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BUSINESS REG. NO. 198601157K

TEHO Ropes & Supplies Pte Ltd

MAGNARO®

Fibre rope user manual

For MAGNARO® 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 TEHO sales representative.

This document is valid for ropes from the below makers:

DONGYANG MFG. CO., LTD.

DAEJUNG CO., LTD.

MANHO ROPE & WIRE LTD.

DAE HAN ROPE CO., LTD

TUFROPES PVT LTD.

2 Storage

Unlike natural fibres such as manila or sisal, synthetic fibres are not susceptible to rot or mildew. They can however, be damaged by heat, exposure to UV light and contact with certain chemical/fumes. Thus, for new ropes designated as spares, they should be kept indoors in a cool and dry area, away from any chemicals such as strong acid/alkali, solvents and paints. The ropes should be placed on pallets to ensure adequate ventilation underneath and prevent pooling of water.

Under optimal conditions, new MAGNARO® ropes in their original packaging can be kept for years without affecting their physical properties. It is not recommended to put *used* ropes into long term storage with the intention of using them again in the future.

3 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 synthetic ropes (including tails) supplied by TEHO has a unique serial number tagged onto the eye of the rope 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.

3.1 Surface preparation

All synthetic ropes, regardless or constructions and material, are prone to damage from abrasion and cuts. It is thus important to make sure that any deck equipment that come into contact with the ropes are smooth and free from rust and sharp edges. Areas to take note are the winch inner surface, winch flanges, chocks and fairleads.

TEHO recommends that all metal surfaces be made smooth and painted with bi-component epoxy paint to finish and preserve the smooth surface. Deck surface should also be non-slip epoxy paint. Any paints with grains will ultimately be detrimental to the life of the rope.

This is especially important for HMSF ropes due to their higher cost. It makes sense to take additional precautions to ensure their longevity in service.

3.1.1 Switching from wire ropes to synthetic ropes

There is an increasing trend where ship owners are switching from steel wire mooring ropes to HMSF lines. For such cases, it is even more important to pay attention to the deck equipment finishing, as all contact surface will likely be badly abraded by the steel wires (Figure 1). All equipment needs to be sandblasted, hard welded and smoothened before the lines can be switched out. Even after a full refurbishment is done, it is advisable to engage TEHO to perform an on-board inspection before installing our HMSF ropes.

Figure 1: Deck equipment that has been damaged by steel wire mooring lines

Figure 2: HMSF line installed on a winch that has not been sufficiently reconditioned, resulting in rope damage

3.2 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 3). For HMSF ropes, TEHO can supply the ropes in wooden drums on request. We can also provide rollers (Figure 4) to ensure fuss free installation. Refer to section 4.1.4 for additional information on rope twisting.

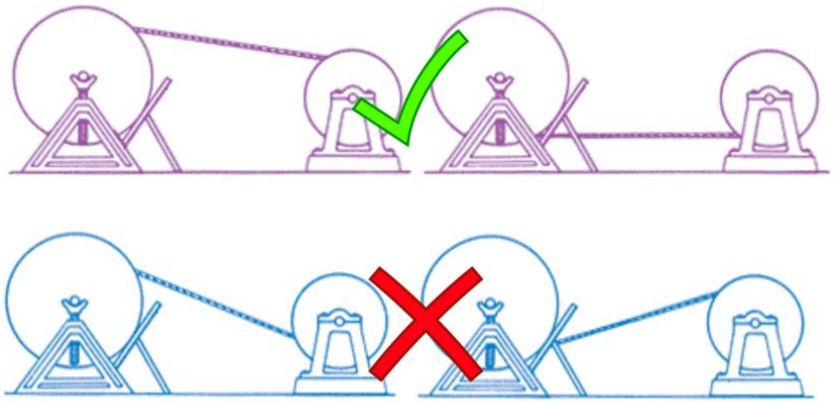

Figure 3: Proper rope installation

Figure 4: TEHO supplied HMSF rope with wooden drum and rollers

3.3 Winch

3.3.1 Single drum winch

For older winches with undivided drums, it is common for the mooring rope 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.

