Lanex
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INSPECTION AND RETIREMENT CRITERIA (SERVICE LIFE)

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Traditional manufacturer since 1949

CONTENT

FIGURES

INSPECTION AND RETIREMENT CRITERIA

Inspection

The rope / line should be inspected along its entire lenght everytime before put into use. Inspecting your rope should be a continuous process of observation before, during and after each use. After each use, look and feel along entire rope length inspecting for abrasion, glossy or glazed areas, inconsistent diameter, discoloration, and inconsistencies in texture and stiffness (see retirement criteria). Rope inspections frequency should be determined based on number of mooring operations, loading history and other factors influencing rope's lifetime (such as bending radius, mechanical abrasion, chemical exposure, UV exposure or combination of those factors). It is highly recommend to avoid using damaged ropes or ropes showing signs of aging. If there are any doubts about the rope's safety or rope's integrity, it should not be used and should be retired.

Deyployment inspection

The working length of the line (outboard of the tension side of the winch) is inspected for defects which may impair the performance of the line. This is typically completed during mooring operation.
The line is inspected by the mooring party (training requirement stated in Line Management Plan LMP) every mooring operation.
An output of this inspection should be an inspection report (e.g. Inspection Record Sheets - see Figure no.1), Incident report (e.g. line failure, or other significant damage), liaise with manufacturer, Go/ no go decision to use lines in next mooring operation and document repairs. Photograph the rope if appropriate.

Routine inspection

The full length of line on the in-service section of the line (typically on the tension side of the mooring winch) is inspected. This is visual inspection, externally and internally where possible (i.e. unjacketed). Jacketed lines will require a routine inspection as recommended by line manufacturer and operator experience.
We recommend to do this type of inspection in period of every 250 mooring hours or in period of every 6 months, according to fact which period comes earlier.
The line is inspected by the ship personnel (training requirement stated in Line Management Plan LMP).
An output of this inspection should be an inspection report inspection report (e.g. Inspection Record Sheets - see Figure no.1), repair requirements and recommendation. Photograph the rope if appropriate.

Detailed inspection

Either the full length of line, or the full length of the in-service section of the line (typically on the tension side of the mooring winch) is inspected externally and internally where possible (i.e. unjacketed lines). Jacketed lines will require a detailed inspection as recommended by line manufacturer and operator experience.
We recommend to do this type of inspection in period of every 1 000 mooring hours or ship special survey (e.g. five years), whichever occurs first.
The line is inspected by the manufacturer´s representative, third party expert or ship personel (training requirement stated in Line Management Plan LMP).
An output of this inspection should be an inspection report (e.g. Inspection Record Sheets - see Figure no.1), repair requirements, recommendations (end-for-end/retire/repair) and details of repairs undertaken. Photograph the rope if appropriate.

Residual strength

For more definitive estimate of residual strength, a portion of the rope or its components (yarns or strands) can be removed and tested for residual strength. Residual strength testing can be used as a tool for supporting the line condition based monitoring. Testing may use the procedures of relevant ISO or CI standards. Gathering this information assists with evaluating service life expectations and post-incident analysis. When conducting testing and analysis, usage history for each line should be supplied to the manufacturer or test facility. This typically includes mooring hours, line service location, end-for-end, rotation history and any other information related to the line, such as damage or repairs. If available, mooring line load history data is helpful in determining the residual strength of mooring lines.
As a minimum, the following information should be documented and provided to the manufacturer or testing facility in any such testing or analysis:

- Mooring line product name/material
- Mooring tail product name/material
- Mooring line position/winch number
- Mooring line usage history (mooring hours)

If operational loading history is available (e.g. mean operating loads, dynamic loading events and
frequency, etc.), either on the ship or terminal, this data should be recorded, stored and shared to allow for more comprehensive analysis. Manufacturers of such systems are encouraged to offer systems that can produce historic loading data that can be provided to ship operators for retention on board and for use in the more robust analysis that takes place in the residual strength testing effort and during the refinement of line service life policy. Data should be available in easily readable formats such as spreadsheets.

