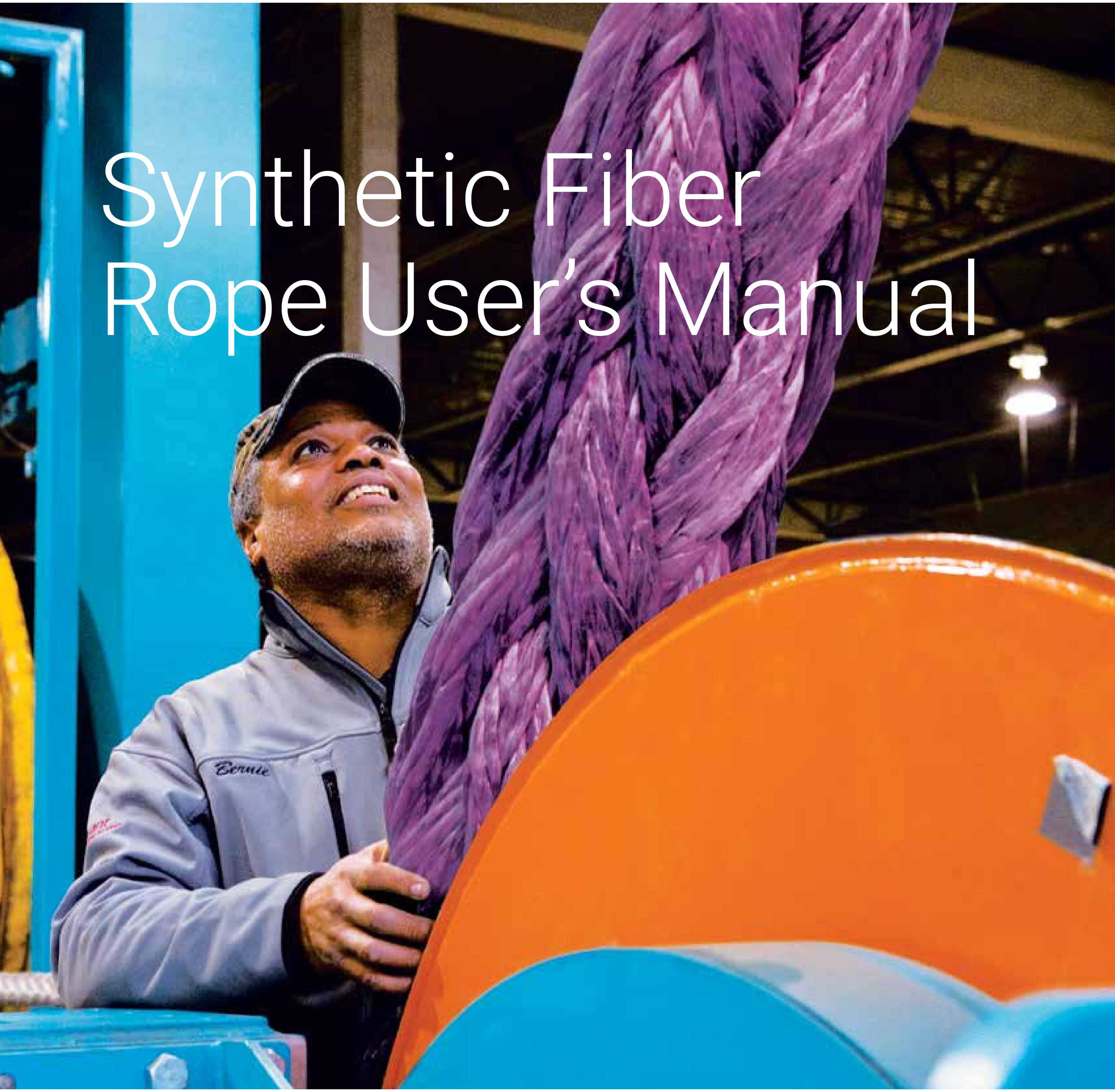
Synthetic Fiber Rope User's Manual



Detailed information for usage of Cortland International Synthetic Fiber Ropes

CORTLAND INTERNATIONAL™

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1a. Overview

Over the last decade synthetic high performance ropes have become a critical load handling component, replacing steel wire rope. Modern, high strength synthetic fibers are remarkably durable and will not rust, corrode or produce broken/protruding wires. They are not affected by salt or fresh water, and wear points can be protected from abrasion, cutting and heat damage. Easy to inspect and repair, they are also soft on hands, offering a safer solution for riggers and expensive payloads.

The expertise that Cortland International has acquired in the use of high performance synthetic fibers hails back to the introduction of Kevlar® more than 30 years ago. The high strength, high modulus, low elongation, and light weight of modern high performance fibers are optimized by our manufacturing techniques and specialized constructions.

We design, manufacture and supply synthetic fiber ropes using both conventional and modern high performance fibers. Each rope is designed carefully by our team of engineers based on the application.

Not all modern synthetic fiber ropes are designed and produced the same. While raw material choice, quality, construction, twist, braid levels, and coatings vary by manufacturer, Cortland is proudly innovative in our rope design and performance.

1b. Objective

The purpose of this document is to provide information and guidelines for the proper use of Cortland International synthetic fiber ropes.

While not attempting to cover every possible factor in the usage of a fiber ropes, this guide provides a basic foundation for correct choice and proper use. If the information provided within this document does not address or answer all product support needs, please contact Cortland at contact@cortlandinternational.com.

Be advised: the most current and accurate content regarding rope use, inspection and retirement can be found at cortlandinternational.com. The information found at cortlandinternational.com may supersede the information in this and previous printed manuals.

1c. Industry Standards

Fiber rope usage guidelines are referenced in several existing industry standards. This guide is specific to synthetic fiber ropes and may offer guidance and direction in use and inspection not available in existing certification standards.

As reference documents the following standards have been utilized in this document:

1. The Cordage Institute International Guidelines
   a. CI 2001-04 Fiber Rope Inspection and Retirement Criteria
   b. CI 1500-02 V.2 May 2006 – Test Methods for Fiber Ropes
   c. CI 1500A-15 May 2015 - Test Methods for Fiber Rope Physical Properties
   d. CI 1500B-15 May 2015 - Test Methods for Fiber Rope Performance Properties
   e. CI 1401-06 – Safer Use of Fiber Rope – Oct 2015

1d. Abbreviations

The following standard terms are important and/or have been used in this document.

