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BUSINESS REG. NO. 198601157K

TEHO Ropes & Supplies Pte Ltd

Mooring wire ropes user manual

For WREXCO® series

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1 Introduction

This guide is written with the end users in mind. It is assumed that the people reading this document possess at least some background knowledge about ropes. As such, little attempt is made to explain common terms and abbreviations used in the marine and related industry. If any clarifications are needed, please to contact your local TEHO sales representative.

2 Rope specification

For mooring wires, TEHO strongly recommends using ropes with a 6 x 36WS IWRC construction, with a minimum tensile strength of 1960 N/mm^2. The rope should be hot-dipped galvanized according to EN 10264-2:2002 standards (or equivalent) for additional corrosion resistance. 6 x 37 construction for mooring wires are NOT recommended.

3 Storage

Wire ropes should never be stored in the open where they can be exposed to the sun, rain and marine environment. Although sunlight is not directly detrimental to the rope, it can dry up the grease and speed up the onset of rust formation. Steel wire ropes should always be stored indoors in a cool, dry area. If possible, the reels should be placed on pallets to ensure adequate ventilation underneath and prevent pooling of water. If placed in long term storage, ropes should be rotated 180^o at least every 3 months to prevent grease from pooling at the bottom section of the rope.

4 Installation

Before installation, the crew should inspect the rope for damages and take note of the rope's tag number and match it with the certificate. All ropes supplied by TEHO has a unique serial number stamped onto the aluminium ferrule with a matching number on the cert. This number should be noted down in the mooring log together with the winch number to ensure future traceability.

4.1 Twisting

During installation, it is important to ensure that twists are not being introduced into the rope. In order to prevent twisting, ropes should be installed using a pivoted stand or at minimum, a turn table. Ropes should be installed top to top or bottom to bottom (Figure 1). Refer to section 5.1.4 for additional information on rope twisting.

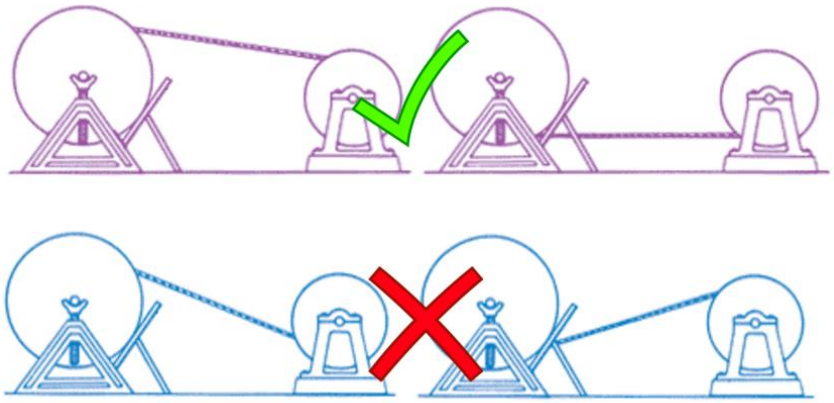

Figure 1: Proper rope installation

4.2 Winch

4.2.1 Single drum winch

For older winches with undivided drums, it is possible for the mooring wire to get "buried" into the bottom layers during usage. This will greatly reduce the lifespan of the rope. It is thus important to include sufficient back tension during installation to ensure that the lower wraps are packed tightly to reduce chances of bury-in. Additional precautionary measures should be taken if it continues to be an issue.

4.2.2 Split drum winch

In the case of split drum winches, ensuring tension during installation is not as critical, although it is still good practise to do so. Instead, users must ensure sufficient wraps on the tension drum to ensure that there is no load on the line when it crosses over to the storage drum.

MEG 4 recommends 10 wraps on the tension drum but in real world scenario this is often not possible due to space constraints on the winch. TEHO has consulted with winch makers and industry personnel on this matter and we recommend a minimum of 4 wraps on the tension drum. That is a much more practical yet safe figure that can be achieved. Note that there can only be one layer on the tension drum and never a second layer as that will reduce the break holding capacity of the winch.