Inspection process

- Prepare Inspection Record Sheets (e.g. see Figure no.1) or make entries in a log (this will include data on the type of rope, time in service and description of intended use,…). Fill-in know rope information, such as: type, diameter/cirkumference, fiber material, length, manufacturer, length and type service. Add name of the inspector, date and location.
- Photograph the rope if appropriate.
- Lay out the rope in a straight line, on a smooth surface, under hand tension. Attempt to apply enough tension to straighten the rope (in increments if space is limited). Small diameter ropes may be inspected by pulling segments hand-over-hand. For long lengths of larger ropes, it is best to utilize a mechanical advantage to apply light tension on the rope while i tis being inspected.
- If a rope is long, it may be marked and coded in evenly spaced intervals. For easier identification, mark each fifth and tenth length interval more strongly. If the rope is very dirty, intervals could be marked by using knotted twine pieces passed through the rope. Tape is also appropriate if wrapped completely around the rope.
- Visually examine, stepwise, the entire rope length for detectable damage and deterioration; include eye splices and/or end-to-end splices. Record all findings; identify end-to-end location of detectable damage areas.
- Sight the rope down its length as you would a plank or mast. Inspect for high or low strands and randomly uneven cross sections. Look for twist in braided and plaited ropes, and corkscrewing in stranded ropes.
- For ropes small enough for a tactile inspection, feel for unevenness, rough spots and stiff (lacking flexibility) sections.
- Measure the rope circumference. Determine the circumference in a number of places, in particular in any damaged areas. This is most easily done with a thin whipping twine, thin metal or fabric tape measure or a pi-tape, wrapped around the rope with slight hand tension. Make note of nominal circumference, and any point on the rope where the circumference varies more than 10% from what is found on most of the rope. Ropes may decrease in circumference if well used and may be less than specified for new ropes.
- Look for variations in the lay length (in a twiste drope) or pick length (in a braided or plaited rope). Apply a small tension to the rope and check this length at various locations along the rope. Note any appreciable deviations in lay or pick length. This length should not vary by more than ± 5% over the rope length. On long specimens, the tension must be high enough to minimize the effects of friction with the ground.
- Examine the rope for abrasion, cuts, broken yarns. Make a note of the type, location and level of damage such as, number of broken or noticeably damaged yarns, depth and length of abrasion or wear spots, frequency and spacing of damage, if damage is done strand or multiple strands. Estimate the loss of strength be comparing abraded or cut fibers as a percentage of the rope diameter or strand diameter.
- Lengthwise damage of several adjacent strands should be summed the same as if it were around the circumference.
- Check any broken rope specimens in detail. A meaningful inspection must include both ends of a broken rope. Note location and nature of break. If possible, identify the conditions that caused the damage, such as rough hardware surfaces, points of contact, excessively sharp bends, or introduction of twist from winching practices.

- Open the rope and examine the interior. Turn twisted rope slightly to open the interior for observation. Push on single braided or plaited ropes and/or use a fid to open the interior to view. On double braided ropes, push on the rope and use a fid to open a small hole to view the core. Be careful not to pull strands excessively. Look for broken filaments, fuzzy areas, kink bands.
- Check braided ropes for hardness. Pushing on the rope should cause the braids to open. Braided ropes should be supple and bend easily. They should flatten slightly when compressed laterally.
- Check Kernmantle, jacketed ropes or double braids for core breaks. This is manifested by sudden reduction in diameter and can be felt by running hands over the rope.

Inspection schedule

Important part of inspection is the inspection report. It should contain:

- Rope technical parameters and properties
- Maintenance service time
- Usage of the rope

Every inspection record should contain the date, place and inspection summary. Every inspection record should contain regular inspection schedule. (Figure no. 1)

SAMPLE MOORING LINE LOG

	Vessel	I. D. Number	
Size	Fiber	Construction	
Length	Number Eyes	Size Eyes	/
Mfg or NSN			
Spliced by		Date	
Inspection Schedule			

HISTORY

Date put in service Mooring station

Date	Inspection or Incident	Comments

Figure no. 1: **Inspection schedule**

SERVICE LIFE / RETIREMENT CRITERIA

Synthetic fibre ropes are used in many different applications. These applicatlions are very variable in terms of rope´s mechanical durability demands.
Various diameters, constructions and materials of the ropes can show differences in lifetime in spite of the fact that they are used the same way.
Rope tenacity strenght/rope lifetime depends on use conditions and rope condition that must be checked regularly.
Knowing the causes and appearance of damage is essential to a good rope inspection and essential in determining retirement criteria. This section describes the most common causes of rope damage and describes the effects.

Excessive Tension/Shock Loading

Overloading or shock loading a rope above a reasonable working load limit can cause significant loss of strength and/or durability. However, the damage may not be detectable by visual or tactile inspection. The usage history of a rope is the best method to determine if excessive tension or shock loading has occurred. Overloading and shock loading are difficult to define and the inspector must take a conservative approach when reviewing the history of the rope. Shock loading may cause internal melting of fiber.

Cyclic Tension Wear

Ropes that are cycled for long periods of time within a normal working load range will gradually lose strength. This loss of strength is accelerated if the rope is unloaded to a slack condition or near zero tension between load cycles. The subsequent damage is commonly referred to as fatigue. Although there are various mechanisms for the breakdown of synthetic fibers under cyclic tension, the most common is fiber to fiber abrasion. See figure no. 2 where long term loading and unloading has caused a breakdown of yarns in the outer braid of a double braided rope. This rope was extremely hard due to internal compaction of broken fibers.