Term	Description
CF	Configuration factor
CoG	Center of gravity
D	Diameter of interfacing hardware
d	Diameter of fiber rope sling
D:d	Bearing surface diameter with respect to sling nominal diameter
DF	Design Factor
EWL	Effective Working Length. Specified as the distance between Load Bearing Surfaces
FOS	Factor of Safety
HDPE	High Density Polyethylene
HMPE	High Modulus Polyethylene
LCP	Liquid Crystal Polymer
MBL	Minimum Breaking Load
MTS	Minimum Tensile Strength
SWL	Safe Working Load
UHMWPE	Ultra-High Molecular Weight Polyethylene
WLL	Working Load Limit = MBL / DF

1e. Glossary

ASME – The American Society of Mechanical Engineers.

Bearing Surface – The area of contact between two objects.

BS EN – A national standard adopted by the British Standards Institute (BSI) from a global standard.

Choke Point – A point where a sling in a choker hitch configuration passes through itself.

Choker Hitch – When using a choker hitch, one eye of the hitch is wrapped around the load and then passed through itself and then attached to the crane or hoist hook.

Coating – Additive applied to the rope which can affect the rope surface abrasion resistance, flex fatigue resistance, and/or surface coefficient of friction.

Cordage Institute – An international trade association of fiber rope manufacturers, their suppliers, and affiliated end-user organizations.

Core – Inner braid of a double braid rope; the core is contained within the cover braid.

Cycle Length – The cycle length is the distance along the axis of the rope in which one strand makes one complete revolution around the circumference of the rope. A length of six consecutive picks running along the longitudinal axis of the final braid is the cycle length for a 12-strand rope.

D:d Ratio – Bearing surface diameter with respect to sling nominal diameter.

Elongation – The measurement of stretch at a given load, expressed as a percentage of the original untensioned length.

Eye Splice – Method used to form an eye at the end of a rope.

Final Braid – The overall rope is referred to as the final braid.

Grommet Sling – (or Endless Grommet or Endless Loop) – A fiber rope sling that is spliced into a loop.

HMPE – See UHMWPE

Hitch – How slings are configured to lift a load is called a hitch. Most lifts use one of three basic hitches: vertical, choker, basket.

Modulus – The modulus of a material describes how well it resists deformation. A material with a higher modulus is stiffer and has better resistance to deformation.

PPE – Personal Protective Equipment.

Picks – The point at which one strand running in one direction, crosses over or under a strand running in the opposite direction, is called a pick. Pick density is expressed as picks per unit length.

Qualified Person – A person who, by possession of a recognized degree or certificate of professional standing in an applicable field, or who, by extensive knowledge, training, and experience, has successfully demonstrated the ability to solve or resolve problems relating to the subject matter and work.

Primary Braids – Each of the 12 strands comprising the final braid is a smaller 12-strand rope. The primary braids may also be defined in terms of picks and cycle length.

Primary Braid Strands – Each strand of the primary braids is a single twisted structure made up of fiber.

Shock Loading – A sudden or unexpected load that is imposed upon a system.

Splice – A method of terminating a rope by forming an eye or connecting two pieces of rope together.

Thimble – A ring or tear-drop shaped form, often of metal or plastic, that fits on the rope on the inside of an eye splice. It is used to prevent sharp bending of the rope at the top of the eye & to protect the inside of the eye from chafing or cutting.

UHMWPE – Ultra-high-molecular-weight polyethylene.

WLL – Working Load Limit (WLL) is the maximum working load specified by the manufacturer.

WLL (Rated Capacity) Tag – A tag on a sling that includes the name or trademark of manufacturer or if repaired, the entity performing repairs; code or stock number from the manufacturer; rated load for at least one hitch type and the angle upon which it is based; type of fiber material; and number of legs if more than one.

2a. Important Safety Instructions

Read all instructions carefully. Follow all recommended safety precautions to avoid personal injury as well as damage to the product and/or damage to other property. Cortland International [Cortland] cannot be responsible for any damage or injury from unsafe use, lack of maintenance or incorrect operation. Do not remove warning labels, tags, or decals. In the event any questions or concerns arise, contact Cortland or a local Cortland distributor for clarification.

All products supplied and manufactured by Cortland are sold with the express understanding that the purchaser and user are thoroughly familiar with the safe and proper use and application of the product. The qualified person[1] and rope user has the responsibility for use and application, and must have sufficient training and knowledge of all applicable standards to responsibly use our products.

This manual follows a system of safety alert symbols, signal words and safety messages to warn the user of specific hazards. Failure to comply with these warnings could result in death or serious personal injury, as well as damage to the equipment or other property.

The **Safety Alert Symbol** appears throughout this manual. It is used to alert you to potential physical injury hazards. Pay close attention to Safety Alert Symbols and obey all safety messages that follow this symbol to avoid the possibility of death or serious personal injury. Safety Alert Symbols are used in conjunction with certain Signal Words that call attention to safety messages or property damage messages and designate a degree or level of hazard seriousness. The Signal Words used in this manual are DANGER, WARNING, CAUTION and NOTICE.

DANGER — **DANGER** Indicates a hazardous situation that, if not avoided, **will** result in death or serious personal injury.

WARNING — **WARNING** Indicates a hazardous situation that, if not avoided, **could** result in death or serious personal injury.

CAUTION — **CAUTION** Indicates a hazardous situation that, if not avoided, **could** result in minor or moderate personal injury.

NOTICE — **NOTICE** Indicates information considered important, but not hazard related (e.g. messages relating to property damage). Please note that the Safety Alert Symbol will **not** be used with this signal word.

Note: any and all components used for load handling activities, including but not limited to slings, fittings, hardware and sling protection may be referred to collectively as rigging.

[1] Qualified person: A person who, by possession of a recognized degree or certificate of professional standing in an applicable field, or who, by extensive knowledge, training, and experience, has successfully demonstrated the ability to solve or resolve problems relating to the subject matter and work.

