LANKHORST

THE VITAL CONNECTION

MA MARITIME

MOORING ROPE MANUAL.

WIRECO
A World Ahead

LANKHORST

CONTENTS

INTRODUCTION

ARE YOU READY FOR MEG4?
The wet Cargo industry cannot ignore MEG4, the OCIMF's Mooring Equipment Guidelines (fourth edition 2018). anymore. Your customers expect that you work in accordance with the new Mooring Equipment Guidelines. With MEG4 the OCIMF focuses more than ever on the safety of the vessel's crew and the terminal staff.

But what is the real impact of the MEG4 on your company and on your activities? What is your responsibility? And how do you prepare your organization for MEG4?

Lankhorst Ropes provides guidance on managing the mooring ropes on your vessels in accordance with the new guidelines. This Mooring Rope Manual ensures you maintain business continuity.

SAFETY FIRST
The main goal for managing mooring ropes according to MEG4 is the safety of your crew, but the guidelines offer more. Lankhorst Ropes' focus on cost of ownership leads to efficiency in your costs, the worldwide availability of our ropes guarantees uniformity in your mooring lines and the recycling program helps you enhance your environmental policies.

LANKHORST ROPES' MOORING ROPE MANUAL MAKES IT EASY
The OCIMF's Mooring Equipment Guidelines (fourth edition 2018) should be the basis for your mooring policy. The document contains information and recommendations for all aspects of mooring in your daily activities. For the mooring ropes and tails Lankhorst Ropes clarifies the most essential subjects in this Mooring Rope Manual. How should you select a rope for your activities? Which factors influence mooring line performance? What are the inspection criteria? And when should a rope be discarded? The Lankhorst Ropes' Mooring Rope Manual will answer your questions.

1. LANKHORST ROPES... THE VITAL CONNECTION

Lankhorst Ropes is a world leading supplier of synthetic and steel wire ropes for the maritime and offshore industries. As a Royal Lankhorst Euronete Group company, Lankhorst Ropes is also part of the world's largest steel wire manufacturer, WireCo WorldGroup.

Founded in 1803, Lankhorst Ropes is committed to setting the standard for maritime ropes through our leading rope brands - TIPTO® 'Strong & Durable' family, EURO 'Strong & Stretch' family and LANKO® 'Strong & Light' family, which provide an optimal combination of breaking strength, life-time safety and ease of handling. In addition, we supply leading WireCo wire rope brands including Casar.

PARTNER AND PROBLEM SOLVER
Lankhorst Ropes develops, manufactures and supplies a broad range of mooring ropes. Besides fast supply of standard items and rope configurations, Lankhorst Ropes has a dedicated R&D department and confectioning centre to meet the needs of different market segment demands for specialised and tailormade solutions. In close consultation with our clients, we can bring nearly any desired product to the market. Moreover, we work closely with our suppliers, such as DSM Dyneema, to ensure the highest quality standards from raw materials, through manufacture, delivery and installation of the finished rope.

SERVICE AND DELIVERY
Lankhorst Ropes maintains stock points at strategic locations and main ports worldwide. Thanks to our widespread network and global presence, you are ensured continuity of supply, fast service and short delivery times. Our global network of stock points and local sales offices includes Bilbao, Brisbane, Cape Town, Dordrecht, Dubai, Durban, Fujairah, Houston, Montgomeryville (USA), Panama, Retford (UK), Rio de Janeiro, Rotterdam, Singapore and Sneek (NL).

RELIABILITY AND SAFETY
Lankhorst Ropes is fully certified according to ISO 9001:2015. Quality is central to our business ethos, ensuring you benefit from the highest quality products, tested to OCIMF MEG4 recommendations, and services. Our EU based factories for both steel wire and fibre ropes are approved by IACS members, such as Lloyds, DNV GL, BV and ABS. In addition, Lankhorst Ropes incorporates features like higher visibility, traceability, snap back protection and lower weight in its ropes, making them easier and safer to use.

SUSTAINABLE AND ENVIRONMENTALLY FRIENDLY
Lankhorst Ropes is committed to sustainability in its products and operations, conserving energy and natural resources wherever possible. We introduced the maritime rope industry's first recycling scheme for retired ropes; our retired ropes are used in moulded public furniture, poles and planks for example. It is an integral part of our sustainability policy and helps many of our partners enhance their environmental policies.

LANKHORST ROPES FOR WET CARGO
Wet cargo shipping companies operate in highly competitive global markets for transportation of non-edible and dangerous liquids, as well as edible non-dangerous liquids. Under increasing cost pressure, wet cargo carriers must operate as efficiently as possible. Optimising mooring and towing operations is an important factor in achieving efficient loading and unloading – reducing unnecessary and costly delays and additional port charges.

Lankhorst Ropes offers a one-stop shop for a broad range of synthetic and steel wire ropes for wet cargo vessels. From Aframax oil tankers (75,000 - 115,000 DWT), through Suezmax (160,000 DWT) and VLCC (150,000 and 320,000), up to T-1 supertankers (550,000 DWT). With Lankhorst Ropes you'll experience outstanding service life performance and, as a result, a low total cost of ownership.

2. MOORING ROPES - AN INTRODUCTION

In the fourth edition of the Mooring Equipment Guidelines the OCIMF describes the definition of mooring, why a mooring system is essential for a vessel and which factors should be considered when making a mooring plan. In this section we pay attention to these basics of mooring. Furthermore, we show you the variety within the mooring ropes spectrum. We examine the most common rope constructions, characteristics and connections. In addition, we underline the importance of rope protection and certification. To guide you with your own rope selection we also give you also some suggestions for your rope configuration.

2.1 MOORING

Mooring is the securing of a vessel to a marine facility, terminal, berth or another ship using ropes. Mooring operations are one of the most important and frequent activities during shipping. For a vessel to be moored securely, each part of the system, including ropes, deck equipment and onshore equipment as well as crew, must fulfill its role.

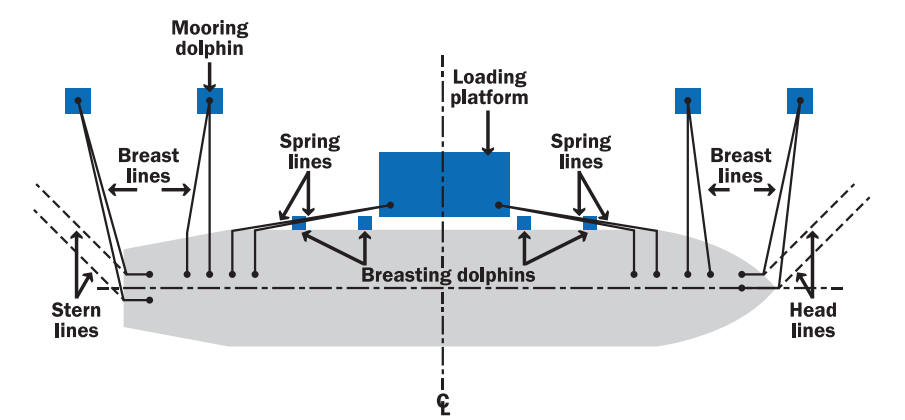
Typically, tankers are moored to the shore at facilities including conventional piers and sea islands. However, in many applications or environments onshore mooring may not be suitable or possible. Tankers therefore use alternatives such as Multi Buoy Moorings (MBMs), Single Point Moorings (SPMs), Floating (Production) Storage and Offloading units and other offshore loading or discharging facilities.

Mooring operations are as varied as the vessels and environments they are required for. Further types of mooring operations include emergency towing, tug handling, barge mooring, canal transit, Ship-to-Ship (STS) transfer and anchoring. These more specialized types of mooring can require dedicated fittings and equipment.

An effective mooring system is essential to ensure the safety of the vessel, its crew, the mooring facility and the environment. To devise a suitable mooring system the forces that may act upon the vessel and how these are best responded to should be determined. All moorings have a limited capacity for the loads they can accommodate, therefore it is extremely important to understand the vessel and the environment to ensure the mooring is safe.

When making a mooring plan, all of the following factors should be considered:

- Wind
- Current
- Tides
- Interaction from other ships
- Waves / Swell
- Ice
- Changes in draught, trim or list.



A typical mooring pattern at a conventional tanker terminal

Although all mooring systems are designed for the likely maximum wind and current forces, if surge, waves or ice conditions occur at the mooring facility, considerable additional loads may be encountered. These rarer forces are difficult to anticipate and analyze except through model testing, field measurements or dynamic computer programs.

2.2 ROPE CONSTRUCTIONS

In this section we are referring to question 9.5 in the OCIMF SIRE Vessel Inspection Questionnaire (VIQ7)

Our high performance synthetic ropes are made from high quality fibres. These fibres combine several characteristics, offering a well-balanced mix of strength, abrasion resistance and other features to provide safety and ease of handling on board.

Synthetic fibres are made from polymers derived from oil refining. The synthetic fibres are produced using an extrusion and stretching process, or other specialized forms of extrusion like gel spinning, melt spinning or wet spinning. These fibres are then twisted into basic yarns and the yarns combined into the final rope. Traditionally, this was mostly in a ‘laid’ construction; three, four or more strands are twisted all in the same direction, similar to steel wire ropes. Over the past few decades, new production techniques have been developed.

Source: OCIMF, Mooring Equipment Guidelines Fourth Edition 2018

Eight-strand plaited, twelve-strand plaited and parallel strand with jacket are now common constructions. The manufacturing of the yarns largely determines the quality of the final rope. Producing a high strength rope or a abrasion resistant fibre is not too difficult. However, to combine both high strength rope and abrasion resistance, as well as add even more features, is where Lankhorst's expertise makes the difference. Carefully developed production techniques, in combination with continuous communication with the end users, have provided Lankhorst with the skills needed to design optimal combinations of raw materials, yarns and rope constructions.

LANKO®FORCE
12 strand braided rope, with or without jacket, made of DYNEEMA® yarns. LANKO®FORCE is an excellent alternative to heavy and lumbersome steel wire ropes in situations requiring manual handling of the rope. The Dyneema® fibre offers maximum strength combined with minimum weight (7 times lower as steel wire rope) and is extremely durable and resistant to moisture, UV radiation and chemicals. The selected fibre grade is designed to perform in highly demanding applications, such as mooring, towing and heavy lifting, and offers the highest strength to weight ratio among all high performance fibres. Another important benefit of LANKO®FORCE is that the rope is floating. Moreover, when replacing fibre rope, the reduction in rope diameter can lead to substantial savings in the weight and size of the mooring winches, for example, when incorporated in the design of a new build vessel the cost saving is substantial.

EUROFLOAT®PREMIUM
Using our latest in-house extrusion technology has made it possible to offer you the newly designed EUROFLOAT® PREMIUM rope which is fully in-line with the requirements of the modern fleet of today. This floating, high performance rope is constructed from high strength polyolefin and polyester yarns. Due to its flexibility, EUROFLOAT® PREMIUM can be used on both the mooring bit's in a figure of eight configuration as well as on the winch.

EUROFLEX®
Continuing industry demand for mooring and towing ropes with higher strength AND smaller diameters has led to the development of EUROFLEX®. Its excellent handling properties, softness and flexibility, combined with high energy absorption capability and abrasion resistance, make EUROFLEX® one of the best ropes available today for mooring and towing for both shipping and offshore operations.

STRONGLINE™
STRONGLINE has a rope construction comprising parallel cores with a braided protective cover. The parallel cores result in a far higher strength rope than might be expected for a rope of this diameter and material. The protective cover ensures a long service life due to its excellent resistance against abrasion. Regular maintenance can significantly lengthen the rope service life. The main applications of STRONGLINE are towing and mooring. A major advantage of using STRONGLINE for mooring is that there is no requirement for mooring tails. This means a major cost and time saving reduction over the life of the vessel. No need for tail replacement.

When STRONGLINE is installed on a winch, twists in the rope during installation can reduce the service life of the rope once put to work. To prevent twisting, it is crucial to use a turning table when unwinding the rope from a coil. To facilitate the installation and avoidance of induced twisting, a longitudinal marking has been added to the STRONGLINE during manufacture. Please make sure the longitudinal marking line is always on the same position while winding up the STRONGLINE on your towing winch.

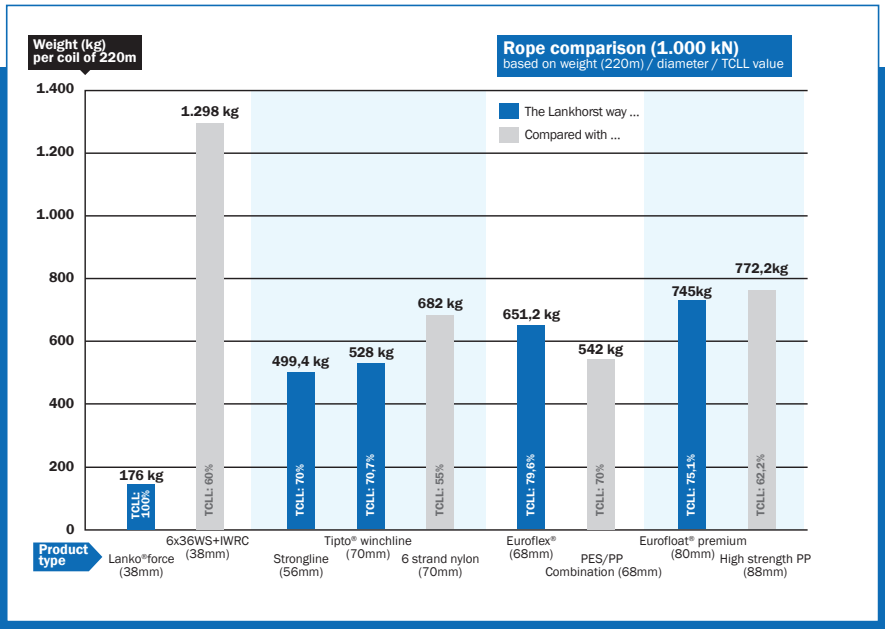
TIPTO®EIGHT
A high performance mooring rope, TIPTO®EIGHT's strength, abrasion resistance and energy absorption ensure a long service life and low cost of ownership. The rope's small diameter and low weight make handling easier on board. As TIPTO®EIGHT is a floating rope, the risk of getting the rope caught in the ship and tug propeller is minimal, thus avoiding costly downtime.

TIPTO®TWELVE

TIPTO®TWELVE is the successor of the well-known TIPTO®EIGHT. The construction is different, but the material remains the same. The 12-strand braided construction makes the rope rounder, more stable, more compact and with a smoother surface. This increases abrasion resistance and, as a result, the service life of the rope. TIPTO®TWELVE can be used for mooring, using either bollards and/or winches. All TIPTO®TWELVE coils are supplied with a quality label, stating “Original product of Lankhorst Ropes”. TIPTO®TWELVE ropes in the range from 32 mm up to 48 mm diameter have been upgraded with an extra marker yarn, enabling the rope size to be easily be identified without mistake.