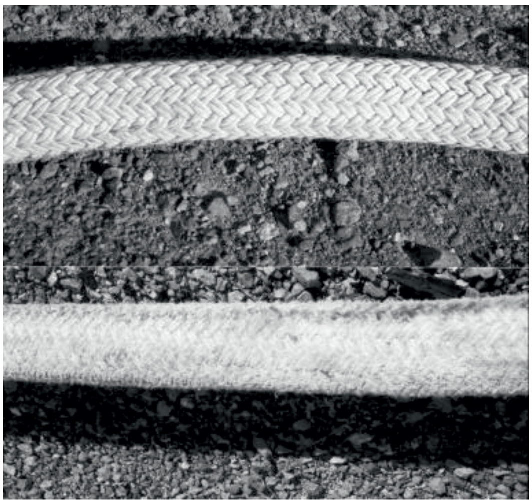


Figure no. 2: **Fibre abrasion - Cyclic tension**

Braided ropes develop many broken filaments at the crossover points of strands in the braid due to fiber-on-fiber abrasion. These broken filaments give the rope a fuzzy appearance on the outside and over the entire length that was under load; this can be so extreme as to obscure the underlying braid structure. Figures no. 3 shows extreme examples of braided ropes that exhibit excessive damage from frequent loading and unloading.

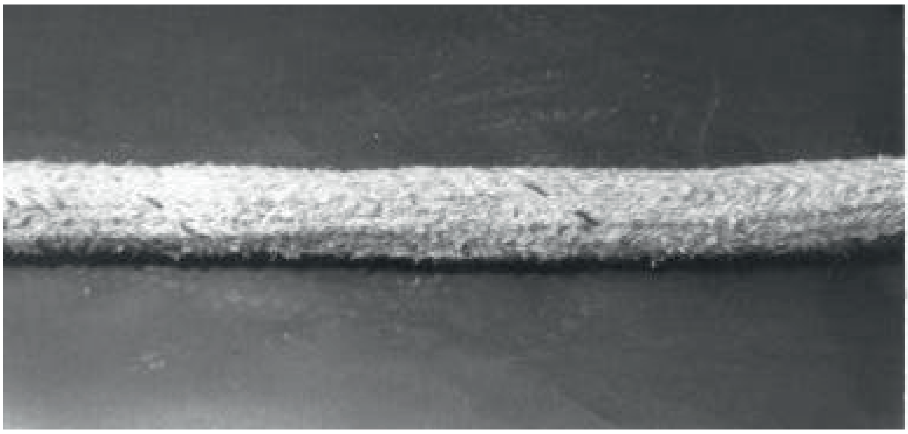


Figure no. 3: **Fibre abrasion - Cyclic tension (extreme wear)**

For braided ropes, broken filaments within the rope can also mat, entangle and/or leave a powdery residue. Extreme internal filament breakage will make the rope very hard, lose flexibility and be noticeably larger in diameter (with a subsequent reduction in length); it may be so hard that it is impossible to try the rope open to examine the interior structure. Melted fiber and fusion may be observed in the core rope or between core and cover. See Figure no. 4 for exposing the inside of the structure.

Figure no. 4: **Inter-strand abrasion (exposed internal area reveals wear at strand internal contact points)**

For twisted and 8-strand plaited ropes most of the wear will occur on the inside of the rope where the strands rub on each other. Broken, matted filaments and a powdery residue may be observed. Figure no. 5 shows how to expose the inside of the structure by pushing on the rope and possibly exposing one strand. For laid ropes, twist the roe in the opposite direction of the lay.

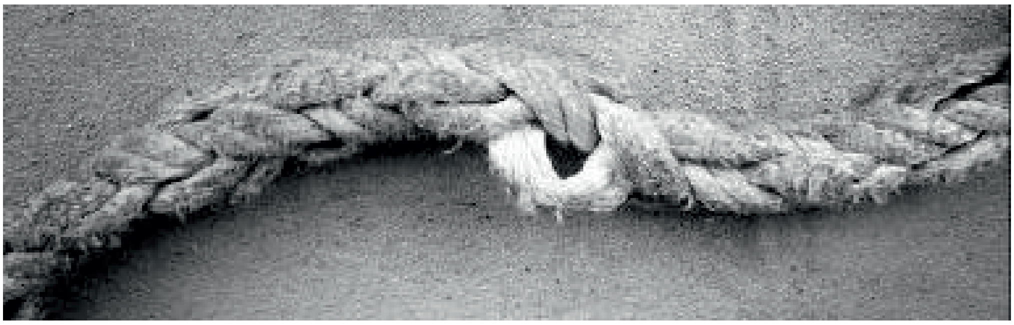


Figure no. 5: **Matted internal yarns (exposed stands reveal internal matting)**

External Abrasion

Most external abrasion is localized. Gouges and strips along one side of the rope are common; these display cut fibers and are often accompanied by fusion. Damage sufficient to degrade the rope is usally obvious. More uniform abrasion may be seen in ropes that are used over fixed objects that bear along a considerable portion of its length. Also dragging over a rough surface will show uniform abrasion Figures no. 6.