General Safety Precautions

DANGER — **Failure to observe and comply with the following precautions will result in SERIOUS PERSONAL INJURY or DEATH. Property damage could also occur.**

- Rope, rigging hardware and/or wear protection may fail if damaged, abused, misused, overloaded or improperly maintained resulting in SERIOUS PERSONAL INJURY or DEATH.
- All personnel must stand clear of lifted loads and never be under, on, or near suspended loads. Personnel must not stand in-line with or next to rigging under tension. An unplanned release of tension could strike personnel with deadly recoil force. Do not stand within recoil (snapback) area. Personnel must be alert to the potential for the rope and/or load to become snagged or hung-up.
- Ropes shall not be shortened or lengthened by knotting or twisting and/or be joined by knotting.

2a. Important Safety Instructions *Cont.*

⚠ WARNING **Failure to observe and comply with the following precautions could result in SERIOUS PERSONAL INJURY or DEATH. Property damage could also occur.**

- It is recommended that Cortland International rope users are properly trained in the inspection and proper use of the products. Failure to follow proper use, care and inspection criteria for rope could result in SEVERE PERSONAL INJURY or DEATH.
- Wear personal protective gear when handling synthetic ropes. Safety equipment such as gloves, eye protection, non-skid safety shoes, hard hat, or hearing protection (used as appropriate) will reduce personal injuries.
- Do not drive or walk over ropes.
- In the case of lifting slings, the sling must be identified or labeled with the following information:
  - name or trademark of manufacturer, or if repaired, the entity performing repairs
  - code or stock number from the manufacturer
  - rated load for at least one hitch type and the angle upon which it is based
  - type of fiber material
  - number of legs, if more than one
- Ensure that rope slings have suitable characteristics for the type of load, hitch, and environment in which they will be used and that they are not used with loads in excess of the rated load capacities. Do not exceed the working load limit (WLL) rated capacity or shock load the rope sling.
- When using rope, careful consideration must be given to the effect of bending in the load handling operation. Potential strength reduction due to inadequate D:d ratios and the length of the eye are factors to be considered.
- Do not bend rope around unprotected, damaging corners. Do not use over abrasive surfaces without rope wear protection. Avoid dragging rope over abrasive surfaces such as "non-skid" vessel decks during use, and from under the load. Make sure rope wear protection is in place or replaced when needed.
- Thimbles shall have a minimum diameter at the bearing surface of at least two times the rope diameter. Use sheaves with a minimum of 8 times the rope diameter.
- Re-splicing of Cortland rope for load handling operations must be conducted by a qualified person.
- Re-spliced Cortland rope slings must be re-tagged with required identification information.
- A qualified person must be designated for every lift. It is the responsibility of this person to ensure that proper rigging practices are followed.
- Cortland ropes or rope slings must not be used for any fall prevention purpose. Only approved fall prevention products which are specifically rated and labeled for fall prevention must be used for fall arrest and/or fall prevention.

2a. Important Safety Instructions *Cont.*

⚠ CAUTION

Failure to observe and comply with the following precautions could result in minor or moderate personal injury. Property damage could also occur.

- Residual strength in a rope is subject to many considerations and a visual inspection can only provide a subjective estimate on retained strength.
- Twist and rotation should be taken out of a rope before application.
- Ropes, slings, rigging hardware and wear protection should be stored in a clean, dry area, out of direct sunlight and/or any source of ultraviolet light and away from sources of extreme temperatures. The storage location should also be free of environmental and mechanical damage, corrosion, dirt and grit. If on a pallet, make sure other items which can damage or cut the sling are not stacked on top of the slings. Do not use or store near damaging chemicals.

NOTICE

- Cortland International ropes can be washed in warm or cold water to remove particulate matter without damage or loss of strength. It is recommended that only fresh water and mild detergents like dish soap be used. Washed ropes should be air dried prior to storage. Ropes must not be pressure-washed.

3a. Selecting the Best Rope for your Application

There are many decisions to be made to ensure the correct rope is selected for each application. Before a rope is used in a load handling application, it is strongly recommended that a complete analysis be performed by a qualified person to determine the correct type and size of rope to be used.

Each combination of rope material and construction has its performance advantages and disadvantages, and the selection of a rope always involves compromises based on the type of service.

Not all synthetic fiber ropes are designed and produced the same; raw material choice, quality, construction, and coatings vary by manufacturer. Cortland International is an innovator in the design and performance of ropes.

Cortland designs and manufactures synthetic fiber braided and twisted ropes using both modern high modulus and conventional fibers. Each product's performance characteristics is a function of:

- Base fiber
- Rope construction / design
- Product methods
- Coatings
- Splice/termination method

These factors combine to optimize products for performance properties such as:

- Tensile strength
- Abrasion resistance
- Tensile fatigue
- Bending fatigue
- Cut resistance
- Fabrication ease / length tolerances
- Ease of Inspection
- Cost

3b. Fiber Selection

The base fiber is the most important choice in the design of a fiber rope. Below is a list of common synthetic fibers used in the construction of synthetic fiber ropes, and some known benefits of each.

Currently there are essentially two categories of synthetic fibers used in the manufacturing of synthetic rope. The first category is commodity fibers, which are typically lower in cost and higher in elongation. The second category is high performance fibers, which typically carry a higher price point and offer higher strengths and better service life.

Commodity
- Polyamide (Nylon)
- Polyester (Dacron®)
- High Density Polyethylene (HDPE)
- Polypropylene (PP)

High Performance
- Aramid (Technora®, Kevlar®, Twaron®)
- LCP (Vectran®)
- PBO (Zylon®)
- Blends (BOB®)
- UHMWPE (Spectra®, Dyneema®, etc.)