5 Preventive maintenance

5.1 Factors that influence rope life

In order to perform effective maintenance of the rope, it is important for users to first understand the many factors that can influence the lifespan of a mooring wire rope. Some of these are:

5.1.1 Greasing program

When vessels are fitting with mooring wire ropes, it is crucial to have a good re-lubrication system in place. The main purpose of lubrication is to prevent corrosion, and this is especially important in a marine environment. It is industry practice for users to perform a thorough visual investigation every three months

and a full re-lubrication regime every six months. Many instances of corrosion start from the core of the rope which is not visible externally. Thus, it is recommended that a high-pressure lubricator is used for greasing to ensure that the lubricant can penetrate the outer strands into the rope and protect the core. Lack of internal lubrication is one of the contributing factors for ropes that fail near the ferrule (See Figure 6, right).

Note that while having a thick layer of grease does protect the rope against corrosion, it can make subsequent visual inspection of the rope difficult by obscuring any damaged wires and can lead to buildup of grit and grime on the rope which can cause rope damage.

Recommended wire rope grease:

For VGP Compliant EAL grease: Biolubri® Greaskote-100 (NLGI 2)

For environmentally friendly mineral oil based grease: Lupromax® WRC (NLGI 2)

5.1.2 D/d ratio

Using the rope at very low D/d ratio (Figure 2) is detrimental to the life of the rope. This is true not just for all manners of bits, fairleads, chocks, but also includes mooring shackles and shoreside mooring hooks/bollards. TEHO recommends that a minimum D/d ratio of 15 is maintained.

All ropes will lose strength when going around a curved surface. The smaller the D/d ratio, the more the rope strength is reduced (Figure 3). With a small enough D/d, it is possible the rope may fail well below its breaking strength. When there is no option but to use the rope with a D/d ratio of less than 15, it is prudent for the user to take extra care during line selection and procurement to ensure the best possible line is supplied. User should also increase the frequency of inspections and be prepared to retire the line earlier than usual.

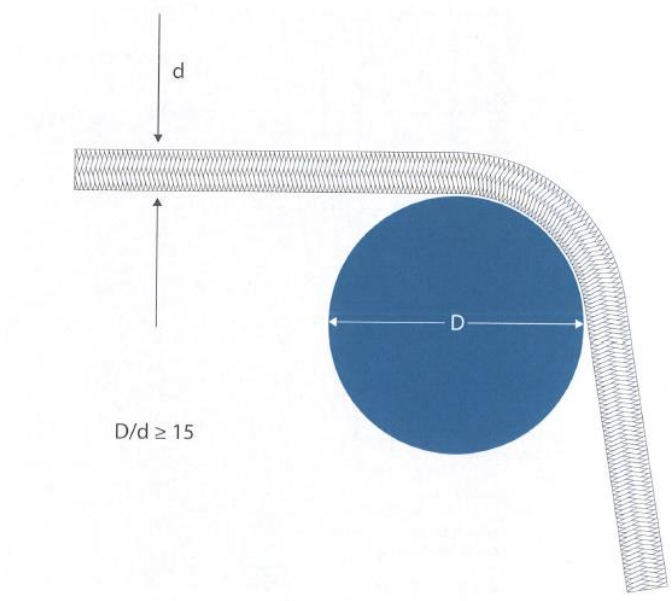

Figure 2: D/d ratio of deck equipment to mooring line (credit: OCIMF MEG 4)