TIPTO®WINCHLINE

A dedicated floating winch line. This load-bearing 7 strand core combines high strength and relatively low elongation. The non-load-bearing braided jacket include a phosphorescent tracer yarn allowing the rope to glow during the hours of darkness, increasing dockside visibility and creating a pleasing visual effect of the moored vessel. The jacket also provides protection of the core for longer service life and increases crew-safety by minimizing the risk of snap-back. The mooring efficiency of the vessel is enhanced by the ease of handling of the rope due to its low weight and ability to float. TIPTO®WINCHLINE does not lose its strength when wet.



	Lanko®force	Strongline	Tipto® range	Euroflex®	Eurofloat® premium
Density	0,98	1,38	0,93	1,14	0,98
Melting point (°C)	147 °C	265 °C	140 °C	165-265 °C	165-260 °C
Dry / wet (%)	100%	100%	100%	100%	100%
Used Rope elongation (%)	1%	4,5%	4,5%	8%	9%
UV resistance	excellent	excellent	very good	good	good
TCLL value (%)	100%	70%	70,7%	79,6%	75,1%

6X36WS+IWRC

A standard steel wire rope with higher breaking strength. Used for many kinds of applications, including luffing, mooring, towing, anchoring and coupling push barges. The independent wire rope core provides more strength and stability to the wire rope compared to a fibre core. Construction is according to ISO standard.

2.3 SYNTHETIC MOORING TAILS

In this section we are referring to question 9.5 in the OCIMF SIRE Vessel Inspection Questionnaire (VIQ7)

Mooring tails absorb heavy shock loads that can occur in the mooring system and are mainly used in combination with low stretching materials as steel wire rope (6x36WS+IWRC) and Dyneema® (LANKO®FORCE). Tails are an integral part of the mooring system and it is not recommended to use them as a weak link.

EUROFLEX® mooring tails are superior in terms of tension-tension fatigue, due to the extremely high TCLL value (thousand cycle load level) of 79,6%. EUROFLEX® is highly resistant to heat build-up due to the A-grade polyester (high melting point) that is used on the outer layer of each yarn. Moreover, the rope does not lose a large portion of its dry MBF when wet.

As the strength of EUROFLEX® is higher than that of nylon, a smaller diameter of rope can be used, providing better handling. Made of polyester and polyolefin composite yarns, the standard length is 11 m (Effective Working Length). For those circumstances where more stretch is required, EUROFLEX® mooring tails are also available in 22 m EWL. Both versions are fitted with two protected and spliced eyes of 2 m and 1m respectively. For those circumstances where more stretch is required, an option is to increase the tail length or to select our TIPTO®LON which is made out of nylon.

The OCIMF recommends mooring tails with a Tail Design Breaking Force (TDBF) of 125%-130% of the ship design MBL. EUROFLEX® MOORING TAILS have equal breaking strength under wet and dry conditions.

2.4 SYNTHETIC ROPE CHARACTERISTICS

In this section we are referring to question 9.5 in the OCIMF SIRE Vessel Inspection Questionnaire (VIQ7)

Minimising the risk of mooring starts with choosing the right ropefor the expected mooring situation. There are many characteristics which influence how a rope behaves and these need to be balanced to suit the application and environment. Different types of mooring require ropes with varying levels of elongation and creep; whilst certain rope materials may not be suitable if the mooring lines are likely to be exposed to chemicals.

2.4.1 ELONGATION

The elongation of a rope is one characteristic that is sometimes undervalued during the selection of a mooring line configuration. The elongation property is extremely important to the durability of the mooring line as well as vessel equipment such as winches.

If a vessel is moored with ropes with different elongation properties at the same location, the vessel will only be moored by mooring lines with the lowest elasticity. As a result, these lines will bear all the forces put upon the vessel; potentially, a dangerous situation.

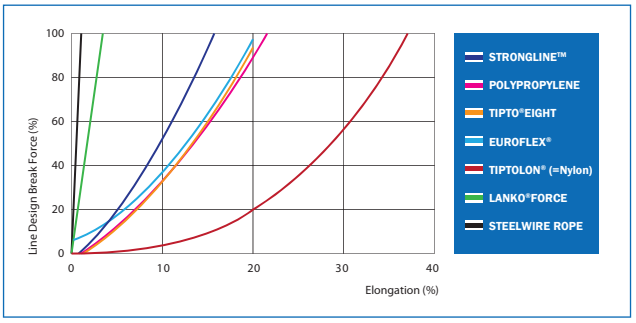
Elongation is, therefore, a very important characteristic of a synthetic rope. The elongation referred to in our product specifications is the elastic elongation in the rope. Elongation properties vary from yarn-to-yarn and from rope-to-rope.

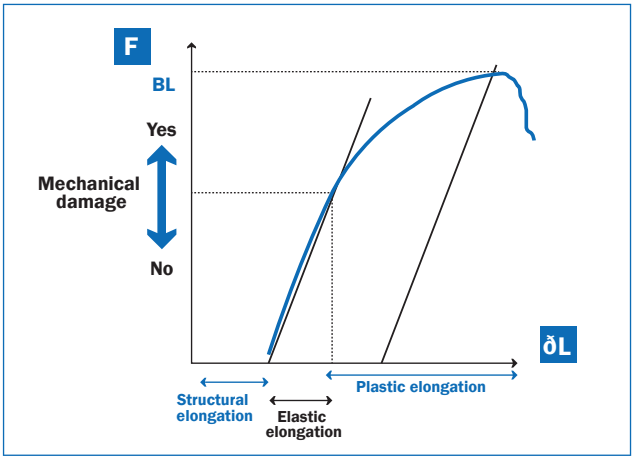
Elongation has three different phases:

1. *Construction elongation.* During rope manufacture, the tension on the rope is only a few percent of the Line Design Breaking Force (LDBF, see for definition paragraph 3.1). There remains 'air' between the yarns and strands. During the first few times a rope is put to work (stretched), 'air' is squeezed out and the yarns and strands set themselves. The rope has 'bedded in'.

2. *Elastic elongation* is the flexibility of the yarns which absorb the energy put into the rope. Once the rope has been released, the rope will come back to its original length.

3. *Plastic elongation* is a hazardous phenomenon. When yarns are overloaded (the elongation is more than the yarns can withstand), the structure of the yarns will change. Deformation occurs inside the yarns. As a result of deformation, the strength of the yarns will drop instantly and the rope will not return to its original length. Overstretching can occur either throughout a rope or in a single place. For example, at a sharp bend in a fairlead, bollard or other devices. The overstretched rope, or part of, must be taken out of action. Plastic elongation may be identified by a reduction in the rope diameter at that point.





Lankhorst Ropes' maritime catalogue includes graphics of the elongation curve of each rope. We show two curves, one is the new unused rope, the other is a used rope. The difference between the unused and the used rope is the construction elongation. In normal applications, construction elongation will disappear during the first weeks of use. What is left, is the used rope elongation property.

Maximum loading should always stay below the designed maximum which, as a rule of thumb, should never exceed the 50% of the Line Design Breaking Force of the rope.

WARNING:
Avoid mixed mooring lines and use exactly the same rope constructions for parallel ropes in your mooring activities. Only use ropes with the same materials, the same LDBF and same elongation properties. If elongation properties differ, the risk of damaging the ropes increases.

2.4.2 CREEP

Creep is the elongation of a material when subjected to a prolonged static load and is generally non-reversible. Several factors can influence the creep rate namely the specific fibre properties, temperature, load and time under load. If the application requires working at high ambient temperatures during longer periods it is recommended to analyze the risks associated with creep. Please don't use the slings if rope temperature is above 70°C.

For a specific project and load scenario, Lankhorst Ropes can provide creep calculations/simulations.

2.4.3 FLOATATION

The specific gravity indicates whether a rope will float (gravity < 1) or sink (gravity ≥1). The floatability of a rope depends on the fibre yarns used in the rope. In general: polypropylene, polyethylene and Dyneema® yarns are floating. The ropes made from these yarns, or a combination of these yarns, will be floating ropes. Aramid, polyester and polyamide (Nylon) are non-floating.

If a rope is made from a mix of floating and non-floating yarns, the floatability of the rope depends the relative combination of the yarns.

2.4.4 WATER ABSORPTION

Traditionally, ropes were made from natural yarns, Sisal for example, and water molecules would penetrate the molecular structure of the material. Of modern synthetic fibre materials, only Nylon behaves in the same way. Nylon becomes heavier when soaked in water and loses strength. If the vessel sails into freezing weather, the water molecules turn into ice crystals and can cause permanent damage to the rope inside.

Lankhorst Ropes' TIPTO®, EURO and LANKO® products do not absorb water or only a negligible amount. If a rope is floating in water for some time, water will lie between the strands and the yarns. However, this will do no harm to the product. Absorption will result in extra weight when pulled from the water, but the water will run out of the rope by itself - this will be accelerated when a force is put on the rope.

2.4.5 CHEMICAL RESISTANCE

Chemical resistance depends on the basic material of the rope and the chemicals it is contaminated with. All synthetic materials are sensitive to some extent to several chemicals; therefore, caution is recommended at all times. In the event the ropes do get exposed to chemicals, we suggest you contact Lankhorst with a photo of the label of the chemical compound together with a copy of the certificate of the rope. We will then be able to inform you if this will be hazardous to the rope or not. Normal household detergents do not harm the rope fibres but can remove the protective coatings. If washing the rope is needed, only water should be used.

A rope should never be put in operation after it has been contaminated without first determining the nature of the contaminant and establishing that it is not hazardous to the material.

The chemical resistance of LANKO®FORCE (Dyneema®) is given by the chemical characteristics of the base yarn, a high performance polyethylene fibre that is very resistant to most chemical attacks.

2.4.6 UV RESISTANCE

All synthetic fibre ropes can be degraded by exposure to UV radiation (sunlight) exposure. The high performance Dyneema® fibres are produced with additives that, in combination with the applied coatings, make LANKO®FORCE ropes highly resistant to UV radiation. UV radiation only affects the superficial layer of the rope, which, depending on the rope size, should represent a minor area in the total cross section of the rope. Nevertheless, ropes should be protected when not in use.

2.4.7 ABRASION RESISTANCE

Mooring ropes are subject to contact with other (rough) surfaces. This contact will lead to external abrasion. Vessel hardware, other ropes and external objects can damage the ropes significantly at the outer side. Furthermore, the performance of the mooring ropes will be influenced by internal abrasion as well. When a rope elongates or runs to a fairlead the yarns will move against each other. Yarn-to-yarn contact and friction causes damages to the rope at the inner side.

Different rope constructions and synthetic fibres have their own level of abrasion resistance, which can be improved by adding protection or coating to the rope.

2.4.8 SNAP-BACK

Snap-back is the tendency of the broken ends of a tensioned line to draw back rapidly after a line breaks. As a line comes under tension, it is stretched and stores energy. Snap-back is the result of the sudden release of that energy (source: OCIMF MEG4 fourth edition 2018) and presents a risk for all people working in mooring areas. The degree of snap-back is dependent on the rope material and construction. The danger of snap-back of ropes with less stiffness can be more severe that the snap-back of other ropes. Furthermore, if synthetic tails are connected to the mooring ropes, the stored energy (and the risk on damages/injuries) increases. Factors affecting the snap-back zone of a synthetic rope include:

- ✔ Elongation at break
- ✔ The location of break on the rope
- ✔ The length of the broken part
- ✔ The path/direction of the rope
- ✔ The tension on the rope

WARNING:
Please be aware of the risks of snap-back. All persons in the path of the rope or in the wider snap-back danger zone are at risk of serious injury or death. They won't react in time to avoid the impact of snap-back. To mitigate the risks it's recommended to have in place at least the following measures:

- ✔ Specific work/action is planned so the work can be completed safely & quickly
- ✔ A supervisor is designated to watch the entire operation
- ✔ A clear communication system
- ✔ Personnel will leave the dangerous snap-back zone as soon as the work has been completed

For all measures to be taken, please consult the OCIMF MEG4 fourth edition 2018.

2.5 ROPE PROTECTION

The main source of damage to a rope is external abrasion or mechanical damage due to a foreign object. Fibre ropes are more susceptible to damage than steel wire ropes. Therefore, it is advised to consider the application of a protection. This protection can prevent damage to the load bearing fibres due to abrasion, cutting, particle ingress or UV degradation. Ropes can be provided with a wide variety of different protections to prevent damage to the base rope.

Jacket
Each of Lankhorst's rope constructions can be covered with a protective jacket. The jacket is non-load bearing. That is to say, the jacket does not contribute to the strength of the rope but instead acts as a barrier to external abrasion, and thereby preserves the strength of the rope core for longer.

Coating
During the production of the rope that will be used in the sling manufacturing, the rope is coated using a proprietary coating technology, which extends rope life and provides increased abrasion resistance.

DEFENDER®
Lankhorst's Defender® is a high performance protection sleeve for permanent fixation offering high abrasion resistance. The hollow braid sleeve can easily be adjusted to the circumferential size of the rope for protection. The DEFENDER® can be made from different types of yarns, offering extra strength.

TIPTO®WEB sleeves
Synthetic ropes can be protected by a sleeve, fixated where needed to prevent chafing. The sleeve opens up and seals with Velcro.

You can tie the sleeves to the vessel by two holes pinched through the sleeves.

Enhanced eye protection
Standard polyester hose eye protection suffers a lot from abrasion which is why Lankhorst has replaced it with a polyester Defender® protection: a hollow braided sleeve that can be easily adjusted to the circumferential size of the rope to be protected, offering a high abrasion resistance. It is standard on our jacketed ropes.

2.6 CONNECTIONS

In this section we are referring to question 9.12 in the OCIMF SIRE Vessel Inspection Questionnaire (VIQ7)

If mooring ropes need to be connected with tails, several options are available. A special link can be used, but this has the disadvantage of introducing a heavy metal unit in the rope, which makes rope handling more difficult. A spectacle splice can be made, basically splicing one eye through another eye. This is a good connection, but any replacement ropes would need to be spliced on board the vessel.

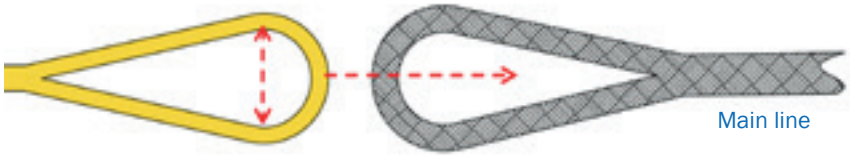
Another option is a cow hitch. This type of connection can be easily performed on deck. The cow hitch is supposed to be easy to separate again, however, in practice it can be difficult to get the knot out. A soft round sling tied on the top of each eye can help to separate the two eyes. If you let us know at the point of order that the rope will be cow-hitched with another rope of much larger diameter then we can add extra sleeving or a seizing to improve the D/d ratio of the two lines, making them work more sympathetically with each other.

The loss of strength in a spectacle splice or a cow hitch is compensated for by a doubling of the rope in the eye. The end result is therefore consistent with a standard spliced rope. When a small diameter rope is cow hitched into a larger diameter rope, one has to be careful that the smaller rope does not cut into the bigger rope. Lankhorst recommends visual inspection on a regular basis.

If a seizing is placed in the top of the eye of the smallest rope, this can help to bring both ropes to similar diameters, as well as reducing abrasion in the eye. One precaution should be noted: ensure that one end is not pulled 'over the top' (see picture on page 13) as this can result in one eye retaining its normal position but the other eye would make a sharp turn around, resulting in compression and overstretching in the bend of the rope. This can significantly reduce the service life of the rope and is a much weaker connection.