3b. Fiber Selection *Cont.*

Rope Material	Material Brand Names	Tenacity (gpd)	Specific Gravity	Water Absorption	Resistance to Sunlight	Elongation	Abrasion Resistance	Creep Resistance	Melting Point (°C)
Polyamide	Nylon	7.5–10.5	1.14	2–6%	Moderate	Very High	Very Good	Good	212
Polyester	Dacron	7–10	1.38	None	Very Good	High	Excellent	Very Good	250
HDPE		6-10	0.95	None	Good	High	Good	Low	135
Polypropylene		6.5-8.5	0.91	None	Moderate	High	Moderate	Low	160
Liquid Crystal Polymer (LCP)	Vectran	22–27	1.41	None	Good	Low	Very Good	Excellent	330
Aramid	Technora Kevlar Twaron	18–29	1.39–1.45	3–7%	Moderate	Low	Good	Very Good	500
UHMWPE	Spectra, Dyneema	25–39	0.97	None	Good	Low	Excellent	Fair	140
Polybenzoxazole (PBO)	Zylon	42	1.54	2%	Poor	Very Low	Fair	Excellent	650

Polypropylene
Conventional fiber used for multi-purpose ropes. It is very cost effective with good impact resistance and moderate abrasion resistance

High Density Polyethylene (HDPE)
Like polypropylene, more abrasion resistant, but slightly higher cost.

Polyamides (e.g. Nylon)
Polyamides are conventional fibers with moderate strength and good elongation properties. They are lighter and more elastic than polyester. However, they will absorb water and lose strength when wet.

Polyesters (e.g. Dacron)
Polyesters are conventional fibers with moderate strength and good elongation properties. They do not lose strength in water and have improved abrasion resistance. However, they are heavier and less elastic than Polyamides.

Aramids (e.g. Technora, Kevlar, Twaron)
Aramids are high-performance fibers specialized for elevated temperature applications. They have an extremely high melting point and great creep resistance even at elevated temperatures. However, they are heavier and have less abrasion resistance than UHMWPE.

Liquid-Crystal Polymers (e.g. Vectran)
LCPs are high-performance fibers specialized for creep applications. They have the best creep resistance of any fiber. Their abrasion resistance is somewhat better than the aramid family, but still not as good as UHMWPE.

Polyphenylene Benzobisoxazole (Zylon®)
PBO is an extreme high-erformance fiber. It has the highest strength and stiffness of any synthetic fiber, as well as the highest melting point and excellent creep resistance. However, it degrades rapidly in both water and sunlight, and is several more times expensive than other fibers.

UHMWPE (e.g. Spectra or Dyneema®) UHMWPE are the fibers of choice for most applications. They have some of the highest strength-to-weight ratio of any fiber, and the best abrasion resistance and chemical resistance of any fiber. They are even light enough to float in water. However, they have lower creep and thermal resistance than aramids and LCPs.

3c. Rope Design and Construction

Rope performance can be tailored based on the construction, twist, and braid level. Cortland International manufactures rope with different constructions, 3- or 4-strand, parallel, double braid, 8-strand, 12-strand, 12x12 strand, 16-strand among others. Strength, elongation and durability can be further impacted by the rope construction.

	12-Strand	12x12	8-Strand	16-Strand	Double Braid	Wire Lay	Parallel Filament	3/4-Strand
Strength	Good	Good	Fair	Fair	Good	Good	Excellent	Poor
Axial Stiffness	Good	Good	Fair	Fair	Good	Good	Excellent	Poor
Durability	Good	Excellent	Fair	Fair	Good	Fair	Good	Poor
Inspectability	Good	Excellent	Good	Good	Poor	Fair	Poor	Fair
Spliceability	Good	Excellent	Good	Good	Poor	Fair	Poor	Good
Bending Performance	Good	Good	Fair	Fair	Fair	Excellent	Poor	Fair
Twist Tolerance	Good	Good	Fair	Fair	Fair	Bad	Bad	Bad

Low cost, multi-purpose ropes are typically made in 3 strand, 8 strand and 12 strand and double braid constructions.

For high-performance braided ropes, the optimal construction has proven to be a 12-strand design for many reasons:

- Strength: Moderate to high—size for size steel replacement
- Elongation: Low to moderate, similar to steel
- Torque: Zero rotation under load
- Inspectable / repairable
- Splice-ability
- Flexibility: Good to excellent

3d. Rope Sling Configuration

Just as important as selecting the right fiber and construction, selecting the correct configuration will further enhance the performance of any rope that is to be used as a sling. There are two primary configurations for fiber rope slings:

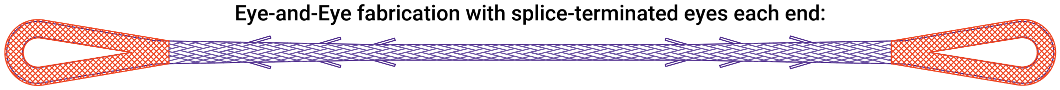
- Eye and Eye
- Endless Grommet

Each configuration has its own features and benefits.

Eye and Eye Slings
When spliced into an eye and eye sling, UHMWPE will essentially act as a size-for-size replacement for a traditional steel wire rope sling in terms of strength. Each end is terminated using a Cortland-approved splice which becomes locked in place after proof load testing.

Due to the splice length and free span requirements as shown in the drawing below, eye and eye slings have minimum length that must be considered. Minimum lengths for rope sling are a function of diameter and the resulting length of the required splices. Larger ropes have longer splice lengths and therefore require longer minimum lengths.

Eye-and-Eye fabrication with splice-terminated eyes each end:



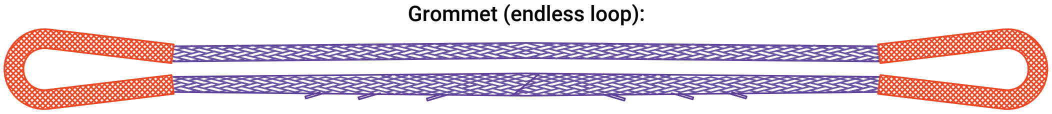
When engineered lifts or other demanding applications require more exacting standards, please consult the Cortland Sling Brochure to assure proper design considerations are given. Generally, those guidelines are:

- Minimum D:d ratio in the eyes is 1:1
- Minimum eye length must be 3x the bearing surface diameter or pin diameter, to maintain the vertex angle below 30° (see vertex illustration on page 26)
- Rated capacity of eye-and-eye sling in a vertical pull includes splice efficiencies
- When basketing eye and eye slings the rated capacity will be affected when the basket point D:d ratio is less than 25:1. Please consult Cortland Sling Brochure for bending efficiency determination.