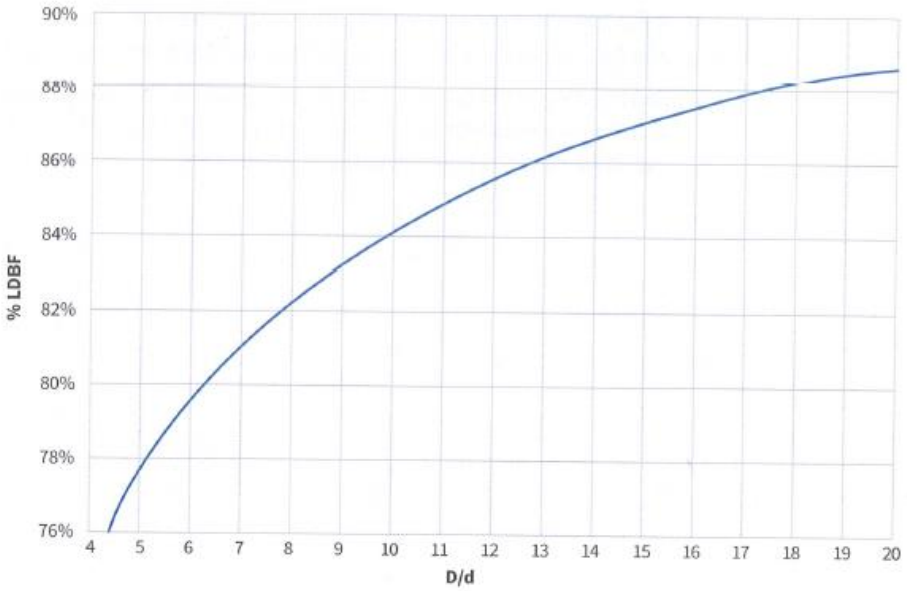

Figure 3: Chart showing estimated strength loss with varying D/d ratio (credit: OCIMF MEG 4)

5.1.3 Mooring angle

Similar to the D/d ratio, using the rope under sharp angles will reduce the strength of the rope and possibly result in line failures well below the rope's certified strength. Furthermore, sharp vertical angles in combination with sharp horizontal angles can cause the rope to get stuck under rollers. In most cases this is detrimental to the rope and will cause direct abrasion. Care should be taken to prevent this not only directly after berthing but also during loading and unloading as the angle can change significantly as the vessel freeboard changes. Refer to Figure 4 for recommended mooring angles.

In most cases, the angle the rope makes depends largely on the actual location of the shoreside mooring bollard/hook and there is little that ship operators can do about it. However, it is still good practise for the crew to take note of sharp angles and note it in the mooring logbook so that when it is eventually time to consider discarding the rope, this fact can be taken into consideration.