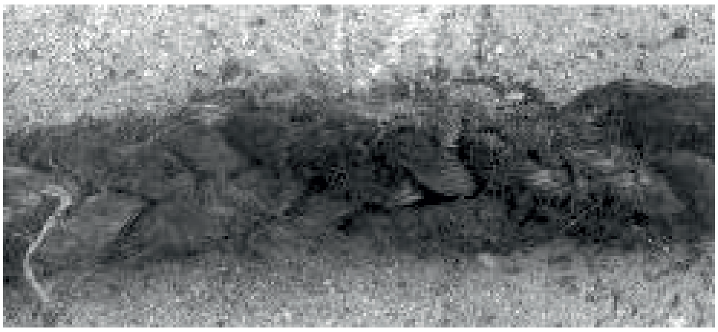


Figure no. 6 a): **External abrasion - Extensive external abrasion**

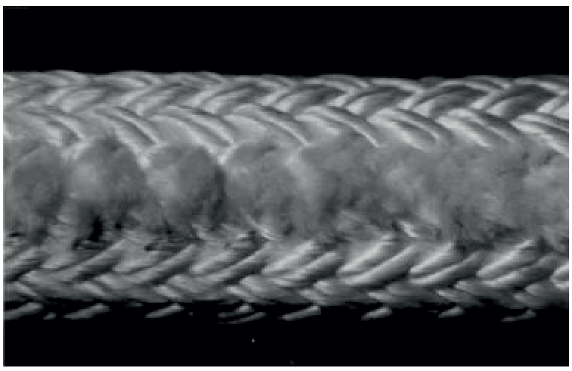


Figure no. 6 b): **External abrasion - Localized external abrasion 1**

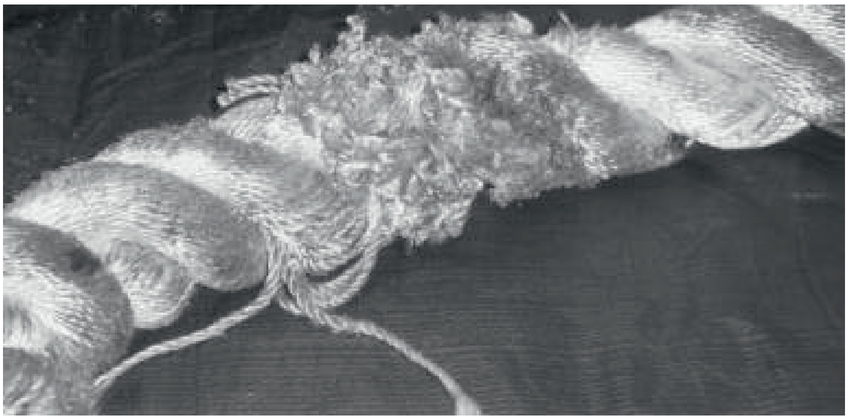


Figure no. 6 c): **External abrasion - Localized external abrasion 2**

The surface of the rope may be melted and appear black due to sliding while bent over surfaces when under high tension (see figure no. 7).

Figure no. 7: **Burn and melting from external abrasion**

Jacketed ropes require inspection of the outer sheath. The load bearing core should not be exposed. Loose strands that mat snag could be a consideration in some cases.

Cutting

It is obvious during visual inspection to see where fibers have been cut sufficiently to degrade a rope. Damage assessment includes an evaluation of the amount of affected fiber, and location and orientation of the cut. For multiple cuts, the space between damaged areas is important.

Figure no. 8: **Localized external abrasion**

For jacketed ropes where the jacket is non/load bearing, a cut that does not damage the core will probably not affect the strength.

Pulled strands and yarns

Strands and rope yarns can be snagged and pulled out of the rope structure (see Figures no. 9 and 10). The level of damage is a function of the percentage of the rope cross section that has been lost.

Figure no. 9: **Localized external abrasion 1**

Figure no. 10: **Localized external abrasion 2**

Flex Fatigue - Polleys, Rollers, Chocks, Fairleads, Blocks

Constant bending of any type of rope causes internal and external fiber abrasion. This is frequently caused by running on pulleys. Repeated bending will reduce the service life of the mooring line. But, other types of flexing such as frequent bending over a small radius surface, can also cause fatigue external and/or internal damage.

The D/d ratio (D/d ratio is the diameter of the bend divided by the diameter of the mooring line) should be as large as possible to maximise mooring line strength and working life.