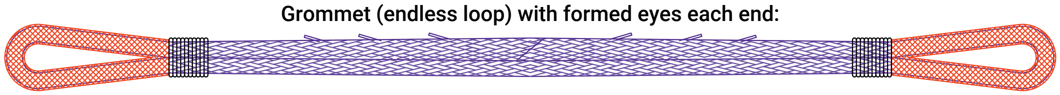
Endless Grommet Slings
Grommets are manufactured by splicing the ends of a rope together to form a continuous loop. Compared to eye-and-eye slings, they have increased strength with little to no increase in the chosen rope diameter due to two (2) legs holding the load. Alternatively, the same load can be held with a smaller rope diameter due to the two (2) legs holding the load.

The breaking strength of endless grommet slings is directly affected by the pin diameter on which they are mounted. Smaller pins/hardware will create higher stresses and result in lower load carrying capabilities.

Grommet (endless loop):



Grommet (endless loop) with formed eyes each end:



- Grommet sling rated capacity is directly related to the contact curvature on which it will be used
- Grommet sling ultimate strength is based on applying a configuration factor (CF) to the single leg strength to which the rope is made
- For more information on D:d and configuration factor see Cortland Sling Brochure

3e. Splicing & Terminations

All splice terminations must be made in accordance with splicing instructions provided by Cortland International and must be performed by a qualified person trained to fabricate these splices.

New Cortland fiber ropes are rated using the splice type with which they are fabricated and delivered. The published MBL and rated capacity of a new Cortland fiber rope take into consideration the splice; no further reduction for splicing needs to be calculated by the end-user.

Please consult with Cortland if you are unsure what the rope splice method needs to be for the type of rope purchased.

Refer to these relevant splicing instruction procedures on cortlandinternational.com or contact Cortland International at contact@cortlandinternational.com for more information.

Effective rope termination splices produce the maximum strength possible throughout the entire fabricated assembly and are far more strength efficient than knots.

⚠ DANGER

- To achieve maximum strength, ropes must never be used with a knot termination, which significantly reduces overall rope strength; by as much as 70%
- Mechanical end terminations such as clips, clamps or wedge sockets must not be used to fabricate fiber ropes
- If thimbles do not have ears to prevent rotation of the thimble in the eye, they should be lashed to the rope
- Some splices have tails; splice tails can either be taped and cut or buried depending on the application

When the application demands restrictive lenth tolerances or no change in diameter, alternative termination methods—such as potted terminations—can be used.

Splice termination with tails exposed

3f. Rope Length

The length of a rope depends on its current loading state and loading history. Rope length is measured in our factory under slight tension, and the length received by customers is +/-5% of ordered length for low performance ropes, and +3/-0% for high performance ropes. When ropes are new, and never loaded before, ropes will experience constructional elongation. This is almost irreversible elongation, caused by bedding in the rope, and removing most of the air trapped between the fibers.

Published load vs elongation curves are approximations and do not include constructional stretch. They also do not include delayed-response effects like hysteresis and creep. In most cases hysteresis is typically much lower than other forms of elongation and fully recoverable. Creep is non-recoverable plastic elongation. Polyolefins like HDPE, PP and HMPE are more heavily affected by creep compared to other fibers, especially at elevated temperatures. If the application requires the rope to be long term statically loaded, lower creep fibers should be considered.

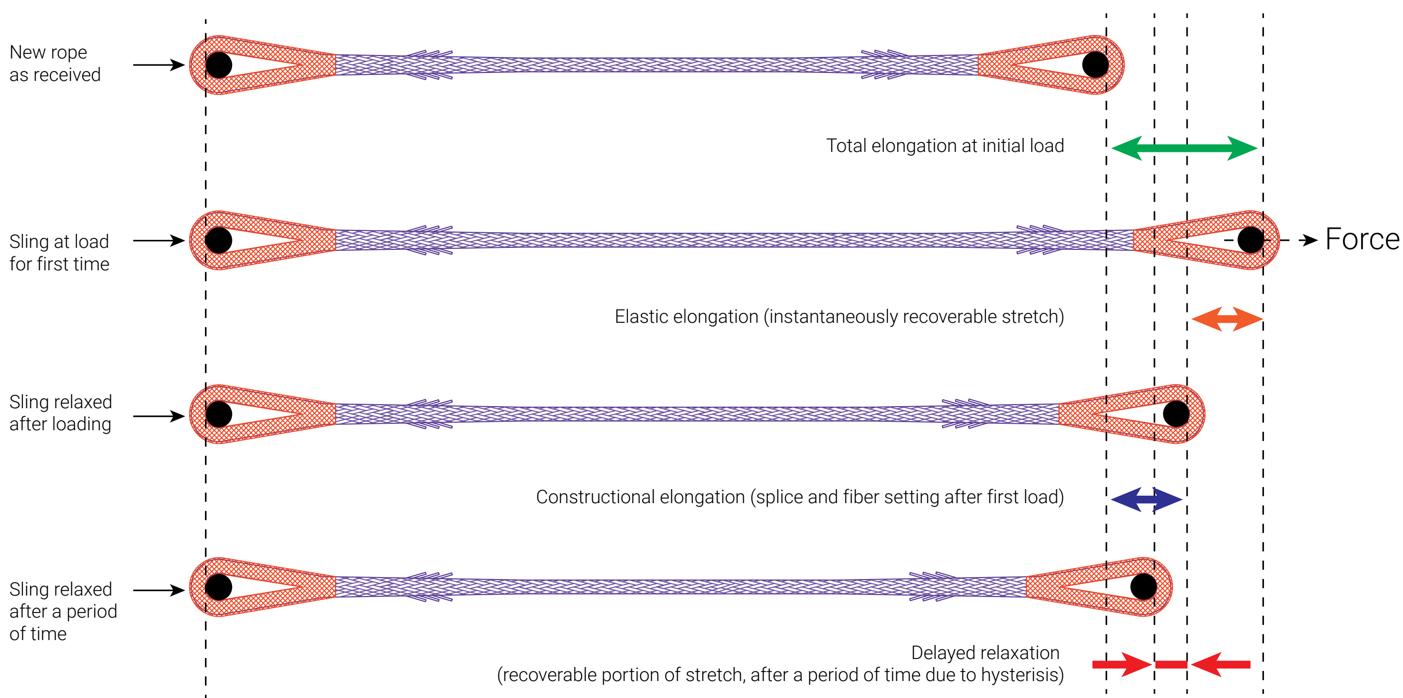
Rope slings of limited length can be pre-bedded if necessary via a process called proof-loading. Proof-loading is a non-destructive process which subjects a fabricated assembly, to a predetermined load, typically 40% of the MBL of the rope.