3.3.2 Split drum winch

In the case of split drum winches, this is not as critical, but it is still recommended to have sufficient wraps on the tension section to ensure that the crossover point of the rope to the storage drum does not undergo too much tension. The number of wraps on the tension drum depends on the material in contact with the winch. That means for jacketed (over-braided) ropes the crew should base the required wraps on the jacket material and not the core material.

The recommended number of wraps on the tension drum is six for conventional material (polypropylene, polyester, polyamide, etc) and ten for HMPE.

4 Preventive Maintenance

4.1 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 rope. Some of these are:

4.1.1 Abrasion

Arguably the single most common factor that reduces rope strength. External abrasion of the rope with deck equipment (especially rusty/poorly maintained ones) cause the rope filaments to break and the rope's strength to drop over time. Internal abrasion of the rope rubbing against itself also causes abrasion and loss of rope strength. Abrasion is an unavoidable part of wear and tear during normal rope use and cannot be avoided entirely. The best way to deal with abrasion is to ensure that deck equipment is well maintained and proper anti-chafing protectors are being used during mooring operations. Refer to section 4.2 for more info on rope protectors

4.1.2 D/d ratio

Using the rope at very low D/d ratio (Figure 5) 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 6). 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.

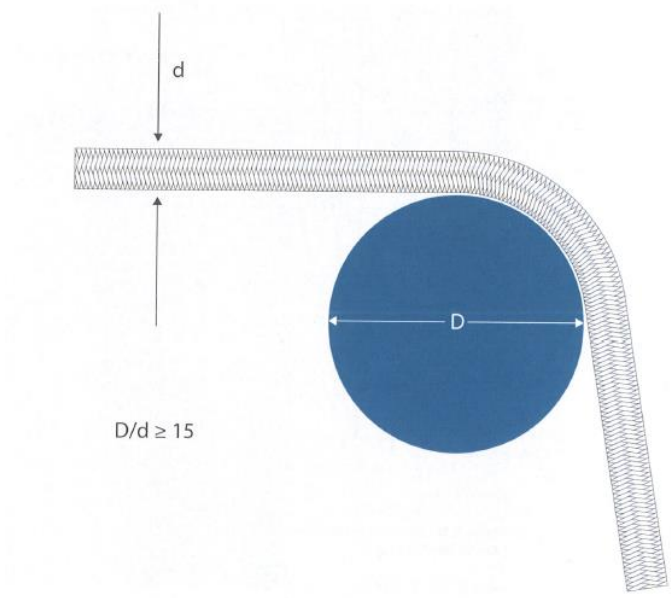

Figure 5: D/d ratio of deck equipment to mooring line (credit: OCIMF MEG 4)