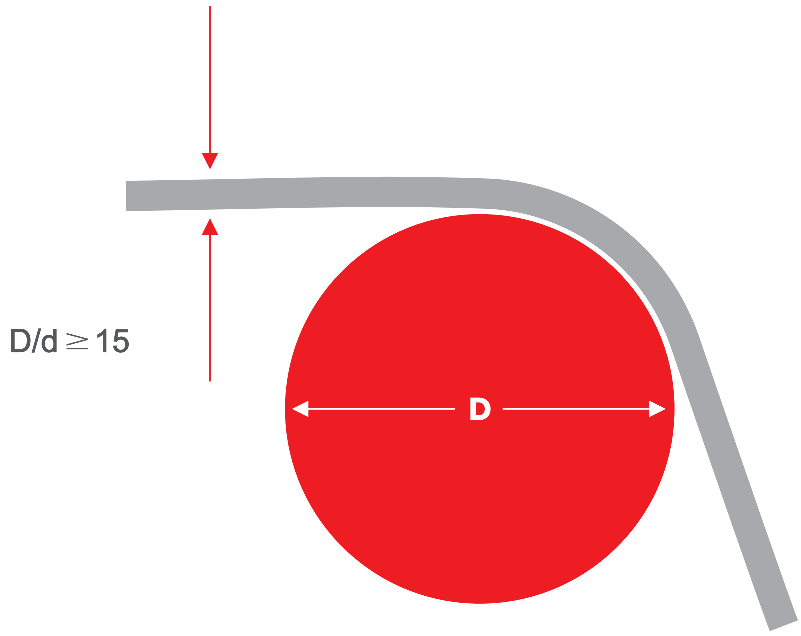


Figure no. 10: **D/d ratio of mooring line to deck equipment**

It is recommended that result in a D/d of at least 15 (see Figure no.10).This will ensure the performance reduction due to bending is kept to a minimum. The D/d resulting from deck equipment design is only one of the factors affecting the condition and service life of mooring lines, but it is a fundamental consideration in the process of assessing the strength and prospective service life of mooring lines.

In case that D/d ratio is lower than 15, it is necessary to record the information to the Line Management Plan (LMP).

Wear will appear on the surface of the contact area. The fibres will become matted on the surface and/or glazed from heat build-up (see Figures no. 6).

Spliced Eyes and Other Terminations

Check for a properly made eye and end-for-end splices; splices should always be based on Splicing instructions.
Damage is common at splices – see Figures no.11. This area always needs to be examined closely. Look for broken strands at the leg junction (see Figure no.11 c)), surface wear in the back (apex) of the eye, flattening where the rope bears on pins or bollards, slippage of tucks in stranded or twisted ropes and displacement of core/cover for braided rope with buried splices.