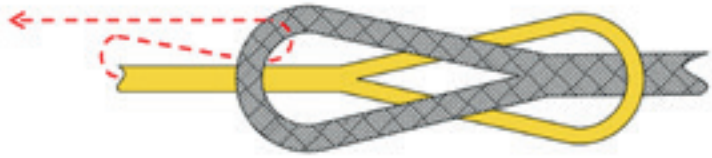
Cow Hitch Instruction

STEP 1



- Open up the eye of pennant and position it over the eye of the main line.

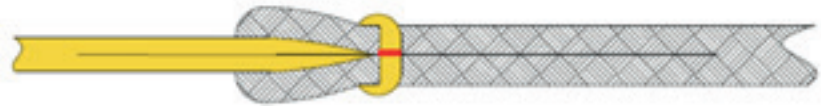
STEP 2



- Pull the other end of the pennant through the eye.

STEP 3

- First pull cow hitch tight by hand, lock the pennant to a fixed point and pull the cow hitch tight by using mechanical pulling force. (winch, ratchet hoist, etc.)
- Note, ensure that the cow hitch is evenly divided into the exact middle of both eyes. This is necessary to prevent unequal loading of the individual eye parts. It can be checked by making a mark into the middle of the eye before hitching. (mark) This same mark should line up again in the middle, after hitching.



- The cow-hitch is now completed.

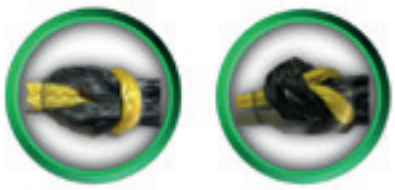
Additional information:
A cow hitch provides a suitable method of joining two ropes without the use of thimbles or other hardware.

The inclusion of a small ‘pigtail’ within the hitch will help when separating the main line and tail.

The cow hitch will reduce the strength of the arrangement by approximately 15%.

Please follow the instructions closely, as cow hitches are quite often not properly installed.

Correct:



Not correct:

2.7 CERTIFICATION

In this section we are referring to question 9.1 in the OCIMF SIRE Vessel Inspection Questionnaire (VIQ7)

Lankhorst Ropes provides as standard a manufacturer’s certificate for each individual mooring line, connecting shackle and tail. Furthermore, Lankhorst Ropes has a DNV GL type approval for the manufacture of synthetic ropes used for mooring and towing. That means that Lankhorst Ropes issues a DNV GL L497 ‘Certificate of Test and Examination of Fibre Ropes’ for each rope supplied. All certificates should be kept and integrated into the ship’s Line Management Plan. Lankhorst’s Online Certificate Portal ensures you have 24/7 access to all your certificates. Please contact your account manager at Lankhorst Ropes for activation.

Rope traceability
Record keeping is essential for the safe use of mooring lines and tails. Each rope should be marked so that identification, certificate and service history can be tracked. Lankhorst high performance ropes carry a unique Product Identification Code (PIC). This PIC code is printed on a tape inside the rope and on the protective barrier in the eye. The PIC code corresponds to the factory number of each rope, providing an effective way of managing rope use and maintenance.

2.8 ROPE SOLUTION OVERVIEW

Mooring lines

single

LANKO®FORCE 143kg / 220m TCLL: 100%
ø 34mm

EWL tails of EUROFLEX® 53,7 kg / 11m TCLL: 79,6%
ø 72mm

double

LANKO®FORCE 143kg / 220m TCLL: 100%
ø 34mm

EWL tails of EUROFLEX® 46 kg / 11m TCLL: 79,6%
ø 56mm

single

6x36WS+IWRC 1.258kg / 220m
ø 38mm

EWL tails of EUROFLEX® 53,7 kg / 11m TCLL: 79,6%
ø 72mm

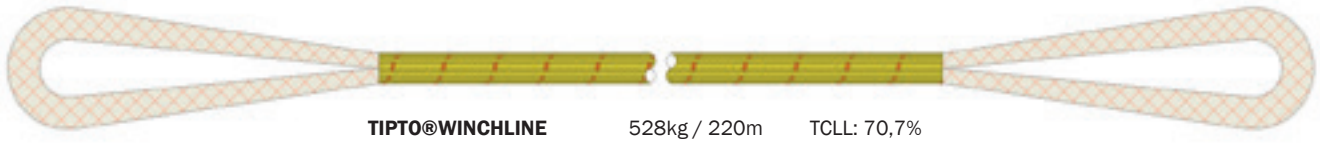
double

6x36WS+IWRC 1.258kg / 220m
ø 38mm

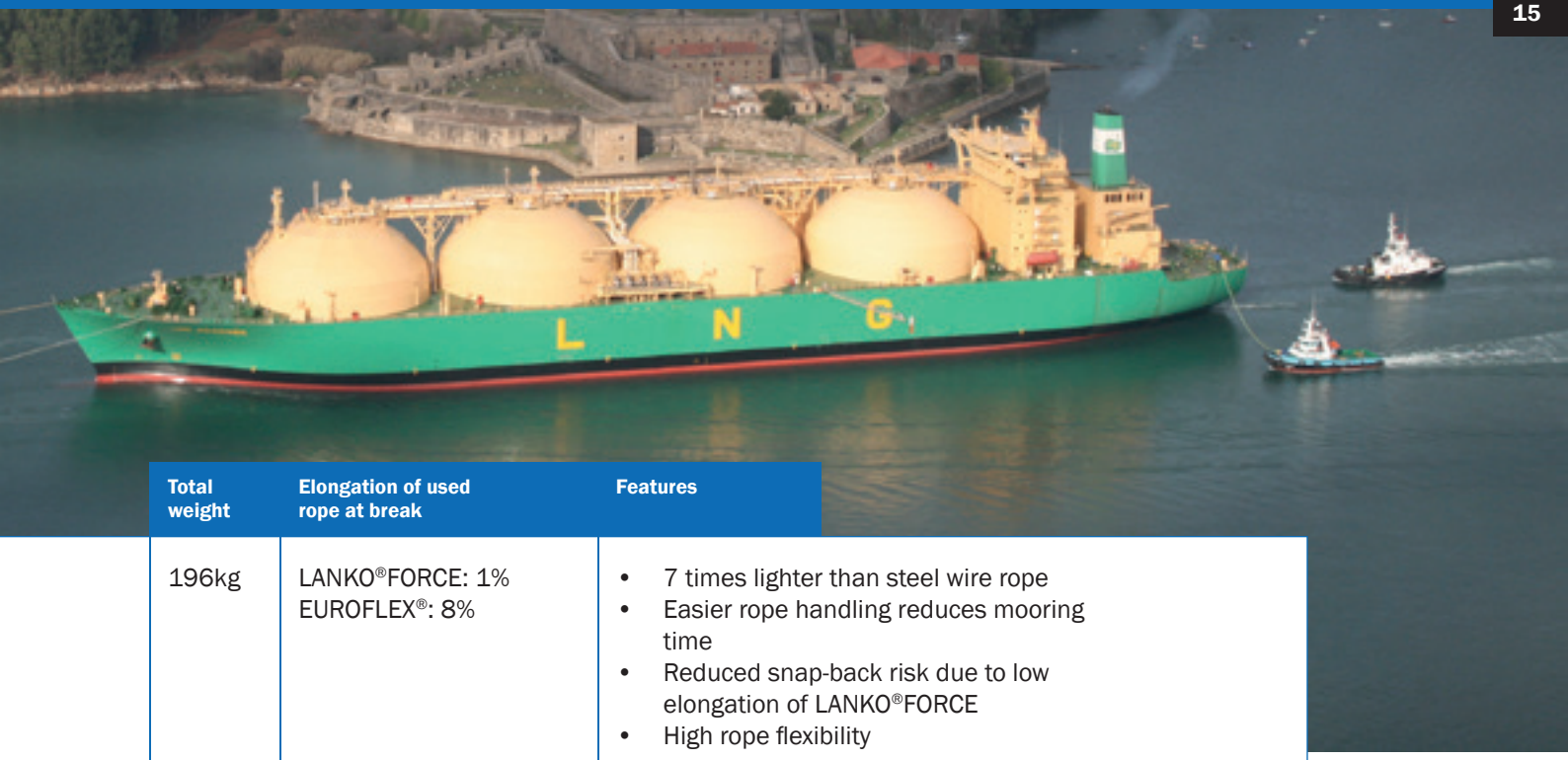
EWL tails of EUROFLEX® 46 kg / 11m TCLL: 79,6%
ø 56mm

EUROFLEX® 578,6kg / 220m TCLL: 79,6%
ø 64mm

EUROFLOAT® PREMIUM 605kg / 220m TCLL: 75,1%
ø 72mm



TIPTO®WINCHLINE 528kg / 220m TCLL: 70,7%
ø 70mm



Total weight	Elongation of used rope at break	Features
196kg 189kg	LANKO®FORCE: 1% EUROFLEX®: 8%	• 7 times lighter than steel wire rope • Easier rope handling reduces mooring time • Reduced snap-back risk due to low elongation of LANKO®FORCE • High rope flexibility
1.312kg 1.304kg	6x36WS+IWRC: 1-2% EUROFLEX®: 8%	• Traditional steel wire mooring system • Proven track record
578,6kg	EUROFLEX®: 8%	• Rope built for extremely long service life • Good heat resistance • Extremely high TCLL value and energy absorption • Excellent tension – tension fatigue resistance
605kg	EUROFLOAT® PREMIUM: 9%	• Floating rope, reduced risk of entangling in propeller • High TCLL value • Good tension – tension fatigue resistance • Good heat resistance
528kg	4,5%	• Excellent form stability on split drum winch • Outstanding abrasion resistance due to TIPTO® jacket • Improved safety due to non-load bearing jacket and bright yellow colour • A3 splice with 100% efficiency

3. ROPE SELECTION

A high standard of mooring rope management is essential for the safety of the crew. It is also essential to avoid mixing mooring ropes, this will lead inevitably to snapback, endangering crew and port personnel. Did you know that 95% of all accidents on board of ships are related to ropes and wire ropes? And that 60% of these accidents occur during mooring?* Furthermore, optimizing mooring operations is an important factor in achieving efficient loading and unloading – reducing unnecessary and costly delays and additional port charges.

STEP 1 ROPE SELECTION

Making the correct rope selection is vital. The cost-effectiveness and safety of shipping operations are dependent on selecting the correct rope. Lankhorst takes a holistic approach to prevent early failure of the rope.

See Lankhorst Ropes' Service Model on page 37.

Spending time on rope selection will pay dividends in terms of longer service life and increased safety. Weight, stretch, flexibility, abrasion and UV resistance, they all impact the rope's integrity. The Line Design Break Force (LDBF) is one of the leading factors when making the right rope selection. Besides safety, a proper selection also saves money over time. The cost of replacement and all expenses that are related to replacement (logistics, scrapping, crew handling) is often forgotten. A proper strategic rope selection saves time and money. Lankhorst Ropes has consistently taken a lead in enabling effective rope management from rope selection to online access to certificates and ultimately rope recycling.

* Source: London P&I Club

3.1 STRENGTH CRITERIA

One of the major changes in the Mooring Equipment Guidelines is the terminology related to the strength of the ropes. The ship design Minimum Breaking Load, Line Design Break Force and Working Load Limit are essential criteria to be aware of when choosing your mooring ropes and tails.

Ship design Minimum Breaking Load (sdMBL)
The sdMBL is the MBL of new, dry mooring lines for which a ship's mooring system is designed. This value is the basis for all mooring rope calculations.

Note: the MEG4 recommend to retire a mooring line or tail as soon as the residual strength has reached 75% of the ship design MBL.

Line Design Break Force (LDBF)
The LDBF is the minimum force at which a new dry, spliced mooring line will break when tested according to MEG4. This applies to all mooring lines and tails with the exception of Nylon, which should be tested in a wet condition.

The manufacturer states the LDBF on each mooring line manufacturer's certificate and on the technical datasheet of the product. MEG4 states that the LDBF should have a value between 100% and 105% of the ship design MBL.

Tail Design Breaking Force (TDBF)
Mooring tails experience more wear in service than mooring lines. For this reason, the Tail Design Breaking Force needs to be higher than the LDBF. The TDBF should be between 125% and 130% of the ship design MBL.

The manufacturer states the TDBF on each mooring tail manufacturer's certificate and on the technical datasheet of the product. Please be aware that the TDBF is tested and defined in a wet condition. So, this is different from the situation for the LDBF.

Working Load Limit (WLL)
During operation, the user of the ropes must take into account the Working Load Limit (WLL). The WLL is the maximum load that a mooring line should be subjected to in operational service. This value is expressed as a percentage of ship design MBL. For steel wire rope the WLL is 55% of the ship design MBL, for synthetic ropes the WLL is 50% of the ship design MBL.