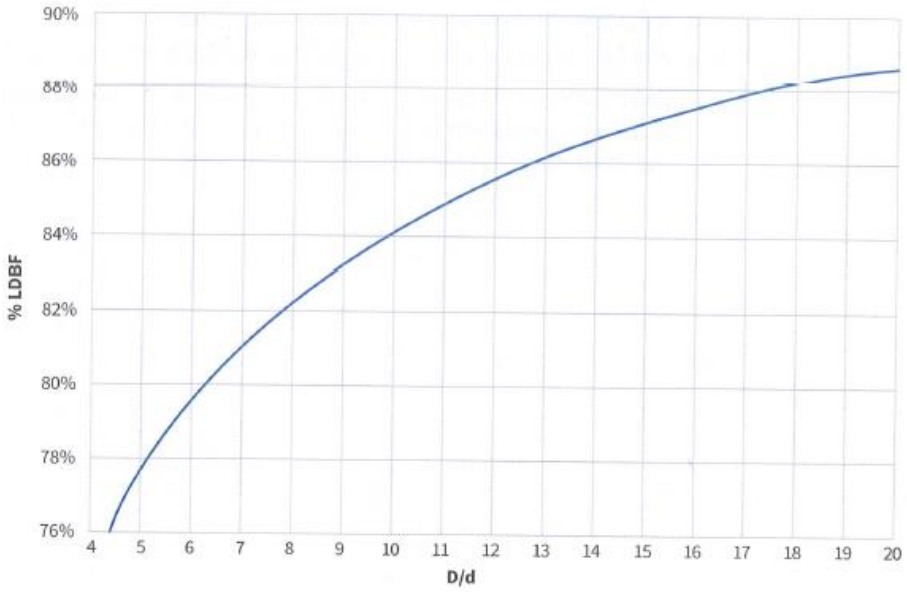

Figure 6: Chart showing estimated strength loss with varying D/d ratio (credit: OCIMF MEG 4)

4.1.3 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 7 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.

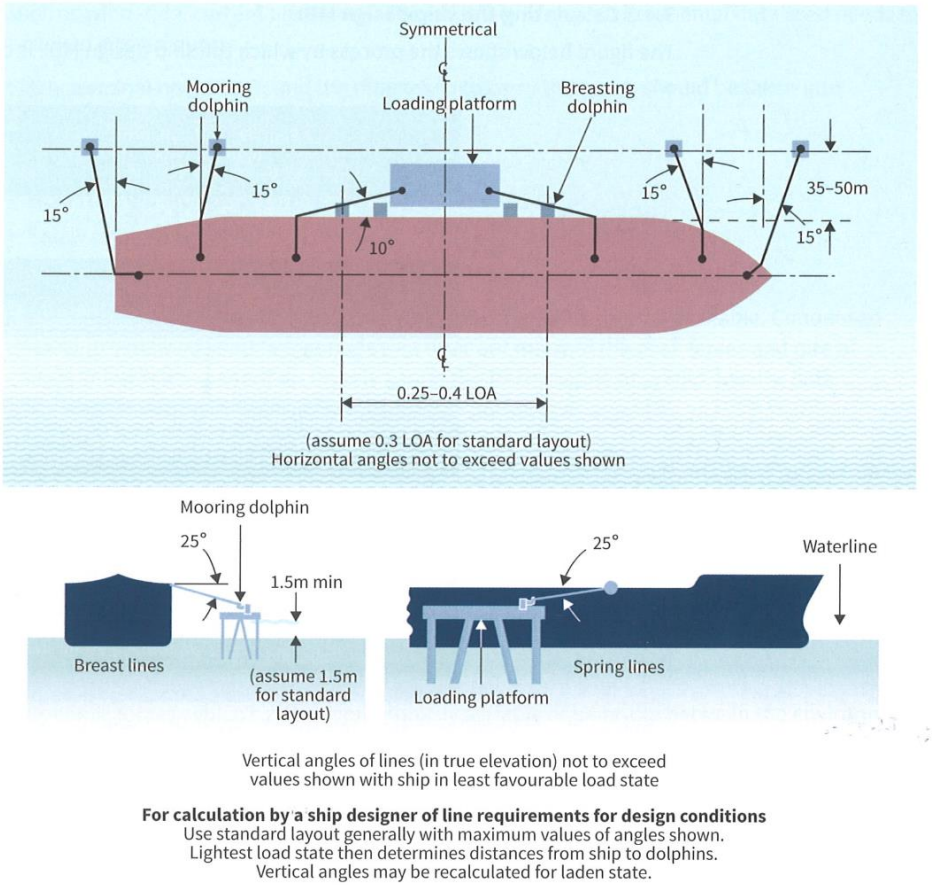

Figure 7: Mooring angles (credit: OCIMF MEG 4)

4.1.4 Induced Twist

Most MAGNARO® ropes come in 8 or 12 strands braided constructions. These ropes consist of an equal number of left and right lay strands. If the rope is twisted, it will cause half the strands to tighten and the other half to loosen, resulting in unequal load sharing. A severely twisted rope can lose as much as 50% of its strength!

One exception to this is MAGNARO®-6 which is a laid rope. This construction is very similar to a wire rope and again should not be twisted at all.