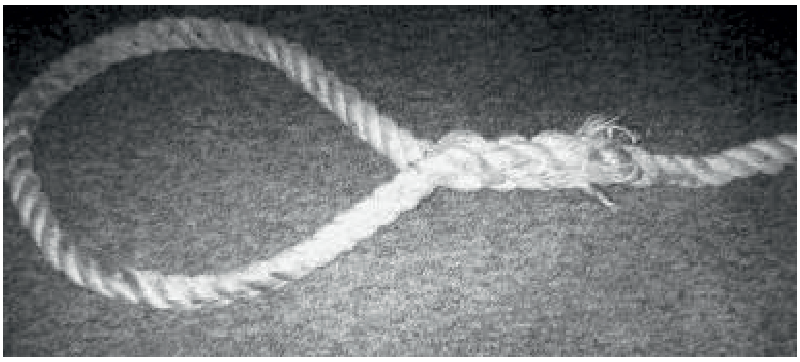


Figure no. 11 a): **damage of splicing - 3-strand splice of poor quality**

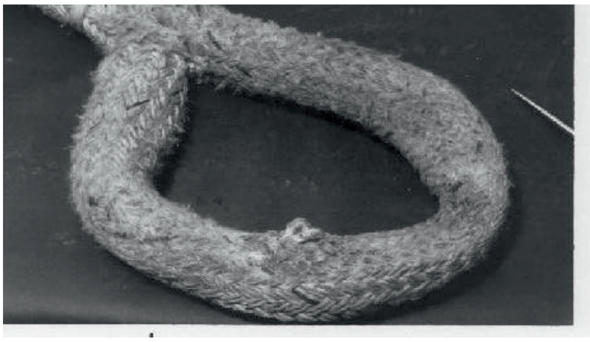


Figure no. 11 b): **damage of splicing - wear in double braid eye splice**

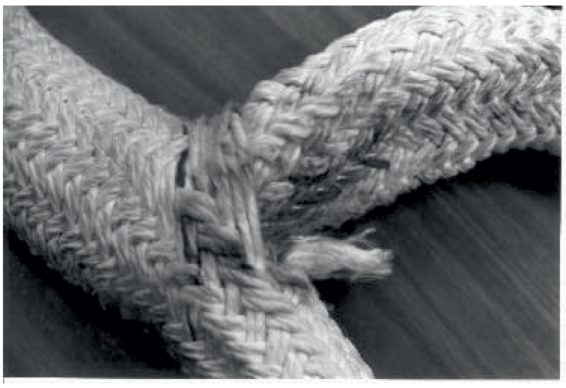


Figure no. 11 c): **damage of splicing - wear in double braid eye splice**

Tucks in 3, 8 and 12-strand and tucks in tuck splices in single braided may have slipped in the splice. The buried leg in single and double ropes may have slipped. Freshly exposed fiber in tucks or buried legs will look clean or have a slightly different appearance where it has pulled out of the body of the rope. See Figure no. 11 a), an example of a poorly made splice.
Lock stitching should be used with bury splices on single braided rope. Check to see if they are present. They are often found on double braided ropes. In both cases, they should not be broken.
Parallel fiber ropes and some parallel strand ropes require a continuous whipping function. Damage that allows the whipping to come loose can be dangerous.

The following should be noted when inspecting thimbles:

- Inspect for corrosion, cracks or sharp edges that indicate weakness or the potential to cut or abrade the rope.
- Check that the groove in the thimble for the rope is slightly larger (5 - 15 %) than the rope when there is little or no tension.
- Check security of thimbles in the eye of a rope. Fiber rope thimbles have ears that prevent the eye from turning in the thimble or allowing the thimble to fall out. If wire rope thimbles are used, they should be tight in the eye or lashed to the legs of the eye to prevent turning or falling out. Adhesives have also been used successfully to secure rope in a thimble.
- Fibre rope thimbles designed for nylon, polyester or polypropylene ropes may not have sufficient strength if used with very high strength fiber ropes. Heavy duty wire rope thimbles are suitable for these ropes when the fiber rope and wire rope size are the same. If data is available, determine strength compatibility.
- Thimble rated load must always exceed the WLL for an application. Ideally, if the breaking strength of a thimble is known, it should exceed the rope strength.
- In some cases, a thimble should be used but is not and excessive wear has occurred in the back of the eye. Figure no. 12 (upper), shows the rope eye directly on a shackle without a thimble. The rope is bent over about the same diameter as the rope itself (D/d ratio is lower than 15). This can give adequate strength when the rope is new or for very few loadings, but wear can be rapid in severe applications. Figure no. 12 (lower), shows a wire rope thimble in the same application.

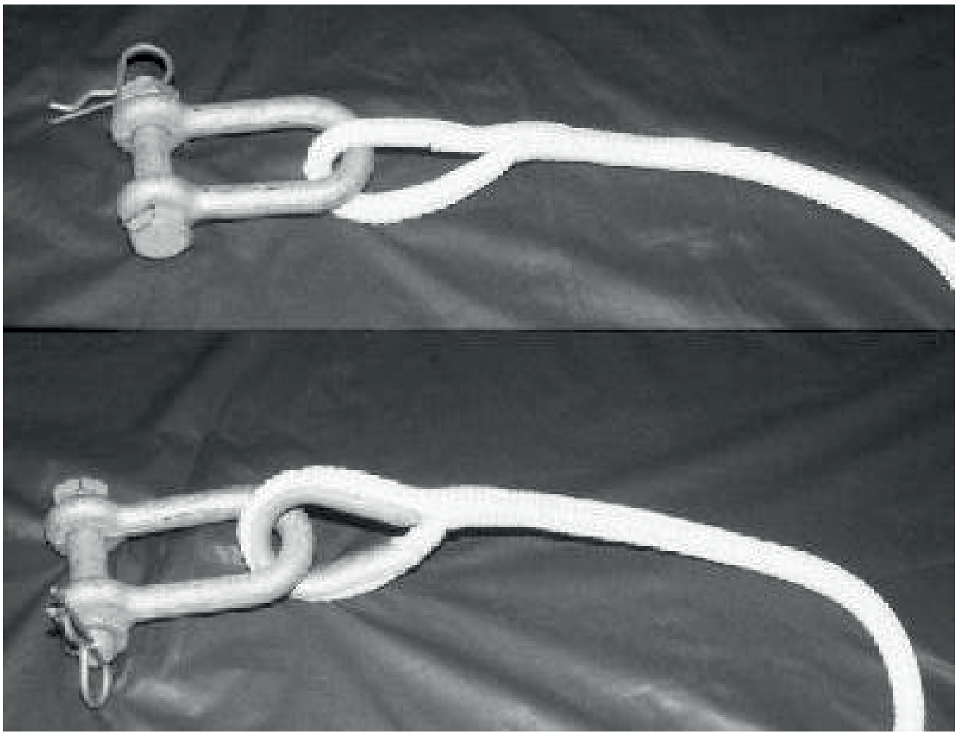


Figure no. 12: **Rope with thimble (lower) and without (upper)**

Creep (cold flow)

Ropes made of materials that creep will be measurably longer if loaded continuously for long periods of time. Creep rates depend on the material, time, temperature and load relative to breaking strength. The inspector should research the loading history of the rope and determine if the fiber material is subject to significant creep at the operating conditions. Ropes made of HMPE and polypropylene are particularly susceptible and nylon is somewhat susceptible.