Cortland fiber rope slings used for lifting will be subjected to preload or proof-load testing after fabrication by default. Physical properties that change while load testing are:

- Diameter will decrease
- Length will increase

During this process the rope will elongate approximately 5–6% and reduce in diameter to a value closer to its nominal diameter.

It is at this time that the as-built fabricated length of the sling is taken (i.e., after proof load testing).

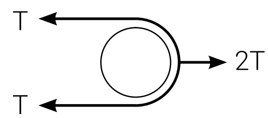


4a. Effect of Bending

When a rope is bent around a bearing contact surface such as a pin or sheave, the rope will experience a loss in overall strength. Care must be taken before every use to ensure that the effect of bending has been considered.

Stress and Minimum Breaking Load
A rope will be overloaded when the stress inside the rope becomes too high. Stress is caused by both tension (tensile stress) and bending (bending stress).

In the case of rope slings, when two legs of a sling are used to hold a load instead of one, both legs share the load. The tensile stress (2T) is cut in half.



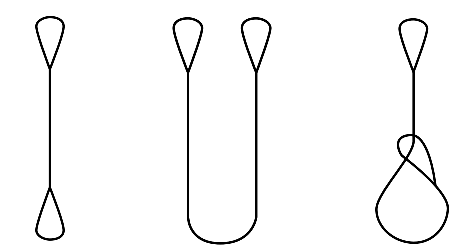
However, this does not necessarily mean that the capacity of the rope sling is doubled. The decrease in tensile stress is partially offset by an increase in bending stress. The magnitude of this bending stress is dependent on the size and shape of the contact surface.

When determining the strength of a sling in bending, there are three subjects to consider: sling configuration (how the sling is made), hitch configuration (how the sling is used), and the D:d ratio of the sling (what the sling is bent around).

All sling bearing contact surfaces must be smooth, free from any burrs or surface irregularities, with a radius that is continuous throughout the bearing contact area. Special attention must be given to any contact surface with damaging edges, small radii, or abruptly changing radii (example: DIN hooks; refer to illustrations at the bottom of page 27).

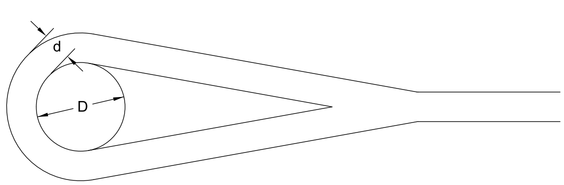
Sling Configuration:
There are two main configurations into which a sling can be spliced, either an eye-and-eye sling (one tension leg) or a grommet sling (two tension legs) as shown on page 20. A grommet can generally achieve higher breaking loads than an eye-and-eye sling of the same rope size, because the load is shared between two legs.

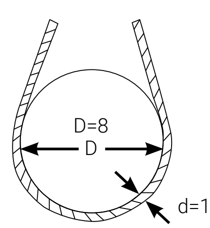
Hitch Configuration:
A sling can be used in multiple ways, such as a vertical, basket, or choker hitch as shown below. A basket hitch shares the load between two legs, achieving a higher breaking load than a vertical hitch. A choker hitch adds extra stress to the rope, and therefore has a lower breaking load than a vertical hitch. Rated loads for these hitch configurations can be found on pages 40–48.



Vertical   Basket   Choker

D:d Ratio:
The bend severity from a bearing contact area on a sling can be expressed in terms of the D:d ratio. The D:d ratio is the ratio between the smallest interfacing hardware curvature in contact with the rope, or bend diameter (D), and the nominal sling diameter (d). The bending stress imposed by the interfacing hardware diameter onto the sling varies inversely with this ratio; i.e. the stress will increase as the bearing contact diameter decreases.

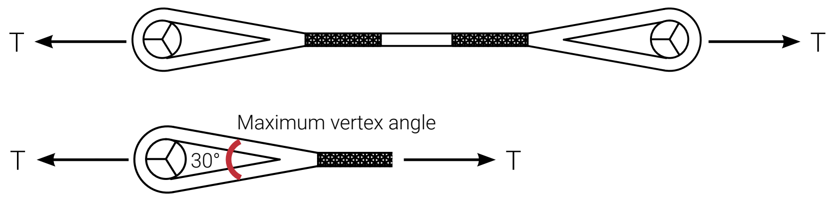




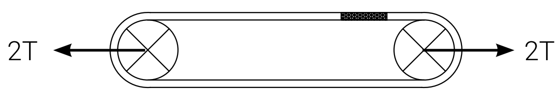
Note: When the interfacing hardware curvature (D) is eight times the fiber rope sling diameter (d), the D:d is expressed as 8:1

4a. Effect of Bending *Cont.*

General Minimum Breaking Load Considerations:
For an eye-and-eye sling in a vertical configuration, the highest stress occurs in the body of the sling, not the eyes. Therefore, bending stress is generally not a concern. The full rated capacity of the sling can be utilized as long as the D:d ratio between the sling eye and the contact point is greater than or equal to 1, and as long as the total vertex angle (α) of the eye is below 30°.

