whipping is at least three centimeters beyond the damage.

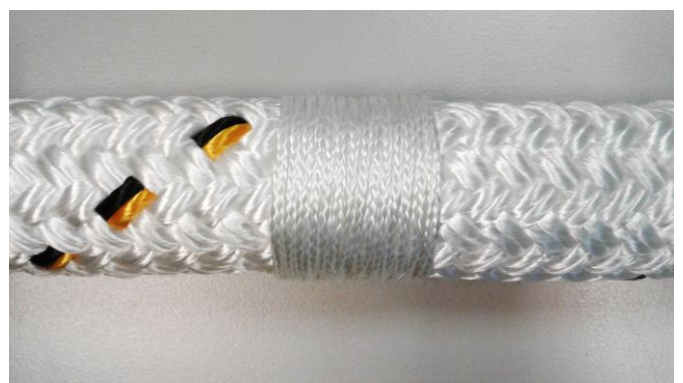


To finish the whipping, insert the working end of the small twine through the loop. Pull on the very end or tail of the small twine until the loop slides completely out of sight. Clip the ends close to the whipping.

If necessary, a temporary cover repair can be made using high quality adhesive tapes such as vinyl electrical tape, etc. A more permanent repair, as described above, should replace the tape as soon as possible.



Temporary repair with adhesive tape



Effective repair by whipping

Extensive repairs

For extensive repairs the following tools are needed: replacement cover, some sewing twine and a large sewing needle. Optionally additional protection can be obtained by a two-component polyurethane.

A full set of such repairing tools can be obtained from the Repair Kit by KATRADIS SA.

Remove all the damaged yarns and inspect the rope. After inspection coat the free yarn ends with the glue, in order to prevent further unraveling of the cover. Wrap the damaged part in the replacement cover.

Stitch the web together, with a special knot that will prevent the stitching yarn from loosening when it is torn.



Protect the beginning and the end of the replacement cover with whipping. Start whipping at least three centimeters away from the edge, as shown in the drawing. Lay a loop of twine across the rope, leaving a free tail after the damage zone of about 10cm. This tail has to be grasped later, so avoid covering it completely.



With the working end of the twine, make multiple wraps around the rope from the tail end toward the apex of the loop, covering the loop until the whipping is at least three centimeters beyond the damage.

To finish the whipping, insert the working end of the twine through the loop. Pull on the very end or tail of the twine until the loop slides completely out of sight.

Clip the ends close to the whipping.



ANNEX A: RETIREMENT CRITERIA FOR MOORING ROPES**For unjacketed Ropes**

CONDITION	Resplice (if localized)	Retire
-Bulk of surface yarns or strands reduced by 50% or more for a linear distance equal to the rope diameter	X	X
-Rope suspected of being shock loaded		X
-Exposure to excess temperature as specified for type of fibre		X
-Burns or melting visible for a length of over four rope diameters	X	X
- Abrasion on inside of eye, with bulk of surface yarns or strands reduced by 50% or more	X	X
-Rust (might indicate chemical damage)	X	X
-Oil and grease	Wash in mild detergent	
-Heavy surface fuzz-progressive	X	X
	Remove source of abrasion	
-UV degradation, splinters on yarn surface		X

For jacketed Ropes

CONDITION	Repair (if localized)	Retire
-Multiple cut yarns of filaments within distance of one pitch length	X	X
-Core visible through cover, because of cover damage	X	X
-Core damage-pulled, cut, abraded, powdered, or melted strands		X
-Herniation-core pokes through cover (sheath)		X
-5% of yarns cut or badly abraded in score between strands	X	X
-Cover yarns cut or abraded more than 50% on one or more crowns of rope	X	X
-Strand cut to 5% of diameter within one lay length	X	X
-Powdering between adjacent strand contact surfaces	X	X
-Hockle or backturn	X	X
-10% abrasion of one strand within one lay length	X	X
<u>Thermal damage</u>		
- Hard, melted, flattened areas of the rope which can indicate serious damage to the rope	X	X
- Short-term exposure to temperature above 65 °C		X
<i>-Melting or fusing affecting 20% or more of cover rope yarns</i>		
--If within one lay length	X	
--If over more than one lay length		X

Information regarding packaging and traceability

The ropes are packaged in Polyethylene heat shrinking film. On this, there is a glossy label where it is marked /stated:

a) Product name / type b) Weight of the coil c) Length of the coil d) Construction of the rope (e.g. 12Strands) e) production code number and f) Date of Production

The marking on the product, also involves **metal labels (2 metal labels per coil)** where the unique code number of the rope coil is marked permanently for traceability purposes. This marking is being carried out in a way that it is visible, legible and indelible. This unique product code number is the reference to the manufacturer's certificate.



Storage conditions

Store the ropes in a clean environment under mild and dry environmental conditions (avoid storage in high temperatures) and away from direct sunlight.

Store the ropes away from heat generating sources and acid (especially sulfuric acid) and alkaline environment. Good ventilation of the storage place is also preferable.

Under these specified conditions, the ropes can be stored without loss of properties for 8-10 years (shelf-life), but the user should keep in mind that once the rope is unpacked and subjected to operation the shelf-life management stops and the service life begins.



DISCLAIMER

Katradis Marine Ropes Industry S.A., to the best of its knowledge, uses reasonable efforts to include accurate and up-to date information on this manual; it does not, however, make any warranties or representations, either express or implied, as to its accuracy or completeness. All material and information provided on this manual are provided "as is" without warranty of any kind, either express or implied, including warranties of merchantability, fitness for a particular purpose, commercial viability, title or non – infringement.

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