4.1.5 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) in the mooring line or the use of mooring tails can help to reduce line loads in these dynamic environments.

4.1.6 UV Degradation

Synthetic fibres will deteriorate under UV radiation and different fibres have a different degradation rate when exposed to UV light. UV radiation will only affect the surface layer fibres of the rope and so a smaller rope (20mm diameter or less) will suffer more damage from the effects of UV compared to a larger rope. Furthermore, special additives and coatings are applied to our MAGNARO® ropes to reduce the effect of UV degradation. For these reasons, if ropes are being stored in-doors when not in use, the effect of UV is unlikely to be a major contributing aspect to the lifespan of the typical mooring rope compared to the other factors discussed.

It is worth mentioning that underlying yarns which were previously protected from UV rays may be exposed later due to surface layer damage from abrasion or wear.

4.1.7 Elevated Temperatures

Synthetic fibre ropes are made from plastic polymers and thus are sensitive to high temperatures. When exposed to excessive heat, the strength of the rope can be permanently reduced. How much strength is lost depends on the actual temperature, the length of time of exposure and the type of fibre.

This exposure to elevated temperature is not just limited to external influence, such as placing the rope near a steam vent, but can also be from the heat produced from external and internal abrasion under tension. The heat built up during usage is significant and cannot to be underestimated. Coupled with high ambient temperature and direct contact with a hot metallic surface, it can prove to be a major factor in the loss of rope strength over time, especially in materials with a low melting point such as HMPE.

4.2 Anti-Chafing rope protectors

TEHO offers 3 ranges of rope protectors to customise for ease of use and degree of protection offered.

4.2.1 MAGNARO® Rope Protector

- Made from reinforced 100% high-tenacity polyester
- Comes in lengths of 3 metres
- Available in 3 sizes, accommodating different rope diameters:
- Orange colour for higher visibility
- Easy installation using extra durable velcro lining

rope size	width
20-40mm	250mm
44-64mm	350mm
68-96mm	500mm

- Cut resistant
- Protection against localized abrasion
- Will not split or crack when bunched or compressed
- Improves lifespan of the rope
- Suitable for all fibre ropes

4.2.2 MAGNARO® Coverguard

- Available in high-tenacity polyester or in HMPE
- Permanently fixed over whole length or used as a movable protection on a part of the rope
- Sleeve is made as a hollow braid and can be adjusted to the diameter of the rope
- Able to accommodate different rope diameters
- Improves lifespan of the rope
- Protects the rope from abrasion yet still allows the rope to be inspected
- Suitable for all fibre ropes

4.2.3 MAGNARO® Chafeguard

- Has to be installed before the rope is spliced
- HMPE yarns in a hollow 48 strand construction
- Special abrasion resistant coating
- High cut resistance
- Usable on rope body or eye
- Greatly improves lifespan of the rope
- Especially suitable for high performance fibre ropes

4.3 Line rotation program

Other than rope protection, to maximise the life of the rope there should be a structured line rotation programme put into place. Different lines of the vessel have different wear zones which also depends on the port that the vessel is calling at. Spring lines and breast lines are typically more heavily stressed compared to head lines and stern lines. By rotating the lines, wear zones and rope fatigue can be distributed throughout a larger section of the rope ensuring a higher degree of safety for the crew and a longer lifespan for the rope.

As an example, a high quality MAGNARO®-FLEX line can have a service life of about 5 years or 2500 hours, whichever comes first. Say that a new rope is being installed as a spring line. After 1.5 years, the rope can be

taken out and put in use as a headline. After a further 1.5 years, the line should be end-for-ended and put back into the same usage. After another year of service, the rope should be switched back to the spring line. Finally, at the end of the 5th year, the rope should be replaced.

This is a very general line rotation suggestion and does not take into account trade patterns, port of call, weather conditions and so on. Please contact TEHO directly if a comprehensive plan for line inspection and residual strength testing is required.

5 Repair

The end termination eye splice is typically one of the first section of the rope that fails. One of the main advantages of synthetic fibre rope over steel wire is the ease of on-site splicing. TEHO supplies synthetic fibre ropes in 8 and 12 strands braided constructions.