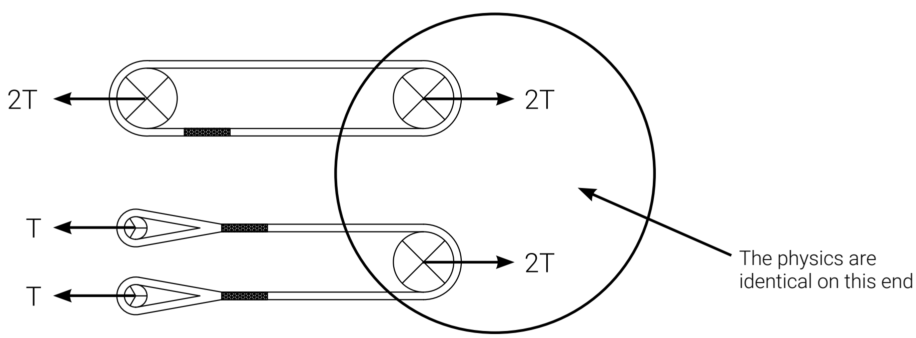


For a grommet sling, the rated capacity depends on the D:d ratio. Cortland grommet slings vertical work load limits are based on an 8:1 ratio; they can therefore be used at full rated capacity at any ratio 8:1 or higher. For any diameter smaller than this, the load handling capacity of the fiber rope sling must be reduced. The lower the D:d ratio, the more the rope sling capacity must be reduced.



Because of these considerations, eye-and-eye slings in a vertical configuration have the advantage of tolerating lower D:d ratios compared to grommets. Grommets can achieve higher strengths and shorter working lengths than eye-and-eye slings, as long as a large enough D:d ratio is maintained. Tables of grommet strengths and their corresponding D:d ratios are shown in Cortland Sling Brochure.

An eye-and-eye sling in a basket will have similar bending reductions as a grommet sling.



Due to frictional losses when basketing or doubling a sling over a bend, the MBL of the sling is reduced by 10% in accordance with the 55:45% guidance given in DNVGL-ST-N001. Cortland has performed extensive testing to understand the effect of bending on strength for our fiber rope slings. For further details and information relating to bending, please reference Cortland document ETN-002, available upon request.

4b. Contact Surfaces and Hardware

Compared to wire ropes, fiber ropes are significantly more flexible. They are pliable, grip loads well, and do not damage load surfaces. Unlike wire ropes which can permanently deform when bent around a surface under load, the deformation of fiber rope is reversible.

While this compression of a fiber rope itself does not reduce strength, if the surface it comes into contact with is not smooth, the fiber rope can abrade. Load handling hardware and attachment points must be maintained in good condition and kept free of burrs and rust. Abrasion can be diminished on fiber ropes with appropriate wear protection (see following page).

When using a fiber rope in an application that previously used wire rope, it is important to ensure connection points and contact surfaces minimize abrasion and stress on the fiber rope.

Any additional mechanical components such as end termination hardware, fittings, and chafe protection used as part of a fiber rope must be selected to meet the following requirements:

1. Suitability of components shall be verified by a qualified person.
2. The material shall be compatible with the mechanical and environmental requirements imposed on the rope.
3. All surfaces shall be cleanly finished and damaging edges removed so as not to cause damage to the rope.
4. Rigging hardware, when employed, shall meet the requirements of the applicable standard when used for lifting.
5. Chafe protection must be compatible and non-damaging to the fiber rope material. It must also be installed with proper manufacturer guidance.
6. Hooks, when employed, shall meet the requirements of ASME B30.10 or other applicable standards.
7. Chocks and fairleads need to be deburred and smoothed out. Surface rust should be completely cleaned out and coated with an appropriate coating to extent the lifetime of the rope.

4c. Rope Wear Protection

If additional protection from the elements, cutting, abrasion, or mud ingress is needed, Cortland International offers several wear protection options. Fiber ropes can be completely covered in protection, or simply protected in critical contact areas; e.g. the basket lifting point, or the eyes. Options include:

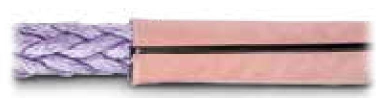
SX™
Combining the lightweight, abrasion resistant and non-water absorbing properties of UHMWPE fiber, SX protection is a tightly braided tubular structure which can be freefloating or fitted onto the rope to offer the highest protection from cuts and abrasion that Cortland offers.

SX wear protection

Cortland Cage™
Combining the lightweight, abrasion resistant and non-water absorbing properties of UHMWPE fiber, Cortland Cage protection is a loosely braided cover sleeve offering high protection from cuts and abrasion, yet allowing inspection of the rope interior and is a lighter alternative to SX.

Cortland Cage wear protection

Asgard™
Combining the lightweight, abrasion resistant and non-water absorbing properties of UHMWPE fiber, Asgard protection is a lightweight woven fabric structure which is easy to install and retrofit on existing ropes, providing protection from cuts and abrasion.

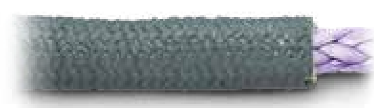


Asgard wear protection

DXC™
Combining the lightweight, cost-effective properties of polyester fiber, DXC protection is a tightly braided tubular structure which can be freefloating or fitted onto the rope.

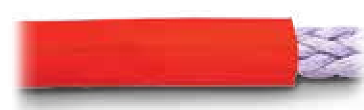
DXC wear protection

XT™
Combining the lightweight, cost-effective properties of polyester fiber, XT protection is a tightly braided tubular protection sleeve with proprietary heavy-duty, rigid polyurethane coating for use in harsh applications. XT sleeves can be fabricated to be free-floating, or fixed in place.



XT wear protection

PNW™
A cost-effective woven fabric material, PNW is the most commonly used protection for abrasion. This protection is available as a permanent installation, or in a removable / replaceable form with a hook-and-loop closure.



PNW (permanent)

For more information refer to our Wear Protection brochure.

4d. Rope Twist

The 12-Strand and 12x12 constructions from Cortland International are torque neutral and designed to be used with no twist to properly share the load between the strands. Torque balanced fiber rope like our 12-strand and 12x12 designs do not tend to twist under load, therefore any twist must be externally induced. This could arise due to asymmetrical loading, off-axis loading, or because of accidental rotation during reeling.

If signs of twist are detected in a torque neutral fiber rope, the twist should be removed or worked out. Continued loading of a rope while twisted can result in permanent deformation of the rope construction which can contribute to permanent strength loss, and may cause hazardous operational issues, e.g., load spinning.

If torque or twist is expected in the application, contact Cortland International for a strength rating.

Non-torque neutral fiber ropes like 3 strand, 4 strand, wirelay constructions and steel wire rope will induce twist when loaded. If connecting a torque neutral rope to a non-torque neutral rope, a swivel is encouraged to be used so that the torque-neutral rope does not get twisted.