3.2 ROPE APPLICATION

To make the right choice the supplier needs to have as much information as possible. The strength criteria are important to follow but a detailed description of the specific application is just as important. The purchaser should provide the supplier with the following information about the application and intended service of the mooring line:

- Ship type/size
- Winch design and arrangements (i.e. drum storage capacity)
- Fairleads (type, dimensions and conditions)
- Ship's likely trading area/pattern
- Potential berth arrangements
- Environmental conditions (i.e. temperature, wind, swell, current)
- Mooring analysis results

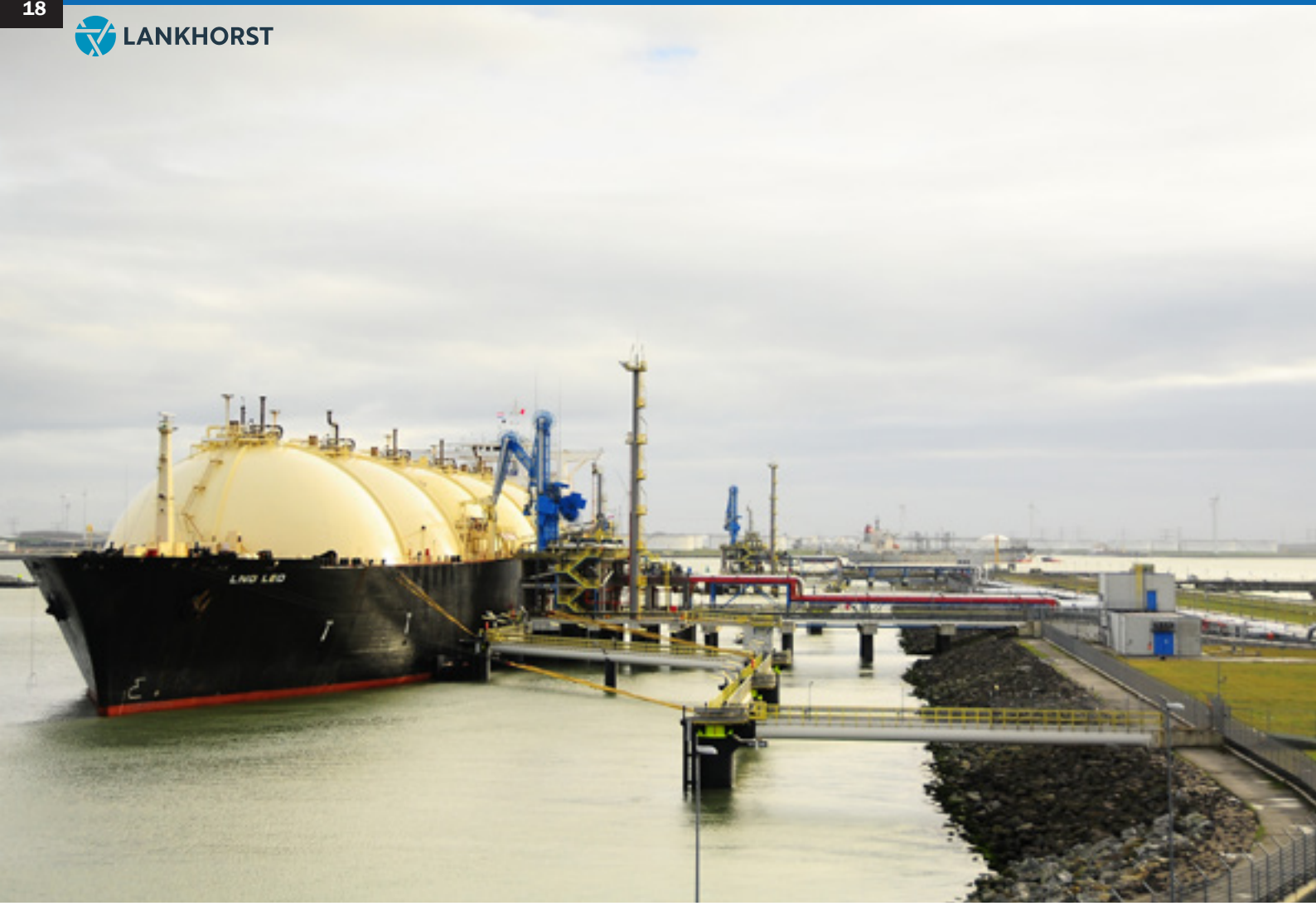
3.3 MAKE YOUR CHOICE

With the specified LDBF/TDBF and detailed information about the application; the next step is to determine the specification of rope you need:

- Material
- Diameter
- Length
- Construction
- Stiffness/elongation (for tails)
- Protection (jacket, chafe protection, coating)
- Colour
- Termination (soft eyes, hard eyes)
- Marking/certificate
- Quantity

The decision on the optimum mooring line should be made in the design stage to make sure that the line and equipment are compatible. When finally purchasing the ropes please pay attention to the following additional parameters:

- Packaging
- Transport/shipping
- Delivery terms
- After sales support
- Installation
- Training
- Inspection & Maintenance
- Testing
- Quality control procedures



4. FACTORS INFLUENCING MOORING LINE PERFORMANCE

As soon as the mooring lines and tails are in use the performance can be influenced by several factors. We have divided these factors into three main areas: Damage, Operation and Environment.

4.1 DAMAGE

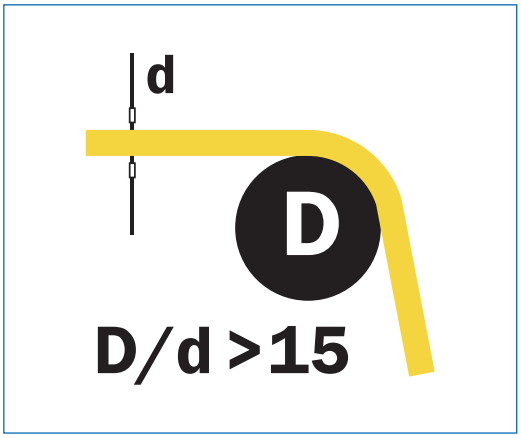
In this section we describe the common causes of fibre rope damage and how these can be minimized to extend rope service life.

4.1.1 BENDING FATIGUE – D/d RATIO

Bending the mooring line under tension will lead to a loss of efficiency. This efficiency loss is related to the D/d ratio.

D = diameter of the surface on which the rope is bending
d = diameter of the rope in use

The D/d ratio has a significant impact on the length of the rope's service life and should be as optimal as possible. The higher this ratio is, the longer the life time of the ropes will be. A minimum ratio of 1 to 15 is recommended, but the bigger the better. Please contact Lankhorst Ropes in case of any doubt with regards to your application.



The D/d ratio applies also to two ropes connected to each other by cow hitch or spectacle splice. If the two ropes are of equal diameter, the required ratio will be 1. However, if one rope is of a smaller diameter than the other, care needs to be taken to prevent the smaller rope cutting into the larger diameter rope. OCIMF MEG4 prescribes a D/d ratio >15. Lankhorst can assist in looking for options to meet this criteria.

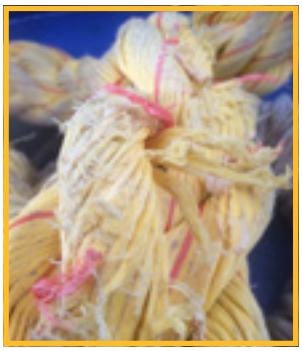
4.1.2 EXTERNAL ABRASION

External abrasion results from the contact between the rope and another surface of the vessel, such as the deck, fairlead, and bollard or if the rope comes in contact with the quay. These contacts and their effects will accelerate under high tension and when the rope moves against the surface, leading to fleece; shown by the rope's appearance becoming 'fluffy'. If this is not excessive, there is no cause for concern.

Although the rope may appear worn, there are millions of filaments in a rope, consequently, the strength loss due to individual broken filaments is very small. Only excessive fuzziness, which is a consequence of advanced rope service life and abrasion, should cause concern.

How to prevent or minimize external abrasion:

- ✔ Regular inspection
- ✔ Smooth surface
- ✔ Clean, smooth and rust-free fairleads
- ✔ Minimal contact with ship structure
- ✔ Protective jacket (see 2.5 on page 12)
- ✔ Chafe protection
- ✔ Proper use of mooring lines and tails.



4.1.3 INTERNAL ABRASION

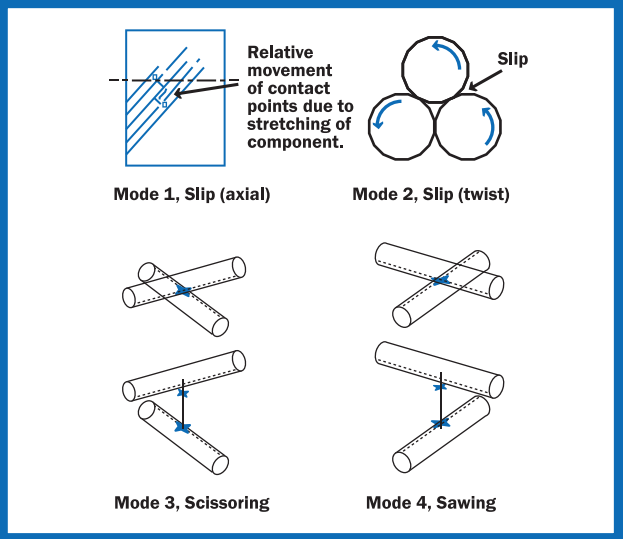
Internal abrasion results from yarn-to-yarn contact and friction, both within the rope structure and between inner and outer strands. An elongating rope, running through a fairlead or around a frame will cause the yarns to move against each other. This is normal for working ropes and cannot be avoided. Yarns laid in a longitudinal position will rub against each other, yarns crossing each other will scissor or saw into each other. These relative movements between the yarns can lead to abrasion and fleece forming on the surface of the yarns inside the rope.

Damage from this mechanical action is accelerated by higher tensions, higher temperatures, and higher coefficients of friction. If the fleecing is not excessive, there is no cause for concern. Yarns with a better natural resistance against abrasion will suffer less and last longer under the same conditions. Coatings can significantly reduce the effects of friction and thus abrasion on the yarns.

The problem with abrasion inside the rope is that it is a lot more difficult to spot than external abrasion. One would have to open the rope to see the fleece on the yarns. This is especially difficult with jacketed ropes.

How to prevent or minimize internal abrasion:

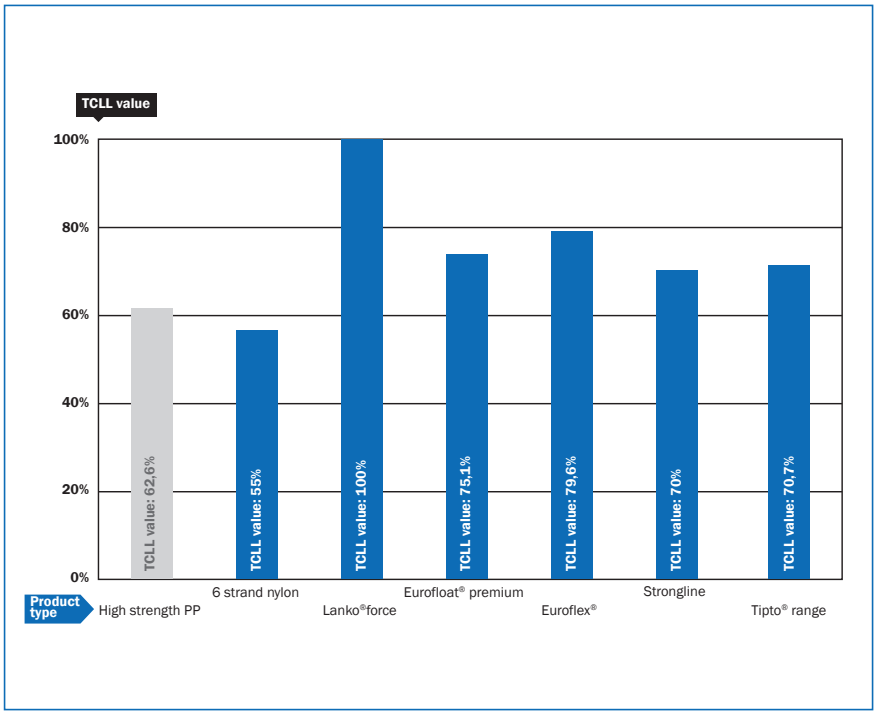
- ✔ Coatings
- ✔ Construction choice
- ✔ Storage procedures
- ✔ Protective jackets
- ✔ Handling procedures.



4.1.4 TENSION-TENSION FATIGUE

Tension-tension fatigue occurs under conditions of cyclic loading. High Performance Fibres (HMPE, LCP, and Aramids) are characterized by having long tension-tension fatigue life, while steel wire is known to have a moderate tension-tension fatigue life.

A new synthetic rope has a specific Line Design Breaking Force (LDBF). When ropes are first put into use, they tend to increase in strength, however, the increase is not substantial. This is due to elongation during mooring or a pull, which can be compared to a bedding in process. Once the rope has reached its full strength, it will work at this level. In time the yarns will gradually start losing their strength, due to tension-tension fatigue. The ABF (actual breaking force) of the rope will decline and eventually, the rope will break under a normal load.



Mooring ropes are subject to dynamic loading; dynamic loading describes the ever-changing load on the rope due to movement of the vessel. The maximum loading should always stay below the designed maximum which, as a rule of thumb, should never exceed the 50% of the LDBF of the rope. Dynamic loading will cause fatigue in the yarns that will eventually result in loss of strength. This is impossible to detect from the outside of the rope.

A Thousand Cycle Load Limit (TCLL) test is commonly used to expresses the rope resistance against tension-tension fatigue. TCLL expresses the maximum percentage of the nominal breaking strength at which a rope can be cycle loaded 1000 times as tested under strict laboratory conditions.

Lankhorst Ropes designs ropes to provide long service life. To achieve this, Lankhorst has determined the TCLL value for each rope. An average polypropylene rope will have a TCLL value of about 52%. STRONGLINE™ has one of 70%, TIPTO® 71%, EUROFLOAT®PREMIUM 75%, EUROFLEX® 80% and LANKO®FORCE (Dyneema®) 100%.

By choosing the right type and length of mooring lines/tails you can prevent or minimize the tension-tension fatigue.

4.1.5 AXIAL COMPRESSION FATIGUE

Ropes with a braided cover or extruded jacket on a load bearing core are subject to axial compression. This mostly occurs when the jacket is very tight. The rope should be inspected if axial compression is suspected. You can recognize axial compression from bands of kinked fibres or yarns in the inner core.

If the rope's jacket cannot be removed; destructive inspection or testing is the only option. Axial compression can also be a problem for high strength, high modulus ropes.

Source: Cordage Institute, International Guideline CI 2001-04

4.1.6 HOCKLE, KINK, CORKSCREW

A synthetic rope will tend to hockle when tension is applied. Once a hockle has occurred, the rope's structure cannot be restored; the rope is permanently damaged.

Similar problems can also occur in steel wire ropes with too many twists. When the twists are concentrated in a specific length of steel wire rope this can lead to kinks. If the kinks cannot be put back into the steel wire rope there is probably serious damage to the rope.

A further issue that can occur in steel wire ropes is a 'corkscrew'. A corkscrew occurs when one or more strands move into the rope body, pushing the other strands outwards. If these strands cannot be pushed back, the rope has probably been damaged too much and should be replaced.

Source: Cordage Institute, International Guideline CI 2001-04

4.1.7 CREEP

Creep is the elongation of a material when subjected to a prolonged static load at an elevated temperature. The deformation is generally irreversible.

Several factors can influence the creep rate, namely the specific fibre properties, temperature, load and time under load.

How to prevent or minimize the effect of creep:

- ✔ Keep ropes within safe working limits
- ✔ Choose the right rope fibre / construction
- ✔ Choose a bigger diameter rope.

4.1.8 OVERLOAD OR CUT

If a rope breaks it's important to identify the cause. In the event the rope was overloaded, the cause of the rope break will be obvious. The rope was probably broken at the weakest point, but the yarns in the remaining rope will certainly also be damaged. The rope must be discarded over the full length exposed to the overload. If there was no overload, and the rope still broke, the rope might have been weakened on a previous occasion, still holding out at that occasion but now breaking on a new job.

In the case of a 'clean cut' usually the rope is still intact. The rope has been damaged probably by a (sudden) contact with a (sharp) object. A survey of the remaining rope is needed and if it looks alright the rope can be repaired and used again.

How to prevent or to minimize the risk of cuts:

- ✔ Regular inspection hardware on sharp objects
- ✔ No crossing with other ropes
- ✔ Chafe protection.

4.1.9 COMPRESSION

Compressing the rope will damage the yarns, causing a weak point in the rope. Compression is caused by pressure on the rope from the side. For example a crossing point of two ropes (or the same rope, see photo), when the rope makes a short bend over the railing of the vessel and in a fairlead or rollers that are too small in combination with a high load on the rope. On a low D/d ratio the inside yarns are compressed and the outside yarns are over stretched.

A contact point where under high tension rope compression can appear on the yarns. When a rope is in this position it will start running around the warp head, leading to increased wear on the rope's jacket.