Refer to Appendix A and Appendix B for splicing instructions of 8 and 12 strand ropes respectively.

For repair of over-braided jacket, TEHO can supply the MAGNARO® repair kit. The kit contains all the tools and instructions necessary for on-site repair of the damaged rope jacket.

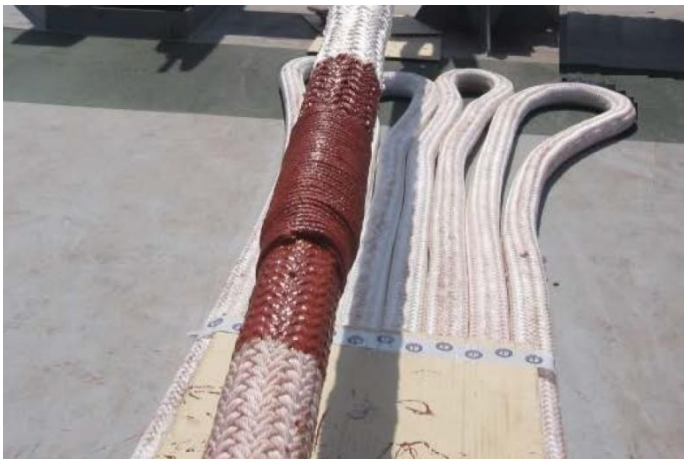

Figure 8: Damaged rope jacket after using MAGNARO® repair kit

6 Inspection and discard

The lifetime of a rope is strongly influenced by its material, construction, the environment it is used in and the type of application. It is recommended to keep a detailed log of the rope and plan inspections depending on the rope usage. The inspection interval is dependent on the frequency of use and environmental factors such as temperature and weather condition when the ropes are being utilised. The results of an inspection should be documented in an inspection card.

Synthetic mooring lines should be replaced when its residual strength has fallen to 75% of the ship design MBL (equivalent to about 75% LDBF).

Synthetic mooring tails should also be replaced when its residual strength has fallen to 75% of the ship design MBL (equivalent to about 60% of TDBF).

There is no way to know the actual residual strength of the rope other than to perform a break test. Consequently, rope inspections are strictly qualitative and very much based on experience. For this reason, it is recommended to always err on the side of caution as the consequence of a broken line very much outweighs the cost of replacing the line before it parts.

Inspections are typically carried out via visual assessment on the whole rope with additional focus on the following areas:

- The sections in wear zones like deck fairleads and rollers
- At the crossover point on split drum winches
- The eye and eye splice region

If local damage is found, then a rope length of 50 times the diameter before and after that section should be closely inspected and all reductions in strength should be added together.

During inspection, the residual breaking strength of the rope should be estimated as far as possible by estimating the percentage of the intact load bearing yarns versus the damaged yarns. Due considerations should also be given to factors discussed in section 4.1 that also influence the breaking strength but cannot be seen visually.

6.1 Common types of rope damage

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

6.1.1 Wear and Abrasion

Wear and abrasion are the most common causes of rope failure. Rough surfaces, sharp edges, burrs, rust and dirt can cause serious damage to a rope. Winches, pulleys, chocks, bitts, etc. should be clean and in good condition.

Wear and abrasion can occur locally or over greater lengths. Extra attention should be paid to the splice area and the eye as well as any area that may come into contact with deck equipment during use. As the rope pay-out length is different for every mooring, the entire wear zone area should be checked. Frayed and broken yarns should be removed and the reduction in strength estimated.

Figure 9: Left – a new rope; Centre – rope with normal fluffiness from abrasion; Right – rope with severe abrasion

6.1.2 Friction Burns

Friction burns can occur over greater lengths or locally. Direct contact with hot objects should be avoided. When using the rope on a winch, capstan, fairlead etc. care should be taken to avoid surging the rope while

it is under load. If the rope slips, the heat generated through friction may be high enough to melt and fuse some of the fibres. Any part of the rope that has fused loses all its strength and forms a hard lump that can further abrade the surrounding fibres.