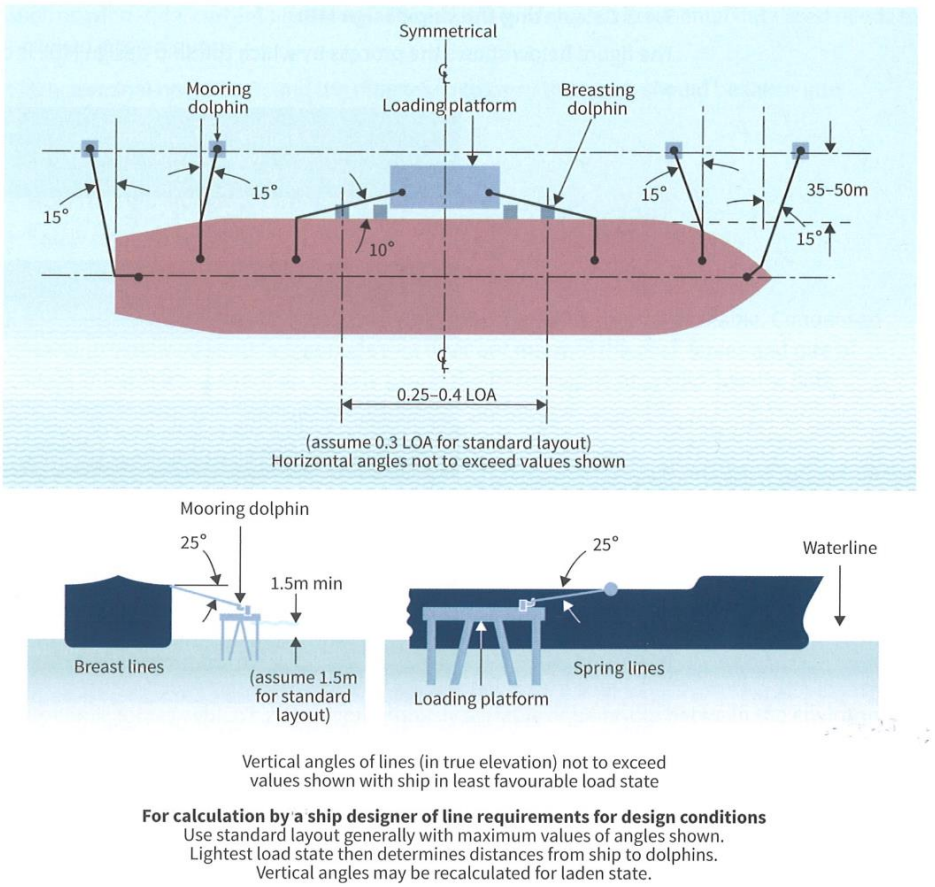

Figure 4: Mooring angles (credit: OCIMF MEG 4)

5.1.4 Induced Twist

All steel wire ropes are susceptible to rotational damages. If twists are introduced into the rope, it may result in the formation of kinks, birdcages, core protrusion and/or other deformations that will permanently damage the rope.

5.1.5 Dynamic Loading

Exceptional weather events like wind, wave and current forces can result in excessive dynamic loading (aka shock loading) of the mooring lines. This can cause a peak load in the rope that is higher than the recommended working limit. Repeated dynamic loadings can cause significant loss of strength in the rope, resulting in it failing at a later date, even when under much lower loads.

Record keeping of excessive dynamic loading is recommended. The use of more elastic materials such as polyamide (Nylon) as mooring tails can help to reduce line loads in these dynamic environments.

5.1.6 Corrosion

Corrosion is an irreversible damage that will slowly cause the rope to lose mass over time resulting in a gradual loss of strength. It may also affect the rope's mechanical characteristics which will reduce the lifespan of the rope. The best way of preventing corrosion is to have a suitable lubrication program in place together with regularly performed inspections. (Section 5.1.1)

6 Inspection and discard

The decision to discard, repair or continue using a wire rope can never be taken on the grounds of exact standards or rules, because so many parameters can affect the rope's lifetime. For correct use of the criteria given here, general knowledge of, and experience with wire ropes are essential, as well as keeping a close eye on the load history of the rope. It should be common practice to check the rope after each use. In case of doubt it is advisable to consult directly with TEHO.

The lifetime of a mooring wire is influenced by its quality of manufacturing, frequency of use, environmental factors and type of application. Adequately and regular performed preventive maintenance can also greatly prolong the life of the rope.

It is recommended to keep a log of the working life and plan inspections depending on the use. The inspection interval is dependent on the type of application. The results of an inspection should be documented with an inspection card.
Based on historical records for the TCC fleet, TEHO recommends that the mooring wire be replaced every 8 years for Aframaxes and every 10 years for VLCCs. The ropes should be turned end to end every 2.5 years during which the entirety of the rope should be thoroughly re-lubricated, taking extra care at the region near the aluminium ferrule and at the tip of the soft eye.

6.1 Common types of rope damage

Below are some of the common types of damage that can affect the mooring wire rope.

6.1.1 Visible wire breaks

For crown wire breaks, the rope should be discarded if any section of the rope shows 4 breaks in 6d or 8 breaks over 30d. (d being nominal diameter, 6d means 6 times the nominal diameter)

For valley breaks, 1 break will hint at internal deterioration and warrants closer investigations. The rope should be discarded if there are 2 valley breaks or more in 6d.

Mooring wires are heavily coated with grease so in practise it will be much more difficult to find these wire rope breaks than it sounds.