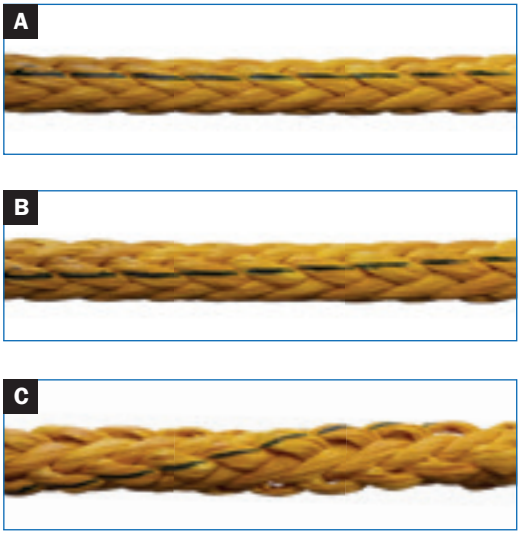
4.2 OPERATION

In this section we review the risk to ropes from everyday use such as the incidence of rope twist, bend loss and dynamic loading and how these can be reduced, and thus increase service life.

4.2.1 INDUCED TWIST

Braided ropes are torque free. Nonetheless, care should be taken not to induce a twist in the rope. If the rope shows evidence of an induced twist, action needs to be undertaken to eliminate or at least minimize the twist. During rope handling, twists can arise due to working at multiple angles. Twists reduce the service life of the rope considerably, through decreasing the LDBF and the rope's loss of efficiency. The higher the number of twists per meter, the higher will be the loss of efficiency.

Braided ropes have an equal number of right-handed and left-handed strands. The forces are divided equally on all strands when the rope lies straight. When there are too many twists on a braided rope this will result in disproportionate forces on the strands. The half of the strands will be more tightened by the twist and so will be more heavily loaded, the other half of the strands barely. As a result, the excessively loaded strands are working harder causing them to fatigue much more quickly than the less loaded strands. In the worst case scenario the rope will break.



Different levels of twist. A - acceptable level, B - maximum twist, C- reduce twist

Try to avoid getting twist in the line as much as possible. If twists are already in the line, please get them out as soon as possible. Marker lines can help you to detect twists more easily.

How to prevent or minimize twisting:

- ✔ Proper installation on drum
- ✔ Proper line handling
- ✔ Regular inspection
- ✔ No mixed mooring, match constructions
- ✔ Trace marker.

4.2.2 BEND LOSS

All (synthetic and steel wire) ropes lose strength when bent over a radius. Bending a rope under tension will eventually lead to internal and external abrasion. This will happen when a rope runs frequently on a pulley, over a roller or over another surface. Frequent bending over a surface with a small D/d ratio also causes fatigue damage. The rope fibres will probably be matted on the outside and glazed from the build-up of heat caused by friction on the inside. Inside the rope, filaments can break in the bending area; this damage will result in strength loss as well as significantly decreasing the service life of the rope.

Source: Cordage Institute, International Guideline CI 2001-04

4.2.3 DYNAMIC LOADING

Under extreme conditions, dynamic loading (often referred to as shock loading) can play a negative role with regard to the rope and tail's performance. Dynamic loading is an ever-changing load on the rope due to movement of the vessel, where overloads or shock loads can occur.

The maximum loading should always stay below the designed maximum and so should never exceed 50% of the LDBF of the rope. Dynamic loading will cause fatigue in the yarns that will eventually result in loss of strength. This is impossible to detect from outside the rope. The history of the rope (log book) will tell you if the rope has been subjected to an overload or shock load.

Shock loads happen when a high load is suddenly applied to the rope, typically greater than a 10% increase in tension. As a result of a shock load the rope may fail later. If a shock load is suspected, the rope should be inspected. A symptom of shock loads could be melted fibres or increased stiffness of the rope on the affected section. Conservatism in evaluating this condition is advised, the rope should be discarded if shock loading is suspected. Please contact Lankhorst Ropes for advice.

Source: Cordage Institute, International Guideline CI 2001-04

4.3 ENVIRONMENT

In this section we review the wide range of environmental conditions in which fibre ropes are used and their effect on rope service life.

4.3.1 UV DEGRADATION

All synthetic materials are sensitive to sunlight. Lankhorst minimizes the risk of UV radiation to its ropes by treating them with UV stabilizers during production. These stabilizers significantly increase the service life of the rope. The dosage is based on the highest intensity of UV, the levels typically found at the Equator.

If UV degradation occurs, splinters show up in the rope. Splinters are sharp edged yarns poking out of the rope. UV radiation will penetrate only a few millimeters into the rope. Therefore, a thicker rope will be less affected by UV.

Dyneema® has a very good resistance against UV. For jacketed ropes, UV will be less of an issue anyway as the jacket is a non-load bearing member and it will protect the load bearing core fibres from UV penetration. High temperatures have a huge impact on the tensile properties of all common high performance fibres. Care must be taken to prevent the rope from overheating.

How to prevent or to minimize the risk of UV degradation:

- ✓ Minimize exposure to UV
- ✓ Protective jacket
- ✓ Regular inspection
- ✓ Proper storage.

4.3.2 ELEVATED TEMPERATURE

Melted and fused fibres are the consequence of excessive heat. This can occur as a result of elastic energy released as heat caused by friction or other external heat sources, such as hot deck or chocks/ fairleads.

A different colouration (glazed or glossy appearance) will be evident. In the case of burning, the combustion will leave a hard, black residue of molten plastic. Visual inspection may be difficult in a used rope. Spots of fused fibre will feel hard and coarse to the touch. The filaments cannot be pulled apart without breaking.

4.3.3 REDUCED TEMPERATURE

Mooring at sub-zero temperatures (arctic circumstances) affects the performance of ropes and tails. Ice forms on the ropes. The ice crystals are sharp resulting in an increased risk of rope damage both inside and outside the rope. Furthermore, the cold may affect flexibility and strength. You can use synthetic ropes without any problem within a temperature range of plus 50 °C and minus 20 °C. For lower temperatures please be aware of a significant decrease in the service life of the ropes. Lanko®force (Dyneema®) is an exception in this context. This rope can be used up to 70 °C. And if the temperature is below 0 °C, the strength of Lanko®force will increase.

How to prevent or minimize the effects of sub-zero temperatures:

- ✓ Regular inspection and maintenance
- ✓ Protective jacket/covers
- ✓ Work with a higher safety factor if temperature is below minus 20 °C.

4.3.4 CHEMICAL DEGRADATION

In general, synthetic ropes are not sensitive to soft cleaning detergents or fuels. However, there are many other chemicals that can destroy the properties of the synthetic fibres within moments.
The rope should never be put in operation after it has been contaminated without first determining the nature of the contaminant and establishing that it is not hazardous to the material.

A change of colour or change of appearance could indicate damage arising from exposure to chemicals; but you need visual inspection to know for sure. The inspector will look for discolouration and brittleness in the fibres. Other typical findings from chemical degradation include melted areas, bonding of fibres, hardening and stickiness. These manifestations are not always present. That's why the inspector should use the log book (history of the rope) as well.

In the event of exposure to the chemicals, please replace the rope immediately. Before reusing the rope, it must be inspected. Please contact your supervisor or Lankhorst directly if you are in any doubt.

4.3.5 CORROSION

Steel wire ropes are subjected to corrosion. Moisture and oxidation will influence the performance of the steel wire rope. There are no standard tests for this issue. Please be aware that steel wire ropes should be lubricated to prevent accelerated fatigue.

Contrary to steel wire rope, a fibre rope does not have any corrosion issues, so lubrication is not needed.

4.3.6 OVERLOAD

The Working Load Limit (WLL) is the maximum load that a mooring line should be subjected to in operational service. If the maximum load exceeds the WLL, for synthetic ropes this is 50% of the rope ship design MBL, we refer to this as an overload. Overloading a rope can cause significant loss of strength and reduce service life. It can be difficult to determine if there's been an overload. Next to visual inspection, checking the log book (history of the rope) will help.

5. INSTALLATION AND MAINTENANCE

In this section we are referring to question 9.17 in the OCIMF SIRE Vessel Inspection Questionnaire (VIQ7)

For optimal safety on your vessels, it is recommended that you implement a scheduled maintenance program in use for rope maintenance, inspection and retirement.

In this chapter all related issues with regard to rope maintenance will be reviewed. In chapter 6 we pay particular attention to the inspection and retirement. Rope maintenance, inspection and retirement should be an integral part of the mooring line specification and selection process and documented in the ship's Line Management Plan (see chapter 7).

For rope inspection and discard guidance, OCIMF MEG4 refers to the following industry standards:
ISO 4309 - the care and maintenance, and inspection and discard of steel wire ropes used on cranes and hoists. And CI-2001 - Fiber Rope Inspection and Retirement Criteria.

5.1 INSTALLATION

Care should be taken when installing a new rope to ensure safe operation and long service life. In this section we describe the preparations you must take when first handling and installing the rope, the installation options for different types of winches, rope storage and repair.

STEP 2 ROPE INSTALLATION AND CREW TRAINING

Lankhorst Ropes is committed to equipping crew with the knowledge and skills needed to ensure safe use of fibre ropes and maximum service life. Specifically, we provide:

- Training on rope handling
- Splicing instructions
- Installation on new (shipyard) or existing (ports) vessels
- Hardware inspection including all on-vessel equipment.

See Lankhorst Ropes' Service Model on page 38.

Preparation

New ropes are supplied to the vessel either on a reel or as a coil. It is imperative that ropes are spooled on the drum of a winch without any twist in the rope. A twist in the rope, in combination with a high load on the rope (once put to work), may lead to reduced service life. Some yarns will be overstressed and others hardly contribute to the holding power. The rope in a coil should not be taken from the top of the coil. The coil must first be unwound to remove twists in the rope. This can be done by means of a turntable or by putting the coil on a cross and hanging it from a crane with a turnbuckle. Spool the rope until it is flat on the quay without any twists. Spooling onto the winch can then commence. Before the rope is laid out on the quay, the area to be used should be inspected and cleaned from any type of particle that could penetrate and damage the rope immediately or in the long term. Nails, sharp steel objects, grit, and glass shards, for example, should all be removed before the rope is run out on the quay.

Smooth path for the rope

Synthetic ropes are sensitive to external damage. Any sharp edges, cracks in steel, burrs or any other means of rough surface, especially in combination with a high tension on the synthetic rope, are hazardous for the rope. It will cut into the rope from the side, destroying the outer yarns, causing an immediate loss of strength in the rope. This is particularly important on vessels that alternate between using steel wire rope and synthetic ropes. An exception is, of course, a rope with a non-load bearing jacket. Such a rope will also be damaged by a rough surface, although the jacket can be (partly) destroyed without losing strength in the rope. The jacket must be repaired (see Appendix A) as any further damage to the rope core will immediately affect the properties of the rope. The vessel should be prepared for the ropes in such a way that any contact point between the vessel and the synthetic rope, the A-frame, a fairlead, the stern are covered with polished stainless steel plating.

Before the spooling can commence, make sure the path of the rope is free from sharp edges or any other imperfections that may cause surface damage to the rope. The bollard must be absolutely smooth, preferably polished. Once the rope has been installed on the winch, if is not to be used for some time the rope should be protected using the winch cover.

Installation of the rope on the drum

Installation of a fibre rope on a winch drum requires a great deal of care. The construction of synthetic ropes makes the installation of the rope different from installation of steel wire rope. It depends on the type of drum: single drum or multi (split) drum, a plain surface drum (without groove) or a grooved drum and a single layer or multilayer drum.

Type of drum
In general, there are two types of winch drums used for mooring: split and undivided drum designs. When using a split drum winch design, the rope is divided between two drum sections: storage and tension sections. The biggest advantage of this design is that tension is mainly built up on the tension side of the drum, and none or only low load is transferred to the rope on the storage side. The rope used in the tension section is preferably using only 1 layer (in order to prevent diving issues). The minimum number of wraps to be used on the tension side is dependent on the Coefficient of Friction (CoF) of the rope. For ropes with a low CoF (like HMPE) the minimum number of turns is 8-10, for high friction ropes a minimum of 5-6 turns is needed. In case of any doubts, please contact Lankhorst Ropes for further information.

When using an undivided drum in a multilayer spooling arrangement, the rope must be correctly spooled and tight onto the drum. This can be done by applying back-tension and the use of a spooling guiding system to create a solid base, preventing possible diving of the rope in between the layers. If there are ≥3 layers used on the drum, the risk of serious diving issues is, in general, low.

Example of a split drum

Example of an undivided drum

Drum profile; grooved/un-grooved
In general, we recommend the use of an un-grooved, plain drum, when using synthetic ropes, for routine mooring applications. The use of a grooved drum type is, in principle, only usable for jacketed, or at least more firmly constructional types of fibre ropes. It is important to make sure that the groove radius is min. +10% of the nominal rope diameter and that the groove top is round and smooth.

Rope connection to the drum
The rope end connection to the drum can be made in many different ways. The most straightforward way of connecting the rope is by guiding the plain rope-end through a hole in the side flange or barrel of the drum, and clamping this end by using a steel plate(s) which can be tightened by several bolts. When using this type of end connection, it's very important to respect the minimum number of turns advised to remain on the drum at all times, this is in order to prevent too much load being transferred to the rope slot and the rope pulled out of it unexpectedly. The min. number of turns which needs to be made is dependent on the type of rope and winch design used. In general it should be min. 5 till 10 wraps. It is possible to reduce the number of wraps by using a winch eye end connection (this a

Correct installation is important

small and short eye with a limited MBL compared to the complete rope capacity, and only to be used for installation and winch connection purposes) which then can be placed around a pin/bollard type end connection outside or inside the drum. Another option is to provide the original rope with two spliced eyes at both ends and secure a smaller pre/runner to this at one of the ends (by using a cow hitch or spectacle splice). This smaller diameter pre-runner can then be spooled on the bottom layer of the drum and secured to the winch. The benefit of this option is that it makes it relatively easier for the rope to be end-for-ended (turned around) without the need for onsite splicing.

Pre-tension

Key to the proper functioning of the whole spooling system is the initial rope installation. During the installation process, the constructional elongation of the rope should be removed as much as possible - a rope bedding-in process enables the rope layers to run smoothly over each other, reducing potential abrasion issues. The back-tension during the initial installation should be between min. 2% and 5% of the rope MBL; this could be achieved by using a spooling machine with a back tension capability, or alternatively by making a figure 8 around bollards available on board. Spooling the rope onto the winch without proper back-tension might not seem to lead to improper spooling, but it can still cause serious problems later on during an actual operation, such as diving issues etc.

WARNING:

Working with ropes should be restricted to qualified personnel.

The following practices must always be respected:

- ✔ Check if ropes are free of damage and protect ropes from sharp edges and rough surfaces.
- ✔ Keep fingers, toes, etc. clear when tensioning.
- ✔ Don't use damaged or contaminated ropes or accessories.
- ✔ Don't use ropes that have been in contact with
- ✔ chemicals or heat without the manufacturer's approval.
- ✔ Don't twist, knot or tie ropes.
- ✔ Don't load ropes beyond their Safe Working Load.
- ✔ Don't drag ropes over floors or other surfaces.
- ✔ Don't allow anyone to pass under the ropes in use, or during spooling.
- ✔ The snapback area should be kept clear at all times.