When friction burns are detected, then the rope should be opened up fully and users should check how much of the rope is fused. The damaged area should be considered to be about twice the fused area for the purpose of estimating residual strength.

Figure 10: Left – rope with friction burns; Right – rope with severe friction burns

6.1.3 Crushing/pinching

When a rope has been crushed or pinched it should be removed from service. Typically, with this type of problem the resulting damage in the rope is a combination of broken/cut yarns and pulled yarns or strands, which makes for very unreliable estimates of the resulting reduction in strength. A knot has a similar effect.

6.1.4 Pulled yarns or strands

Individual yarns or strands can be caught by protruding objects (such as nails, burrs, etc.) and be pulled out of the rope. This damage makes the rope unsafe as yarns or strands that are pulled out from the core do not take any load, resulting in unequal loading on the remaining yarns/strands. The pulled yarns can also get caught by other equipment and break.

If the pulled yarn occurs on a rope jacket, the yarn can be cut and the ends worked back into the rope. A pulled yarn or strand from the working core of the rope should not be cut. Great care should be taken to work the yarn or strand back into the rope. The number of pulled yarns or strands should be counted and noted in the inspection card. The cause of the damage should then be traced and alleviated.

Figure 11: Left – Single yarn pulled out; Centre – several yarns pulled out; Right – entire strand pulled out

6.1.5 Cut yarns or strands

Individual yarns or strands can be cut through chafing against sharp objects or rusty deck equipment. The number of cut yarns or strands should be counted and the remaining rope strength estimated and noted down in the inspection card.

Figure 12: Left – several cut yarns; Right – Almost an entire strand cut

6.1.6 Inconsistent diameter

After a line has been used, it may be possible that the rope diameter is found to be inconsistent, i.e., bigger and/or smaller in certain sections compared to the nominal diameter. This is typically more obvious in a jacketed rope. The difference in diameter may be due to a shock load or a broken internal strand. If the damaged section is close to the end of the rope, it should be cut off and resplice. If that is not possible, it should be considered for discard.

Figure 13: A jacketed rope showing inconsistency in its diameter

6.1.7 Jacketed ropes

Jacketed (sometimes known as double braided) ropes deserves a special mention as the jacket effectively prevents all inspection of the core. Such ropes should be checked for obvious damages on the jackets, which should be fixed immediately with the repair kits. The diameter of the rope should be checked to make sure that it is consistent (refer to section 6.1.6). Ropes can also be bent by hand back and forth to check that the stiffness is also consistent.

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6.1.8 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!*

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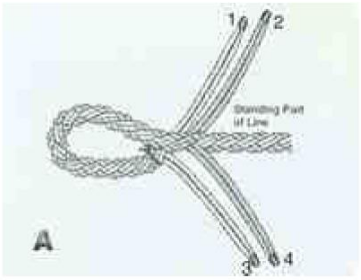
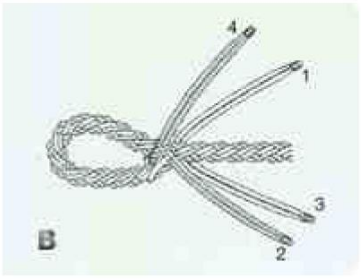
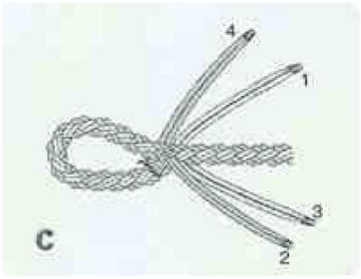
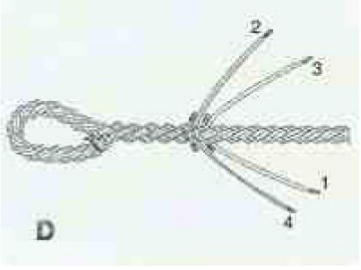
Appendix A Splicing instruction for 8 strand braided rope