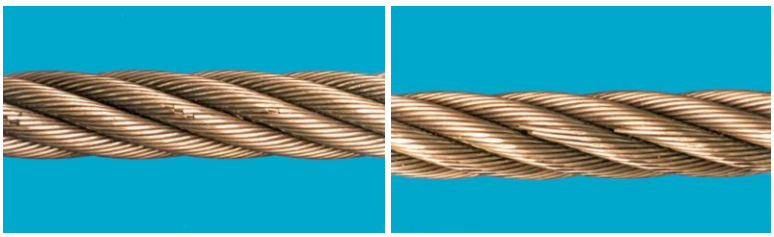

Figure 5: Left – crown wire breaks; Right – valley wire breaks (credit BS ISO 4309:2010)

6.1.2 Localised grouping of broken wires

Where there is localised grouping of wire breaks, it may be necessary to discard the rope even though the total number of breaks is lower than that mentioned in Section 6.1.1.

An example of this is if there are 7 wire breaks over 30d, but all occurring on the same strand. This could point to a case of uneven loading on the rope rendering it unsafe for further use.

6.1.3 Wire breaks at terminations

If there are any wire breaks at the termination (the entire soft eye up to and including a distance 9d away from the ferrule on the straight end of the rope), the eye should be re-spliced if deemed viable or the rope discarded.

If the rope did not suffer from any shock loading or otherwise abnormal damage during its use, the highest chance of failure usually occurs at the tip of the eye or just below the aluminium ferrule.

Figure 6: Left – wire parted at the tip of soft eye; Right – wire parted below ferrule

6.1.4 Broken strands

If parts of a strand are broken, the rope should be discarded immediately.

6.1.5 Reduction of rope diameter

The most likely reason for a decrease in rope diameter is due to wear and/or corrosion. Diameter may also be reduced when the rope has suffered from plastic deformation (irreversible elongation). The rope should be closed monitored and discarded if the diameter reduces by 10% from the nominal diameter.

6.1.6 Corrosion

Corrosion may occur on the external or internal parts of the rope. Severe external corrosion can lead to pitting on the surface of the rope and will be visible even when the rust is removed. Internal corrosion is more difficult to detect as the strands need to be opened up first. A local change of diameter may be indicative of internal corrosion. If there is severe internal or external corrosion, the rope should be assessed by a competent person to judge if it is suited for continued use.

Figure 7: Heavily corroded rope (credit BS ISO 4309:2010)

6.1.7 Excessive wear of outer wires

The rope should be discarded if the outer wire diameter has reduced by 7% or more due to wear (abrasion).

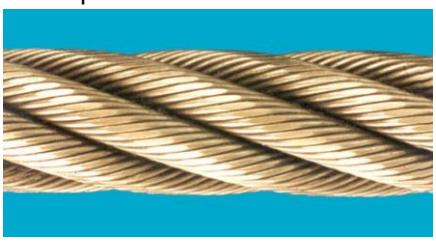

Figure 8: Severely worn rope (credit BS ISO 4309:2010)

6.1.8 Heat damage

Steel wire ropes are generally not affected by heat under normal mooring operations. However, a sudden massive increase in temperature can lead to the formation of martensite which is a hard but extremely brittle form of steel. This may happen due to electric arcing when welding operations are conducted near the ropes or by lightning strikes.

The rope should be discarded immediately if there are any evidence of such damage.

6.1.9 Deformation

There are many types of deformation that may occur in a wire rope. Most of them occur due to mechanical damage (such a hard knock) or rotational damage (such as birdcaging due to introduced twisting).

Any of the below damage occurring is sufficient reason to discard the rope.

Birdcaging

Kinks

Core or strand protrusion

Sunken strand

Waviness

Permanent bends

Crushing

6.1.10 Others

No attempt is made here to provide a complete list of possible rope damage. It is important to apply both experience and a large dose of common sense during inspection to evaluate if the rope is fit for continued use.

For ambiguous cases, it is always better to take the rope out of service and consult with the experts from TEHO, because at here at TEHO, *we know the ropes!*