5.2 STORAGE

This section contains useful information for your Line Management Plan

All synthetic ropes should be stored in a clean, dry area; out of direct sunlight and away from extreme ambient temperatures. Furthermore the risk on contact with chemicals should be minimized. Oil and petroleum products will not damage the ropes but it's better to avoid contact with these materials as well. The most likely (potential) causes of damage to synthetic mooring ropes are mechanical abrasion and cutting (sharp edges, rough surfaces), high temperatures (welding, weld splash, torches), chemicals and prolonged exposure to direct sunlight. These sources of damage should be considered at all times when handling and storing the ropes. Packaging material should be carefully removed without cutting or damaging the ropes. The securing material attached to the packaging will still be under high tension and may snap back when cut. Extra care should be taken.

WARNING:

- ✔ Wet ropes picks up particles and grit
- ✔ Never heat dry!
- ✔ Cover the ropes
- ✔ Store in a dark, dry, well ventilated area.

5.3 REPAIR

This section contains useful information for your Line Management Plan

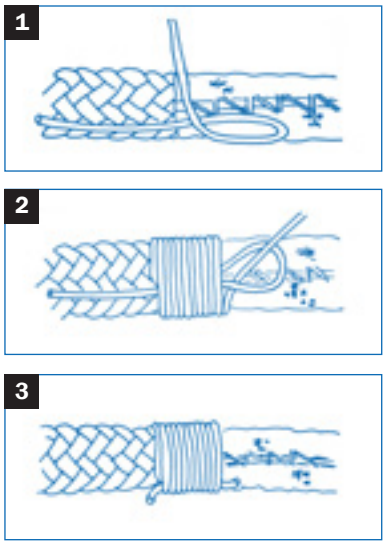
Inevitably the rope will be damaged at some point. In most cases the rope will be repairable. In this section we show you how easy it is to quickly repair the rope and put it back into service.

Seizing

If a rope has been abraided in a certain area, or when the jacket of a rope has been ruptured over a relatively short distance, the rope can be repaired with a seizing. A seizing can be made easily on the vessel. If available, use untreated nylon, preferably a flat nylon braid. After the seizing has been made, pour hot water over the nylon. It will shrink and thus tighten the seizing around the rope.

Small repairs

The most durable method of making small repairs to the jacket braid requires the use of polyester braided whipping twine. Remove all the damaged yarns and tuck the free yarn ends back into the core, in order to prevent further unraveling of the jacket. 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. With the working end of the twine, make multiple wraps around the rope from the tail end toward the eye 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 bitter 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 jacket 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.



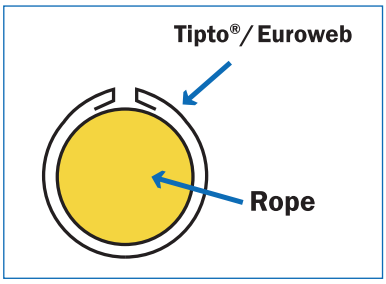
Three steps of putting a seizing over a rope. This can be done on any open plaited rope and on a jacketed rope

Extensive repairs

For extensive repairs, the following tools are needed: TIPTO® or Euroweb, some sewing twine and a large sewing needle. Optionally, additional protection can be obtained by using a two-component polyurethane. Remove all the damaged yarns and inspect the rope. Optionally, the free yarn ends can be tucked back into the core in order to prevent further unraveling of the jacket. Wrap the damaged part in the web cloth. Please note that the sides should be folded back. Stitch the web together using a special knot that will prevent the stitching yarn from loosening when it is torn.

Protect the beginning and the end of the web 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 ten centimeters. 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 bitter end or tail of the twine until the loop slides completely out of sight. Clip the ends close to the whipping.



Note: repairs, even if performed in the most perfect way, will never provide the same protection as the original braided jacket. Lankhorst Ropes strongly recommends that fairleads and roller and all other rope contact points are inspected at regular intervals for burrs, grooves, rust, etc.

Repairing a damaged jacket

When the rope 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.

Splicing

Is your synthetic mooring rope damaged? It's recommended to cut off the damaged part of the rope and to splice a new eye into the remaining length. For guidance on splicing please consult our website (www.lankhorstropes.com).

Conventional splice

At the end of a rope, an eye can be formed by turning the rope back onto itself and splicing the rope back into the rope itself. This is an old technique, well accepted throughout the world. Many people are still able to make a splice into a simple laid rope. Less people nowadays are familiar with the eight or twelve strand plaited constructions. Only a few have the skills to make a good splice in parallel laid cores with an overbraided jacket. The splicing technique involves tucking strands back into the construction several times. No adhesive or other means of holding the strands in place are applied. The splice will hold if done properly. But the holding power of the splice depends on the material (coefficient of friction) and the construction of the rope. Each Lankhorst rope construction has its own specific splicing instructions. In the conventional splice, one should reckon with a 10% loss of strength. Despite careful splicing, the strands, and thus the fibres, are displaced throughout the splice area. At the end of the splice, the strands will return to their normal position. However, this transition point will be the weakest point in the rope. If a rope is pulled to destruction in a straight line, it should break at this point.

A3 splice

Lankhorst Ropes has developed a new splice called the A3 splice. This method of splicing is unique in the world and has been patented by Lankhorst Ropes. The concept of the A3 splice is that the splice and the eye have been fully integrated. Years of development, and field trials, have resulted in the A3 splice, providing a higher efficiency. In addition, the A3 splice handling advantages include:

- ✔ No doubling of the rope in the splice area, therefore no doubling of the splice weight
- ✔ No stiffness due to the splicing, the rope maintains its natural flexibility
- ✔ Neater spooling on the storage drum of the winch if the line has an eye at both ends.

5.4 WEAR ZONE MANAGEMENT

Most of the damages on mooring lines are caused by the daily, regular mooring activities. The location and level of damages depends on several factors, such as:
- variability in ship trading patterns
- variability in terminal layout and design
- mooring tail length and material
- ship movements while at the terminal
- environmental condition
- laden or ballast ship.

To reduce the risk of rope damage it is recommended to use wear zone management techniques. This is especially useful for vessels with regular trading patterns. To manage wear zones effectively, operators should document this within the Line Management Plan.

Source: OCIMF, Mooring Equipment Guidelines fourth edition 2018

6. INSPECTION AND RETIREMENT

In this section we are referring to question 9.17 in the OCIMF SIRE Vessel Inspection Questionnaire (VIQ7)
This chapter contains useful information for your Line Management Plan

With use, especially over a longer service life, a rope's properties may change. The yarn will decline, the strength of the rope will decrease and in the worst case scenario the rope will break under a normal load. To avoid an unexpected break the ropes must be inspected on a regular basis. This can be done periodically or after a pre-determined number of jobs. The intervals will depend on the circumstances in which the ropes are used. Lankhorst Ropes can assist in determining the ideal inspection frequency.

STEP 3 INSPECTION / MAINTENANCE ADVICE / TRAINING

Regular inspection is important in ensuring maximum rope service life. In addition to the crew training on rope handling and inspection, Lankhorst Ropes will make periodic visits to the vessel in port to undertake:

- Hardware inspection
- Full length rope inspection
- Update crew training
- Produce an inspection report.

See Lankhorst Ropes' Service Model on page 38.

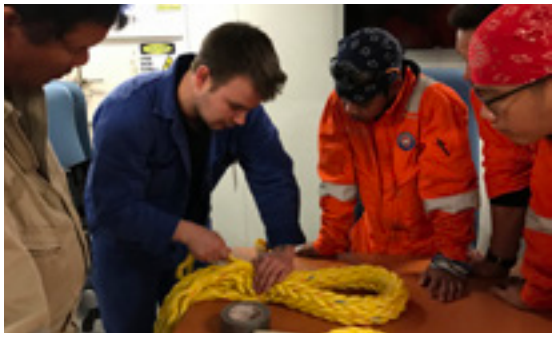
6.1 QUALIFIED PERSON

Lankhorst Ropes recommends that on each vessel and on each project a dedicated, qualified person is assigned to take responsibility for the ropes. This can be someone of your own organization or an external person.
He or she should take care of the proper storage of the ropes when they are not in use, for repairs when necessary, for visual rope inspections at regular intervals and other precautions that will increase the service life time of the ropes and the safety on board. Whenever the ropes are being used, one of the dedicated persons should be present.
Lankhorst Ropes trains your staff to become qualified for visual inspections and repairs and thus become qualified persons. Finally, the manufacturer is the ultimate source for visual inspection, break tests and repairs.

The qualified person will decide if the rope:

- ✓ can safely remain in service and for what period of time (until a next periodic inspection)
- ✓ needs to be repaired (which warrants a subsequent inspection)
- ✓ must be discarded.

Furthermore, the qualified person should have first-hand knowledge of the operations and conditions that the rope has worked in.



6.2 INSPECTION FREQUENCY

Synthetic ropes should be inspected on a regular basis. The frequency of inspection depends on many factors: How often the ropes are used and for what period of time? What are the risks involved in the next operation? What were the environmental conditions during the last rope operation, and which conditions will the upcoming operation have?

Periodic inspection
We advise to do a periodic inspection of all mooring ropes in use twice a year. The qualified person will ultimately define the necessary timespan between periodic inspections. For a periodic inspection many aspects should be checked, such as:

- ✓ Traceability: identification and certificate
- ✓ History log book
- ✓ Rope and strand surface fuzziness
- ✓ Broken yarns
- ✓ Twist
- ✓ Kink in yarns
- ✓ Discoloration
- ✓ Particle ingress/contamination
- ✓ Splice integrity
- ✓ Heat damage.

Event inspection
If, for some reason, it is suspected that an event has caused damage to the rope, an event inspection must be made. Such events could be:

- ✓ Suspected shock loads
- ✓ Chemical contamination
- ✓ Exposure to high-voltage
- ✓ Rope crushed by external bodies
- ✓ Audible cracking noises originating in the rope
- ✓ Accidental twisting of ropes.

The results of the inspection should be logged in the inspection logbook, regardless of the evaluation of the condition of the rope. Should a rope break, an event inspection should be made to determine the conditions that led to the incident. In this case, examining and describing the ends of the broken rope will provide vital clues. In case of rough mooring conditions additional inspections are recommended.

6.3 ADMINISTRATION IS KEY

To interpret the outcome of the inspections in the correct way a log of estimated loads and an inspection logbook should be kept.

Record of loading history
A log of estimated loads and time of operation should be kept for every job. Unusual circumstances, such as suspected peak loads, or environmental conditions should be registered. This record will provide end users with a qualitative evaluation of the lifespan of the rope against a previous history of loading operations.

Inspection logbook
The inspection logbook is a registry of the evaluation of the condition of the rope following periodic and event inspections and of changes in said condition. The information gained from an inspection is used to assist in updating the operational boundary conditions for the ropes. In the case of event inspections, the motivation for it should be clearly stated. The evaluation of the damage to a rope is never clear-cut nor completely objective. A retired rope should be discarded. Where a repaired rope is still in service, this should be clearly marked on the repaired rope and in corresponding logbooks.

6.4 VISUAL INSPECTIONS AND RESIDUAL STRENGTH TESTS

Visual inspections are a practical and easy way of checking the condition of ropes. A more precise way of determining the rope quality at a particular point is to take a sample and have it analysed at Lankhorst Ropes' test facilities, including a break test to determine the residual strength in the rope.In any event, the attentiveness of the crew while working with the ropes is essential. If any defects appear on the rope between regular inspections, a further investigation should be undertaken without delay.

Note: The OCIMF MEG4 recommend to retire a mooring line or tail as soon as the residual strength has reached 75% of the ship design MBL.

STEP 4 RESIDUAL STRENGTH TESTING

Lankhorst Ropes will provide a continuous residual strength testing program in order to assist in determining the best moment to change the rope end-to-end in order to ensure the best economical life time and to optimise safety on board. We believe this should be based on mooring hours, i.e. the number of hours a line has been used in mooring the vessel. This can be quantified by vessel and reported back to the manufacturer. Other factors which ought to be taken into consideration are local environmental conditions at the ports and terminals.

See Lankhorst Ropes' Service Model on page 39.

STEP 5 RECYCLING OF ROPES

The rope testing and recycling programmes can be combined. Ropes which are returned for testing and deemed unusable, can be used for recycling into other polymer products. On the image you see an offshore vessel with KLP® Deck Covers made by Lankhorst Engineered Products.

See Lankhorst Ropes' Service Model on page 39.

LANKHORST

What to look for during inspection
Visual inspection is mostly about spotting inconsistencies in the rope. Where the rope appearance is different from the rest of the line or compared with when the line was new; this indicates that something has happened to the rope at that point. There are several aspects of the appearance of a rope, which should be monitored. Wherever, for instance, a rope section's color, diameter, rope braid structure appears different from the surrounding rope, this is a point that warrants closer inspection.

Inconsistent rope diameter
An inconsistent diameter could either be a reduced diameter or increased diameter of the rope. If the rope shows deviations in the diameter of the body, especially with jacketed ropes, you should be alarmed. The rope probably has been damaged during a previous job and should be taken out of operation immediately. A thorough inspection is needed. An increased diameter, such as a knot, could be the result of a kink or a very sharp bend while under tension. A reduced rope diameter could indicate the rope has been overloaded in a previous job and suffered plastic deformation. If there is no abrasion evident on the surface, it could be an indication of unbalanced load distribution of the rope elements. Broken strands, as well as poor handling of the rope can be reasons for this symptom. The same factors can lead to bulging diameters at other points on the rope.

Measuring rope diameter

The diameter can be measured by using a tape. Firmly wrap the tape around the rope and mark the adjacent wraps. Measuring between the two marks (with the tape stretched) will give the circumference of the rope cross-section. Dividing by π (3.14) will give you the diameter. For less uncertainty in the measurement, two or more loops can be wrapped, but remember to divide the measured length by the number of wraps.

Discard criteria
If the rope diameter changes by 10% or more within the length of one braid pitch, the rope should be discarded.

Pulled yarns/strands
Pulled yarns or strands can result from unprotected ropes snagging. They cause local unbalance in the length of the load-bearing elements which weakens the rope.

Pulled yarns protruding from rope surface: single yarn (left), partial strand (middle), strand (right)

The loose yarns and strands can be worked back into the rope to recover the braid structure and prevent loss of performance. If you detect pulled yarns in the sleeve or jacket, repair is desirable to prevent further degrading. In that case no reduction of the performance of the rope has occurred. Is the extent of pulled yarns large? Contact Lankhorst Ropes for advice on discarding or repair of the rope.

Cuts and broken yarns
Cuts originate from sharp edges and accidental impacts. As a result of prolonged localized abrasion, whole yarns can break as well. These represent a localized loss of strength, which due to the rope construction are compensated by locking of the yarns along the length of the rope. A damage assessment should be made to discover the source of the possible impact. A single cut yarn or a few spread over a longer length will not have a strong negative effect on the rope performance. The recommended practice is to work these yarns back into the construction. By doing this the yarns will be locked again and possible snagging issues are eliminated.