STEP 1 Hold and lay rope so that pairs of white strands are on top and bottom with a knot to the right as look toward the end.	
STEP 2 Bend the rope over the desired eye in such a way as to keep knot inside the loop as shown in **Figure A.**	
STEP 3 Using the fid to make clearance and starting with the gray pairs, tuck them under the diametrically opposite white pairs as shown in **Figure A**. make sure you do not disturb the lay of the pairs. Do not twist them so that the individual strands cross over one another in the pair.	
STEP 4 Now turn eye over, again using the fid to make clearance, tuck the white pairs under the diametrically opposite gray pairs as shown in **Figure B**. Note That in **Figure B** the Splice is Turned Over from **Figure A**. The white pairs to be tucked should follow the white pairs of the stranding part and the gray to be tucked should follow the gray pairs of the stranding part.	
STEP 5 Now you have your eye with the first full tuck complete (a full tuck means inserting all 4 pairs); Pull all 4 ends down firmly. Starting with the gray pairs. Using the fid to separate, Take another full tuck. By starting with the gray pairs you avoid having to go under 1 pairs at once. The splice should now look like **Figure C**, (Which now lays on the same side as **Figure A**). From here on, you should have no difficulty completing the rope splicing.	
STEP 6 Now starting with the gray pairs, take at least one more tuck. with a very soft rope, it may be necessary take a 4th or 5th full tuck.	

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STEP 7

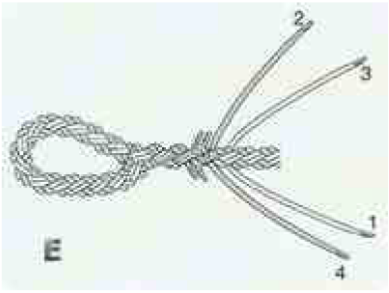
Having completed the 3rd tuck (4th or 5th necessary) select the strand closest to the eye each pairs.

Tape this strand close to where it emerges from the tuck and then cut off as shown in **Figure D**

STEP 8

Now splice the remaining single strands just before for another full tuck.

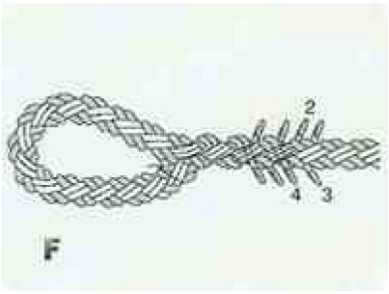
The splice should now appear as shown in **Figure E**, Which will lay on the opposite side as shown in **Figure D**.



STEP 9

Tape first and then cut off the 4 single strands as shown in **Figure F**.

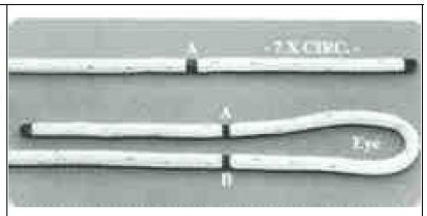
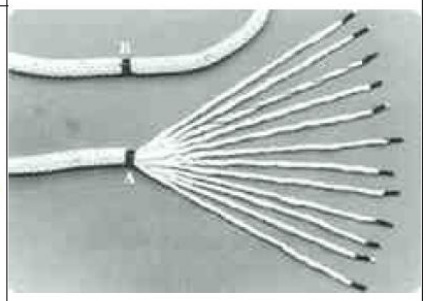
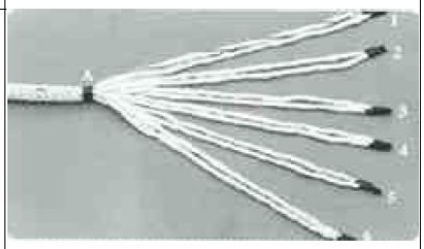
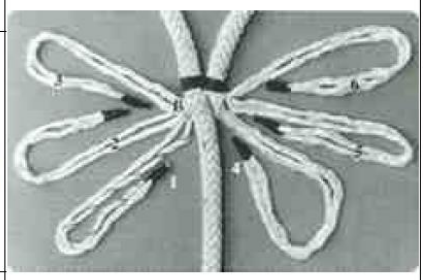
the 8 ends may be heated and fused so they will not fray, Take great caution to be certain that you fuse on the ends and do not damage the strands.