Ropes that fail due to creep often retain relatively high strength until they are very close to failure; thus the need to check for operating conditions that may suggest excessive creep.

Creep also reduces the elongation at failure during a strength test. Maintaining relative high stretch before failure is important in some applications. In most cases, loss of stretch can only be determined by a destructive test. Strength testing may not reveal the true condition of the rope unless stretch is also checked and compared to normal values.

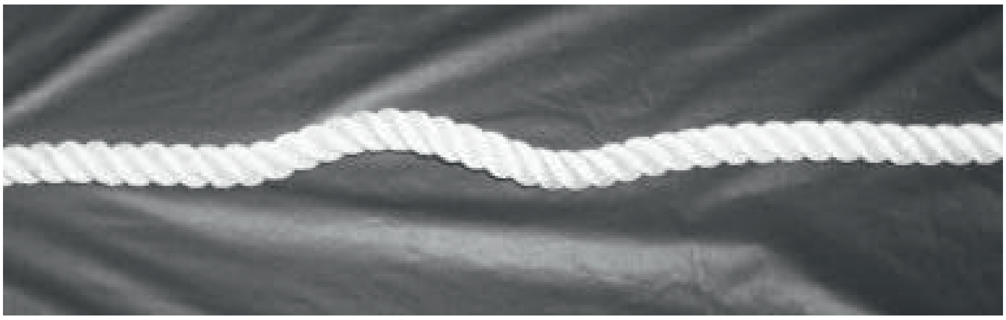
Visual inspection for creep is only possible if the rope is cycled at moderate load a few times to set the structure; then gauge marks are placed on the rope and the length carefully measured under reference tension before it goes into service. The recorded length is then compared to the used length measured under the same reference tension.

Axial Compression and Kink Bands

Ropes that have a braided jacket, load bearing core are subject to axial compression, as manifested by kink bands. This occurs mostly in ropes with a very tight jacket.
Kink bands can also appear in splices of very high strength, high modulus ropes (HMPE,…).
This is an indication that serious damage could be present. Destructive testing may be the only means of evaluation.

Hockle, Twist, Kink or Corkscrew

If a loop is introduced into 3-strand rope (or other multistrand laid rope), it will tend to hockle when tension is applied. Once set, hockles cannot be turned back to restore the rope structure and this indicates severe damage.
Some ropes will display a corkscrew appearance and must not be used unless restored to normal appearance.
Braided and plaited ropes should display little or no twist, and those that do must not be used unless restored to normal appearance (see Figure no. 13).
Induced twist may reduce a mooring line´s strength. Removing Twist - see to Line maintenance guideline.



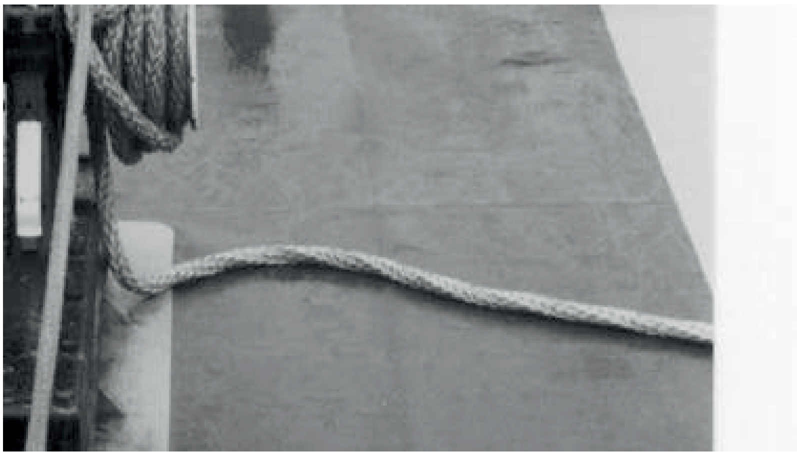


Figure no. 13: **Corkscrew due to twist and Twist in 12-strand braid rope**

Sunlight Degradation

UV radiation from direct sunlight will causebrittle and weak outer rope yarns. UV degradation is difficult to inspect visually. Discoloration and brittleness in the filaments may be observed in some cases. Strength testing of a few surface fibers or the entire rope is required for a definitive assessment (see Figure no.14).
The affect on the rope is much less as diameter increases. Damage to very small ropes can be rapid. Uv degradation is stronger in the lower latitudes and will progress with time of exposure. Non-load-bearing jackets or coatings will protect the core rope. Assessment can be difficult and advice of a qualified person should be sought if there is potential for UV damage.