Cut or rupture yarns. Single yarn (left), moderate damage across a braid length (middle), severe damage with half a strand cut (right)

Cut or broken yarns often protrude out of the rope and can be identified even in a much abraded rope surface. Broken filaments must not be removed since they provide a protective layer to the fibres underneath. In the event of a broken strand, a significant portion of the rope breaking strength will be lost. When one strand is broken and the rope is put under tension, the remaining strands will reposition in the construction. At the starting point and at the ending of this repositioned area, the construction will be slightly deformed and this creates other points of reduced strength. We recommend the rope is taken out-of-service if one strand is broken.

Discard criteria
If the rope is estimated to have lost 5% or more of the strand, along one braid length, then the rope should be discarded. When more than 20% of the yarns in the rope is broken or cut (in one strand) then reject or re-splice the rope. In both cases, remaining lengths which may be still in good condition, can be used for applications where the shorter lengths are required. These remaining lengths should be thoroughly inspected before they are put to work. The end user (qualified person) will decide if the rope should be retired or whether and if rope repairs and re-splicing can be performed.

Full rope break
A full rope break can be due to an overload or contact with a sharp edge. If a rope breaks it's important to identify the cause. In the event the rope was overloaded, the cause of the rope break will be obvious. The rope was probably broken at the weakest point, but the yarns in the remaining rope will certainly also be damaged. The rope must be discarded over the full length exposed to the overload. If there was no overload, and the rope still broke, the rope might have been weakened on a previous occasion, still holding out at that occasion but now breaking on a new job. In the case of a 'clean cut' usually the rope is still intact. The rope has been damaged probably by a (sudden) contact with a (sharp) object. A survey of the remaining rope is needed and if all looks alright the rope can be repaired and used again.

Broken on sharp edge (this rope can be re-spliced)

Broken due to overload (rope must be rejected)

Discolouring/brittle fibres
Chemical exposure can damage synthetic rope, causing discolouration and brittle fibres. The level of damage depends upon fibre type.

In general, synthetic ropes are not sensitive to soft cleaning detergents or fuels. However, there are many other chemicals that can destroy the properties of the synthetic fibres within moments. In the event of exposure to chemicals, please replace the rope with a spare immediately, and inspect the rope before reusing it. Please contact Lankhorst Ropes if you are in any doubt.

Glossy/glazed parts
Glossy or glazed parts of the rope indicate the rope has partly melted at that point. Synthetic yarns are sensitive to high temperatures. The melting points of the ropes is contained in their respective data sheets. Please note that before the melting point is reached, the rope yarns may begin weakening and deforming at much lower loads than usual. The texture of the yarns changes when they melt. The high temperatures are usually created at the point of high tension, in combination with friction. If a rope runs up and down a rough fairlead for hours, it might eventually produce so much heat that the yarns in that part will (partly) melt. The yarns will have deformed and are of no further use. The strength in the melted part has been lost and the overall rope strength reduced. The rope now has a weak point and should be rejected or repaired depending where the damage has occurred.

Discard criteria
- If 10% or more of the yarns within a braid pitch are found to be melted or fused, the rope should be repaired or discarded. If the area of damaged fibres. covers more than one braid pitch, the sling should be retired.
- If it is determined that the rope has been exposed during operation to temperatures above 70 °C the rope should be inspected.
- If it is determined that the rope has been exposed during operation to temperatures above 100 °C, then it must be retired, even if no symptoms are apparent.

Dirt/particles
Penetration of dirt or particles into the rope construction can accelerate the internal abrasion process and should be avoided as much as possible. If a large amount of particles are trapped in the rope construction, recommended practice is to wash this gently out with fresh water, as much as possible. Do not use any high water pressure cleaners, hot water or aggressive chemicals, as this may damage the rope filaments.

Different levels of contamination on ropes. Dirt from dragging on the ground (left). Sand particulates (middle). Heavy dirt contamination (right).

Fibre fleece
Fibre fleece on the outside is normal on synthetic ropes. If it becomes excessive, further inspection is required and replacement of the rope should be considered. Fibre fleece on yarns inside the rope is also normal. Coatings on the yarns reduce the friction in a rope and thus fleece production. If 50% of the yarns show heavy fuzz, the rope must be replaced.
If the area where the excessive abrasion is concentrated can be removed (when in the eye for instance), the specific area can be taken out and the rope re-spliced. The possibility of doing this will depend on the general condition of the rope and its service life. These remaining lengths should be thoroughly inspected before being put back into service again.

It is possible to monitor the loss of fibres due to abrasion (internal and external) by a visual inspection. A cautious approach is advised when evaluating the abrasion damage on the inner rope. The total amount of filament loss due to external abrasion, compared to the full rope should to be closely examined by visual inspection and by measuring the rope diameter at set points. These observations and measurements should be done by a qualified person and recorded in the inspection logbook.

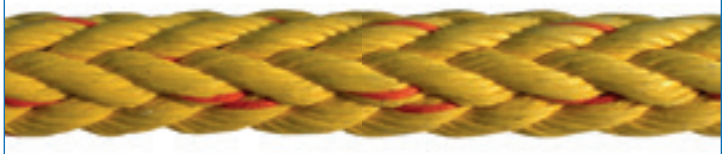
Rope inspection
To inspect an eight strand rope or a twelve strand rope for internal abrasion, one should put the rope on a flat horizontal surface and push the two parts towards each other by hand. The rope will open, allowing you to look inside. A jacketed rope is more complicated. Using a sharp knife, cut open the jacket being careful not to cut into the yarns of the load bearing core over a length of about 10 cm (3 inches). One person can look inside the rope and examine the yarns and any fleece that has formed. The cut into the jacket can be repaired with a seizing over the jacket.

6.5 REPAIR OR REJECT?

Monitoring the natural course of aging is one of the objectives of rope inspection, in order to be sure the rope can be discarded before it has reached the state of being operationally unsafe. Another objective of inspections is to detect abnormal damage to the rope. These are most of the times caused by external influences. By implementing a thorough inspection regime, the rope can be repaired or taken out-of-service in time and unexpected rope failure can be prevented. When should your ropes be repaired and when do you have to reject the ropes? Or are the ropes still in a good condition and can you go on using them without any repair? These are difficult decisions to make. But essential for your daily activities, for ensuring the maximum rope service life, for the safety of your crew. Lankhorst Ropes gives you an overview of the most common situations. Please be aware that in practice it's not always that evident how to handle. Therefore we advise to contact the rope manufacturer in case of doubts.

CAUSE/SITUATION	REPAIR	REJECT
Rope diameter changes by 10% or more within the length of one braid pitch		×
Pulled yarns/strands		×
Rope lost 5% or more of the strand, along one braid length	×	
More than 20% of the yarns in the rope is broken or cut (in one strand)	× (only if section can be removed, otherwise reject the rope)	
Powder between strands directly lying alongside each other	× (only if section can be removed, otherwise reject the rope)	
Parts of the rope melted or yarns melted against each other, more than 20% of the yarns	× (only if section can be removed, otherwise reject the rope)	
Long-term exposure to the maximum temperature for the material		×
Rope broken by a clean cut	× (only if section can be removed, otherwise reject the rope)	
Rope broken by overload		×
Suspected shock load > safe working load		×
Exposure to high temperatures (related to the material)		×
Abrasion inside eye > 50% of surface yarns damaged	×	
Heavy surface fleece on the rope itself	×	
UV degradation, splinters on yarn surface		×
Oils and fats	× Wash / spool with mild detergents	
Jacket damaged and the core has been damaged as well?		×
Jacket damaged, but the core is still in-tact? • jacket can be repaired? • jacket cannot be repaired?	×	 ×
Herniation; core pokes through the jacket and cannot be massaged back into the rope		×

NEW AND UNUSED



REJECTED

7. LINE MANAGEMENT PLAN

In this section we are referring to question 9.3, 9.4 and 9.5 in the OCIMF SIRE Vessel Inspection Questionnaire (VIQ7)

The ship operator is responsible for the development and implementation of the ship's Line Management Plan. This document contains the ship operator's requirements for the management of mooring line and tail maintenance, inspection and retirement during the operational phase of the mooring line lifecycle. The Line Management Plan is specific to an operator, ship type and trade route.

Which components can be included in the LMP?

- ✔ Records of mooring hours
- ✔ Line inspection records and plans
- ✔ Manufacturer and operator retirement criteria
- ✔ Test/inspection reports
- ✔ Manufacturer's recommendations following tests or inspections.

You can use Appendix C* as an example and a good starting point.

Please consult the OCIMF Mooring Equipment Guidelines, fourth edition 2018, for more details about the Line Management Plan.

*Source: OCIMF Mooring Equipment Guidelines, fourth edition 2018

8. MOORING SYSTEM MANAGEMENT PLAN

In this section we are referring to question 9.2 and 9.17 in the OCIMF SIRE Vessel Inspection Questionnaire (VIQ7)

The OCIMF created the Mooring System Management Plan (MSMP) to help ship owners and operators to keep consistent information about the mooring equipment of the ship. The objective of the MSMP is to manage all assessed risks effectively through the design and operation of the mooring system. When the MSMP will be filled consequently you'll ensure that the mooring system is inspected, maintained and operated in the right way, in accordance with the original design basis. The MSMP along with the required Mooring System Management Plan Register (MSMPR) is to accompany vessel throughout all her operational lifecycle.

The MSMP covers the following aspects:

- ✔ **General Ship particulars**
  Goal: maintain a detailed, continuous and up-to-date record of the ship's ownership history.
- ✔ **Mooring equipment design philosophy**
  Goal: provide details of the ship's original design philosophy and show how that philosophy demonstrates that the ship can be effectively and safely moored against standard environmental criteria.
- ✔ **Detailed list of mooring equipment**
  Goal: provide detailed information on all of the ship'mooring equipment.
- ✔ **Inspection, maintenance and retirement strategies/principles**
  Goal: provide detailed information on the requirements for inspecting and maintaining all loose and permanent mooring equipment, as well as the management strategies to test, retire and replace equipment and interface with the OEM.
- ✔ **Risk & change management, safety of personnel and human factors**
  Goal: provide detailed information on the requirements for identification and management of hazards and risks arising from the mooring system.
- ✔ **Records and documentation**
  Goal: provide records of detailed maintenance information on the ship'mooring equipment system, and requirements for documentation management.
- ✔ **Mooring System Management Plan Register**
  Goal: provide details of the records that should be retained by the ship throughout its lifecycle from original design to disposal.

You can use Appendix D* as an example and a good starting point.

Please consult the OCIMF Mooring Equipment Guidelines, fourth edition 2018, for more details about the Mooring System Management Plan.

Source: www.sqemarine.com and OCIMF MEG4, fourth edition 2018

‘THROUGH LIFE, FOR LIFE’ SERVICE MODEL

9. SERVICE MODEL: THROUGH LIFE, FOR LIFE

In this section we are referring to question 9.3 and 9.4 in the OCIMF SIRE Vessel Inspection Questionnaire (VIQ7)

The cost and operational demands on wet cargo operators have never been greater. Maintaining a competitive edge is often the sum of marginal gains, small improvements, which when taken together can make a big difference. Lankhorst Ropes’ ‘Through Life, For Life’ service is designed to do just this.

Lankhorst Ropes: Through Life, For Life gives operators a cost-effective portfolio of rope service life support and sustainability benefits unmatched in the industry. The service model assists ship operators in maximizing rope service life and safety, and offers a corporate socially responsible way of doing business.

From development of a mooring plan to rope selection and management through predictive service-life rope testing and training, Lankhorst provides complete ‘through life’ rope service; we want you to experience the benefit of working with our ropes in terms of longer rope service-life, easier handling and safe operation.

And then we go further. Commitment to Green manufacture combined with a longer lasting rope service-life, and ultimately rope recycling, translates into levels of sustainability that make a significant contribution to your environmental policies. Looked at in this way, life enhancing, sustainability is built-in with Lankhorst Ropes: Through Life, For Life; and it makes good business sense too.

STEP 1 - ROPE SELECTION

Making the correct rope selection is vital. The cost-effectiveness and safety of shipping operations are dependent on selecting the correct rope. Lankhorst takes a holistic approach to ensuring the rope’s service life is maximized.

Review rope route
Along with the operator, Lankhorst will go through all details of the rope route starting from the winch, and calculated winch capacity, to analysis of D/d ratios.

Review ship’s route and mooring conditions
We will jointly go through all details of the trading route, if known, to prevent early failure of the rope. This includes type of mooring (STS or Ship-to-quay) and port, expected swell conditions, possible currents and risk of surging.

Translation to Lankhorst’s solution
Based on the information gained, we will provide you with a product solution considering your requirements with regards to these major technical characteristics:

- ✓ Elongation properties
- ✓ Rope flexibility/stiffness
- ✓ Break load
- ✓ Chafing gear
- ✓ Safety risks
- ✓ Floatability
- ✓ Life time expectations.

STEP 2 - ROPE INSTALLATION AND CREW TRAINING

Lankhorst Ropes is committed to equipping crew with the knowledge and skills needed to ensure the safe use of fibre ropes and maximise service life. Specifically, Lankhorst provides training on rope handling, splicing instructions, installation on new or existing vessels, and hardware inspection including all on-vessel equipment.

Training on rope handling
Rope handling best practice will be shared with the crew as rope service life is heavily affected by conditions of storing, installing, inspecting and using the rope. For example, too many twists in a rope during mooring will reduce the rope performance; with a proper training you will raise awareness.

Splicing instructions
Splicing instruction and training will be provided to the crew. This includes the application of chafe gear.

Installation on new (shipyard) or existing (ports) vessels
Correct installation of ropes onto the winch drum is important to maximise rope efficiency and life-time. Lankhorst provides supervision and guidance during the installation process to make sure that all ropes are properly installed.

Hardware inspection
Prior to the installation a full inspection of all winches, rollers and fairleads will be undertaken. Furthermore the condition of the hardware, surface roughness and potential areas of damage will be reviewed. We will give the crew recommendations for installation. When can you install the rope? Which actions are required to allow installation?

STEP 3 - INSPECTION

Regular inspection is important in ensuring maximum rope service life. In addition to providing crew training on rope handling and inspection, Lankhorst Ropes will make periodic visits to the vessel to undertake hardware condition inspection, rope inspection, update crew training and provide inspection reports.

Hardware condition inspection
A full inspection of all winches, rollers, deck and fairleads/chocks will be done prior to installation. The condition, surface roughness and possible areas of damage are reviewed. Potential causes of damage include chafing, or rust. A summary and list of recommended actions to optimise the rope's lifetime will be given to the crew.

Rope inspection
During inspection, all ropes are taken off the vessel's winches to enable visual evaluation; damaged and/or fused (crystallised) sections need particular attention. If necessary ropes will be end-for-ended or re-spliced.

Updated crew training
Another crew on your vessel? Lankhorst can provide updated training and splicing instructions. Rope handling best practice will be shared with the crew as rope service life is heavily affected by conditions of storing, installing, inspecting and using the rope.