STEP 10

A more professional appearance may be achieved by cutting the ends off flush and then taping or whipping entire splice.

Appendix B Splicing instruction for 12 strand braided rope

STEP 1 – Eye Size Measure from the end of the rope 7 times the circumference (or 21 times the diameter) in inches and make mark "A". Rope at this mark. Form desired eye size and make mark "B".	
STEP 2 – Strand Separation Tape each of the 12 strands and unlay strands back to mark "A". Try to be careful not to remove twist from individual strands.	
STEP 3 – Pair Strands Rope is comprised of a total of 12 strands, 6 strands with left hand twist and 6 strands with right hand twist. Select one left twist strands then one right twist strand and tape together. Repeat this procedure so that you have taped 6 separate strand pairs. Select strands that are near one another as they emerge at tape wrap at mark "A".	
STEP 4 – Marking Pairs Lay rope out, forming eye. Do not twist rope. Select three tapered pairs closest to the stranding part of the rope and mark on tape : "1", "2", "3" respectively. Mark the other 3 pairs "4", "5", "6".	
STEP 5 – Strand Insertion With fid open rope at mark "B" and insert strand pairs "1", "2', "3" completely through the "1", "2", "3" are through the rope, pull each strand so that taped end "A" is snug against body of rope. It may be easier to pass the strand pairs through the rope one set at a time.	

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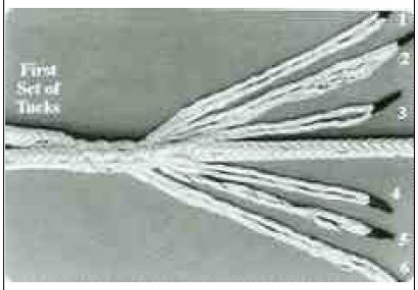
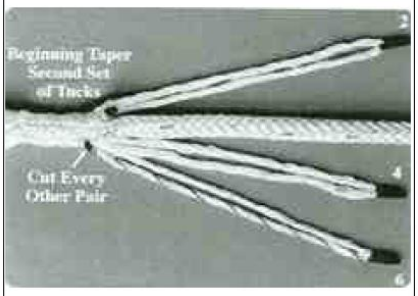
STEP 6 – Initial Strand Tuck

NOTE : Rope braid pattern forms a line of strand crowns running parallel to the axis rope.

1. Starting with strand pair "1", select a row of crowns down the axis of the rope and tuck the pair "1" over one strand and under two strands.
   Once tucked, pull out slack in strand pair "1" make only one tuck.
2. Now tuck pair strands "2" and "3" in the same way with each pair, select crown row and tuck the individual pair over one strand and under two strands. Pull out slack in each strand.
3. With remaining pair strands "4", "5", and "6" select a crown row for each pair so mark one tuck.
   Pull out slack in each pair.
4. Remove tape wrap at mark "A" and Gently but firmly pull on each of the strand pairs so mark "A" is now snug to the base of the eye mark "B".
5. Now complete two more sets of tucks with each taped strand pair.
   Be sure to tuck each strand pair down the same crown strand line, try to keep twist in each pair, and continually remove slack from each strand pair after tucking.





STEP 7 – Taper

1. Cut off strand pairs "1", "3', "5".
2. Tuck strand pairs "2", "4", "6" for additional 3 tucks. retain twist and remove excess slack.

STEP 8 – Final Tucks

1. Split each strand pair "2", "4", "6" into 2 individual strands and tape each strand.
2. Tuck off one strand in each pair leaving a short tail projecting from last tuck.
3. Tuck the remaining 3 single taped strands for 3 tucks (over one and under two) removing slack and keeping twist.
4. Now cut off the tapped strands, leaving a short tail projecting as shown.