Figure no. 14: **UV degradation of PP rope**

Chemical and Heat Degradation

Synthetic fiber materials generally resist chemical attack and heat exposure in normal circumstances but can be weakened in certain situations. Visual inspection may reveal discoloration and brittleness of the fibers. Melting, bonding of fibers (see Figure no. 15) hardening or stickiness may be observed. However, these manifestation are not always present. The inspector should research the exposure history of the rope.
Nylon ropes, when wet, can be seriously degraded by long term contamination with rust. This can be detedted by the reddish or brown color.
Fiber ropes stored at even moderately high temperatures for long periods of time can be degraded without any visual indication of damage.

Figure no. 15: **Melting of fibers**

Dirt and Gift

Dirt and gift causes internal fiber abrasion in ropes that are in regular use. Most ropes can be forced open for internal inspection. A magnifying glass may be helpful for identification of fine particles.
Sea water that has dried and has left a salt deposit can be damaging due to internal abrasion if the rope is used in the dry condition.
Oil and grease deposits, of themselves, do not damage most rope materials. However, they trap dirt and grit and may make the rope difficult or unpleasant to handle. The inspector needs to assess the effects in the light of the application.

Ropes retirement conditions

If the rope is able to continue in service shall be decided based on rope current condition and damages observed during the inspection. The inspection should be provided by competent and experienced person.
The rope should not be used if there are any doubts that the rope could not survive all the forces affect on it.
User of the ropes should be aware of the fact all the ropes are subjected to wear (including the ropes that are handled carefully). It is necessary to remove all the ropes before failure. Do not use the rope until total failure. Retirement or servicing criteria:

Rope Type and Condition	Reassemble (in case of local occurrence)	Discard
For All Ropes		
The number of threads or strands on the surface reduced by 50% or more on the linear distance equaling the rope diameter	x	x
Suspected shock load		x
Exposure to a significantly higher temperature than specified for a given type of fiber		x
Burning or melting visible on a part of rope longer than four of its diameters	x	x
Abrasion on the inner circumference of the eye, with the number of surface threa ds or strands reduced by 50% or more	x	x
Nylon rust (this can indicate chemical damage)	x	x
Oil and lubricant	Wash in a weak detergent	
Strong surface splicing (increasing)	x	x
	Remove abrasion source	
UV degradation, splicing		x

Rope Type and Condition	Reassemble (in case of local occurrence)	Discard
Ropes With a Sheave		
More than four consecutive braids from the sheave are pulled out (and cannot be put back)	x	x
More than three broken sheaves		x
Multiple broken threads or filaments over the length of one lead		x
Core visible through the sheave due to its damage		x
Damaged core - strands pulled out, broken, abraided, crushed or melted		x
Protrusion of the core from the sheave		x
For 3-strand, 8-strand (Braided) and 12-strand (Braided) Ropes		
5% of the threads broken or severely abraded between the strands		x
Threads from the sheave broken or abraded to more than 50% on one or more of the protrusions	x	x
Cut up to 5% of diameter over the length of one lead	x	x
Dust between adjacent surfaces which are in contact with each other	x	x
Deformation or back rotation of the rope	x	x
10% over the length of one lead	x	x
Rope Type and Condition	Reassemble (in case of local occurrence)	Discard
Heat Damage		
Hard, melted, glossy or glazed rope locations can indicate significant damage to the rope	x	x

Hard, melted, glossy or glazed rope locations can indicate significant damage to the rope	x	x
More than 20% of rope yarns burned or melted		
Over the length of one lead	x	
Over the length of more than one lead		x
Short-term Exposure to Temperatures Higher Than the Fiber Operating Temperature		
Polyolefins, over 65 ° C		
Polyamide, over 100 ° C		
Polyester, over 100 ° C		
Two-component polyester / polyolefin fibers, over 70 ° C		
HMPE, over 70 ° C		x
Manila, over 100 °		x
Sisal, over 100 ° C	Wash in a weak detergent	
Hemp, over 150 ° C	x	x
Exposure to Chemicals (see Annex A)		
Chemical Damage		In principle x, however, follow the recommendation of the rope manufacturer

RESOURCES

1. Mooring Equipment Guidelines(MEG4), Fourth Edition 2018, OCIMF

2. International Guideline CI 2001-04, Fiber Rope - Inspection and Retirement Criteria Cordage Institute - International Guideline

3. ČSN EN ISO 9554 Fibre ropes - general specifications, May 2011

You can be sure

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Traditional manufacturer since 1949