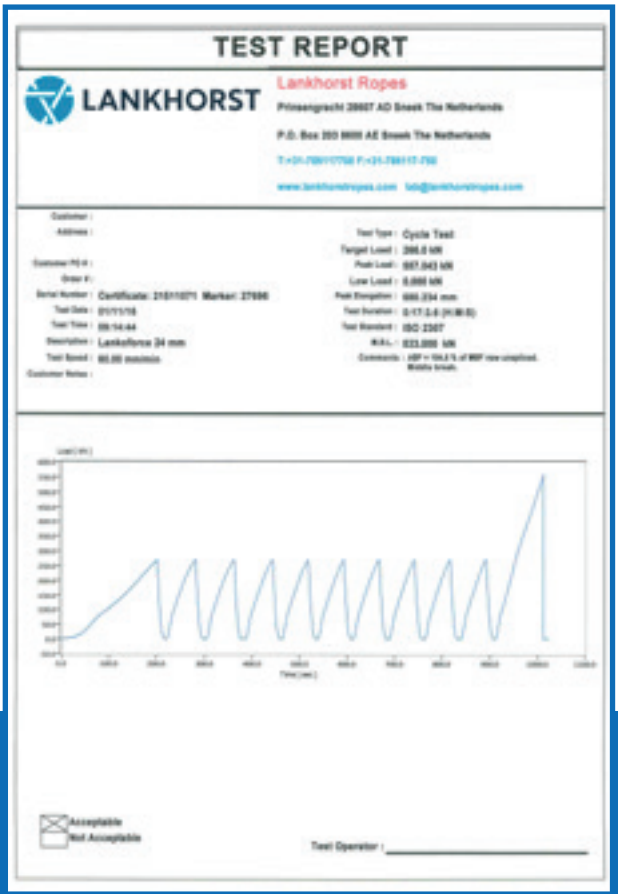
Inspection report
Finally, an inspection report will be made by Lankhorst Ropes' service engineer for crew and office personnel to record in their respective log-books. A report is made on each rope, stating any repairs needed and costs, and the remaining rope length which can still be used. The customer can then decide if the rope should continue in service (using the remaining rope length), be repaired or replaced.

STEP 4 - RESIDUAL STRENGTH TESTING

Lankhorst Ropes provides a continuous residual strength testing program to assist in determining the best moment to change the rope end-to-end in order to ensure the most economical service life and to optimise safety on board. We believe this should be based on mooring hours, i.e. the number of hours a line has been in use mooring the vessel. This can be quantified by the vessel's crew and reported back to the manufacturer. Other factors which should be taken into consideration during the analysis are the environmental conditions at the ports and terminals where the vessel will be moored.

Visual inspection
The rope sample will be visually inspected, and pictures taken for the final residual strength test report before pulling the sample to destruction.

Test report
Each sample will get its own test report as illustrated.


TEST REPORT

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Lankhorst Ropes

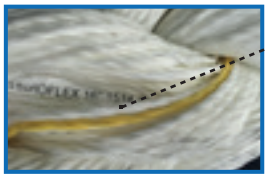
STEP 5 - RECYCLING OF ROPES

The Residual Strength Testing Program can be combined with Lankhorst's Rope Recycling Program. Ropes which are taken back for testing and deemed unusable can be recycled into other polymer products including picnic sets, plastic poles, planks and complete landing stages, riverbank bank protection boards and bridges. Proof of participation in the recycling program is shown by a logo on the rope's works certificate.

The recycling program is an exclusive program, and not meant for the ad hoc return of single ropes. The intention should be that the whole fleet will be sailing with recyclable ropes in time. To participate in this program an intercompany contract should be signed.

24/7 ONLINE ACCESS TO ROPE CERTIFICATES

Lankhorst Ropes offers 24/7 online access to your certificates, regardless of the time zone. Certificates may be mislaid during filing or transportation but can be required immediately to trace and identify ropes. By having direct access to rope certificates, Lankhorst customers will be able to instantaneously check all their ropes' details including construction, diameter, length, minimum breaking load and end termination. Please contact your account manager at Lankhorst Ropes for activation.

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CERTIFICATE OF ROPES

10. WARNINGS – PRECAUTIONS

Buying and using a product that is not properly manufactured and adequately documented as required for certification, although a lower initial investment, will increase the inherent risks of failure, repairs and other surprises.

Manufacturer certificate	Prepared by the manufacturer, the rope is manufactured according to stated requirements. Furthermore, synthetic ropes from Lankhorst Ropes have standardly a DNV GL type approval certificate.
Verification statement	Not a product certificate, but just a statement that a surveyor attended proof load testing.
Approval of Manufacturer	Not a product certificate, but a certificate of the consistency of manufacturing.

When selecting fibre ropes for a next mooring, please consider the benefits of a full-certified delivery. Consider the material and financial consequences of a surprise from a non-certified product, while in the middle of a mooring operation.
Attend to the trust placed in you by your customer, and only trust properly manufactured and adequately documented products, with the appropriate level of certification.

11. FAQ - OCIMF SIRE VESSEL INSPECTION QUESTIONNAIRE

In this section we highlight the most important questions from chapter 9 (Mooring) of the OCIMF Ship Inspection Report (SIRE) Vessel Inspection Questionnaire (VIQ7). All notes below are related to paragraphs or chapters in the Lankhorst Ropes' Mooring Rope Manual. For all other issues, please consult the original SIRE Vessel Inspection (VIQ7) questionnaire.

SIRE VIQ7 CHAPTER 9 MOORING

1. Are certificates available for all mooring lines and wires?

Product certificates for mooring lines, connecting shackles, and synthetic tails should be kept in a file clearly showing to which winch each particular component has been fitted. For ship's following guidance in MEG4, mooring line and tail certificates should follow the guidance for the purchasing and testing of mooring lines and tails as provided in Appendix B of the Mooring Equipment Guidelines (MEG4). Lankhorst Ropes provides as standard a manufacturer's certificate for each individual mooring line, connecting shackle and tail. Furthermore, synthetic ropes have a DNV GL type approval certificate. These certificates should be kept and integrated into the ship's Line Management Plan.

See paragraph 2.7 Certification on page 13.

2. Does the ship have a Mooring System Management Plan?

Each ship should be provided with a Mooring System Management Plan (MEG 1.9).

See chapter 8 Mooring System Management Plan on page 36.

3. Does the ship have a Line Management Plan?

The maintenance, inspection and retirement program should be developed as part of the mooring line specification and selection process and documented in the ship's LMP (MEG 5.4).

The ship operator is responsible for the development and implementation of the ship's Line Management Plan. This document contains the ship operator's requirements for the management of mooring line and tail maintenance, inspection and retirement during the operational phase of the mooring line lifecycle.

See chapter 7 Line Management Plan on page 36 and chapter 9 Service Model: Through Life, For Life on page 37.

4. Have the operator's policies on line inspections, retirement and wear zone management been implemented as outlined in the Line Management Plan?

The maintenance, inspection and retirement program should be developed as part of the mooring line specification and selection process and documented in the ship's LMP (MEG 5.4).

The ship operator is responsible for the development and implementation of the ship's Line Management Plan. This document contains the ship operator's requirements for the management of mooring line and tail maintenance, inspection and retirement during the operational phase of the mooring line lifecycle.

See chapter 7 Line Management Plan on page 36 and chapter 9 Service Model: Through Life, For Life on page 37.

5. Do all mooring lines and where fitted, mooring tails, meet Industry guidelines?

The mooring lines fitted should have a Line Design Break Force (LDBF) of 100-105% of the Ship Design MBL (MEG 5.2.1).
Common materials include polyester, polyester/polyolefin composites and polyamide. To increase fatigue life and strength, it is recommended that tails have the same rotation properties as the main line. Synthetic tails should have a TDBF 25-30% higher than that of the ship design MBL. (MEG 4.5.8)

Mooring tails can be of any length necessary to provide sufficient system compliance but are normally between 11m and 22m. Mooring tail length, construction and material in operation should be as specified the mooring analysis and required by the mooring arrangement.

Mooring lines and tails should be inspected before every use and according to the requirements in the Line Management Plan. For determining the end of service life operators should follow the same process for mooring lines and mooring tails.

See chapter 2 Mooring - an introduction on page 6 and chapter 7 Line Management Plan.

12. If mooring tails are fitted to wires or HMSF lines, do they have proper connections and are they correctly fitted?

Tails should be connected to a wire mooring line using appropriate shackles. The SWL of the joining shackle should be equal to or greater than, the WLL of the mooring line to which it is attached.
It is critical that the connecting links are in good condition and are rigged in accordance with the shackle, line and tail manufacturer's instructions. The eye of the tails should be protected with a suitable sheath. If the manufacturer recommends that it is appropriate, a synthetic tail can be attached to a high modulus line by using a cow hitch. The hitch provides a suitable method of joining lines without the use of shackles or other hardware (MEG 5.8.4).

See paragraph 2.6 Connections on page 40.

17. Are mooring wires, lines, synthetic tails and connecting apparatus in good order?

All splices and repairs should be made in accordance with the manufacturer's instructions by a competent person. Each inspection and repair of a mooring line and tail should be logged.
Particular attention should be paid to the eyes of mooring wires. If there are more than three broken wires in any strand, or five in any adjacent strands in a length of wire 10 times the diameter, the damaged part requires removal and the wire re-splicing.

For optimal safety on your vessels, it is recommended that you implement a scheduled maintenance program in use for rope maintenance, inspection and retirement. Rope maintenance, inspection and retirement should be an integral part of the mooring line specification and selection process and documented in the ship's Line Management Plan. For rope inspection and discard guidance, MEG4 refers to the industry standards ISO 4309 - the care and maintenance, and inspection and discard of steel wire ropes used on cranes and hoists, and CI-2001 - Fiber Rope Inspection and Retirement Criteria.

See chapter 5 Maintenance on page 25, chapter 6 Inspection and Retirement on page 30 and chapter 8 Mooring System Management Plan on page 36.

Source: OCIMF SIRE VIQ7 and OCIMF MEG4, fourth edition 2018

APPENDIX A.1 MOORING LINE ACQUISITION FORM

Completed by the user for each order. This form allows the user to provide information about their line requirements so that the manufacturer can then propose mooring lines of the correct dimensions and appropriate performance.

Ship name(s):					
Ship design MBL:		**Length:**		**Number of lines:**	

Order type / reason *(select applicable):*

- ☐ New build.
- ☐ Existing ship re-outfitting.
- ☐ Existing ship re-outfitting (changing wire to fibre).
- ☐ Scheduled line replacement(s).
- ☐ Replacement(s) due to line failure.

Fabrication requirements (details of eye sizes / termination and chafe protection):

Supporting information: *Add information that will help the line manufacturer to propose appropriate products, e.g. ship minimum deck diameter 'D', intended trade patterns, temperature extreme, operating limits, exposed berths frequency, berthing frequency, desired replacement period, potential for changes to trading pattern, failure analysis and in-service records (e.g. LMP) and existing fibre product experience.*

Additional quality assurance: *The requirement for additional quality assurance measures will depend on a variety of factors including the size or complexity of a specific order, the user's own quality assurance procedures and experience with the selected product and the manufacturer. Additional quality assurance testing (e.g. NSBF) may be requested in this section and detailed guidance should be provided to the line manufacturer.*

APPENDIX A.2 MOORING TAIL ACQUISITION FORM

Completed by the user for each order. This form allows the user to provide information about their line requirements so that the manufacturer can then propose mooring lines of the correct dimensions and appropriate performance.

Ship name(s):		**Ship design MBL:**			
Tail Design Break Force (ship design MBL+25%):		**Length:**		**Number of tails:**	
Assembly type:		**Tail material and construction:**			
Sheltered dynamic stiffness (Ksh):		**Exposed dynamic stiffness (Kex):**			
Main mooring line material / construction:					
Required mooring tail rotation characteristics:					

Order type / reason *(select applicable):*

- ☐ New build.
- ☐ Existing ship re-outfitting.
- ☐ Existing ship re-outfitting (changing wire to fibre).
- ☐ Scheduled line replacement(s).
- ☐ Replacement(s) due to line failure.

Fabrication requirements (details of eye sizes / termination and chafe protection):

Supporting information: *Add information that will help the line manufacturer to propose appropriate products, e.g. ship minimum deck diameter 'D', intended trade patterns, temperature extreme, operating limits, exposed berths frequency, berthing frequency, desired replacement period, potential for changes to trading pattern, failure analysis and in-service records (e.g. LMP) and existing fibre product experience.*

Additional quality assurance: *The requirement for additional quality assurance measures will depend on a variety of factors including the size or complexity of a specific order, the user's own quality assurance procedures and experience with the selected product and the manufacturer. Additional quality assurance testing (e.g. NSBF) may be requested in this section and detailed guidance should be provided to the line manufacturer.*

APPENDIX B.1 INSPECTION REPORT EXAMPLE 1

Rope location (winch number)		End for ended		Date:	
ID/Cert. no. rope		Type of winch			
Date installed		Sheet		1/..	

Date inspection					
Name inspector					
Total mooring hours					
Spooling condition winch		(Rate 1-5)	Jacket damage		(Rate 1-5)
Rope flattening			Constructional firmness		
Abrasion level			Condition of eye		
Twist rating			Cork screw rating		
Hardware condition					
Remarks:					

Date inspection					
Name inspector					
Total mooring hours					
Spooling condition winch		(Rate 1-5)	Jacket damage		(Rate 1-5)
Rope flattening			Constructional firmness		
Abrasion level			Condition of eye		
Twist rating			Cork screw rating		
Hardware condition					
Remarks:					

APPENDIX B.2 INSPECTION REPORT EXAMPLE 2

SUBJECT	INFORMATION	REMARKS
Inspector		
Date		
Vessel name		
Type of vessel		
IMO number		
DWT		
Year built		
Location inspection		
Product name (soft lines)		
Length (m)		
Eye length (m)		
Marker tape		
Product name (tails)		
Length (m)		
Support line details		
Chafe gears		
Rope mooring log available?		
Rope location (winch)		
Certificate number		
Placed in service		
Mooring hours		
End-for-ended		
Date of last inspection		
General impression rope		
External abrasion		
Rope diameter variances (Y/N)		
Rope diameter variances (Y/N)		
Splice and eye (type & condition)		
Condition of the hardware		
Conclusion of inspection		

APPENDIX C LINE MANAGEMENT PLAN - EXAMPLE

SUBJECT	ACTIVITY	INFORMATION TO BE INCLUDED	SUPPORTING DOCUMENTS
Maintenance	Line installation	Methodology Tools required Equipment preparation	Line manufacturer's guidelines Winch manufacturer's guidelines (where applicable) SMS
	Storage	Duration, including: Impact on mooring ropes over prolonged storage times Effective use of labels for tracking mooring ropes and traceability	Line manufacturer's guidelines
	Repair	Splicing methods Cover repair methods Tools required	Line manufacturer's guidelines Line manufacturer's representative Line manufacturer's splice methods
	Line maintenance	Lubrication/greasing Cover/chafe gear adjustment Twist removal process	Line manufacturer's guidelines Industry guidelines (e.g. CI, ISO) Line manufacturer's splice methods
	Wear zone management	Definition of minimum length of mooring line Frequency of: Line/winch rotation Line end-for-end Outboard crop	Ship schematic Line manufacturer's guidelines Line manufacturer's splice methods SMS/planned maintenance records
Inspection	Routine inspection Detailed inspection		
Service life and retirement criteria	Determination of expected service life Residual strength testing and condition analysis Planned retirement criteria policy		
General			

APPENDIX D MOORING SYSTEM MANAGEMENT PLAN - EXAMPLE

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