Non-torque neutral fiber ropes like 3 strand, 4 strand, wirelay constructions and steel wire rope will induce twist when loaded. If connecting a torque neutral rope to a non-torque neutral rope, a swivel is encouraged to be used so that the torque-neutral rope does not get twisted.

4e. Rope Operating Temperature

Users of synthetic fiber ropes need to be aware of ambient, reflected, or frictional heating in applications, as well as proximity to localized heat sources such as open flames or welding torches. If it is anticipated that heat will be an issue, care must be taken to protect the fiber rope.

Signs of temperature damage include melting, fused or brittle strands and significantly reduced diameter. Note—fused strands must not be confused with strands that have been tightly compacted and stiffened due to high loads. Compressed strands can be separated, while fused strands cannot.

PP, HDPE, and HMPE Fiber ropes must not be used in loading conditions with temperatures greater than 150°F (65°C). If high temperatures are unavoidable, an alternative synthetic fibers with higher critical temperatures should be used. Cortland manufactures fiber ropes from heat resistant fibers such as Vectran® (LCP) and Technora® (Aramid).

Fiber Type	Critical Temperature (°C)
Polypropylene	65
HDPE	60
Polyamide	162
Polyester	177
HMPE	65
Aramid	272
LCP	149
PBO	650

The critical temperature is defined as the temperature beyond which mechanical properties of the fiber are reduced.

Due to the critical nature of load handling operations, any sign of heat damage on a fiber rope is cause for immediate removal from service.

Low temperatures are generally ok for ropes. Ropes will tend to get stiffer when colder, especially with ice formation. Generally, ice is not an issue but its advised that its removed from the rope prior to use. At very low temperatures most fibers will become brittle and should not be used. If operating in very low temperatures it is advised that the brittle point of the rope is researched prior to use.

This is fiber compression. If the strands can be separated by flexing the rope, it is not heat damage.

Glossy or glazed areas, fused or melted strands are signs of heat damage.

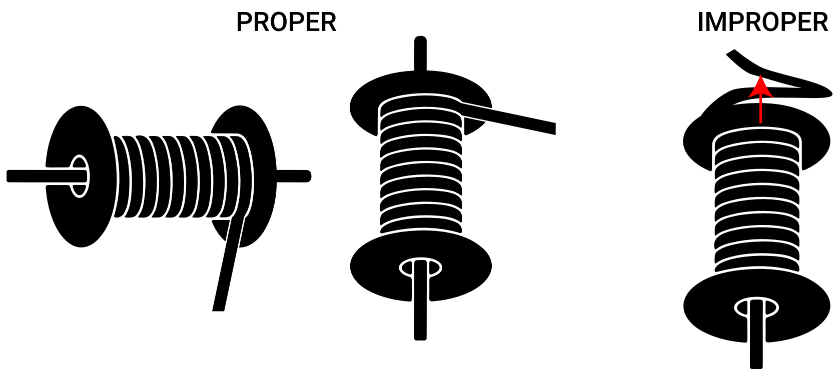
4f. Handling & Storage Procedures

The service life of fiber ropes can be prolonged with proper storage and care.

⚠ WARNING

Receiving Rope:
Typically, rope is shipped to customers either coiled on a reel or coiled in a bag, depending on the type of rope. The reel should be placed on a shaft and the rope should be pulled in a direction that is parallel to the rope. If the rope is pulled from the side of the reel, twist will get induced into the rope which would sacrifice the feel, strength and longevity.

Reels should be allowed to rotate during uncoiling. Braided or twisted ropes should be removed along a line parallel with the rope, never across the grain.



Handling:

- Avoid dragging ropes on the ground
- Avoid pulling on ropes from single strands. Always handle the rope as a unit, not individual strands.
- Avoid pulling on ropes by the tails of the splice if the tails are exposed
- Avoid exposing ropes to contact with abrasive surfaces
- Do not weld, grind or cut metal in areas where ropes are stored. Welding slag or sparks may damage the rope.
- Do not use or store near damaging chemicals.

Cleaning:

- Cortland ropes can be washed in hot or cold water to remove particulate matter without damage or loss of strength. It is recommended that only fresh water be used.
- Use of harsh or damaging cleansers must be avoided.
- Washed ropes are recommended to be air-dried before storage or used immediately.
- Ropes must NOT be pressure-washed.

Storage:

- Ropes, rigging hardware and chafe protection should be stored in a clean, dry area, out of direct sunlight and/or any source of ultraviolet light and away from sources of extreme temperatures.
- The storage location should also be free of environmental and mechanical damage, corrosion, dirt and grit.
- A tarp or cover to protect from UV is recommended if storing the rope on a reel outdoors.
- If stored on a pallet, make sure other items which may damage or cut the rope are not stacked on top of them.
- Stranded ropes like 3 strand and 4 strand ropes have twist in them due to their construction. When coiling the rope care should be taken such that it is coiled in the same direction as the lay of the rope. Left hand lay ropes should be coiled counter-clockwise and right hand lay ropes should be coiled clockwise. Not doing so would induce kinking or hockling of the rope. If the rope is coiled in a figure 8 then no twist will be induced or removed.

4g. Winch Line Installation

The rope is spooled onto the transportation reel under little or no tension. Winding from the transportation reel directly onto the storage drum of a traction winch system or to a direct drive winch is not recommended as this will cause the rope to dive into the bottom layers of the transportation reel and potentially damage the rope. The rope should be transpooled back and forth onto the storage drum and back to the transportation reel while slightly increasing the tension on each pass until the appropriate tension is achieved without the rope diving into the layers below it. This is very important especially if level winding patterns are used. With traction winch systems transpooling the rope to the storage drum by working the rope through the traction capstans is recommended as this works the rope and reduces dive in and thus back and forth transpooling from storage drum to transportation reel may not be necessary.

A spooling tension of 1-2% of the rope's MBL is recommended for traction winch systems. For direct drive systems the recommendation is 4-5% of rope MBL for the first time the rope is spooled. Once the rope is used, pay-in tension may be reduced if the pay-out tension is not high enough to cause dive in. Cross-winding patterns may be used if it is not possible to pay-in the rope with the required tension.

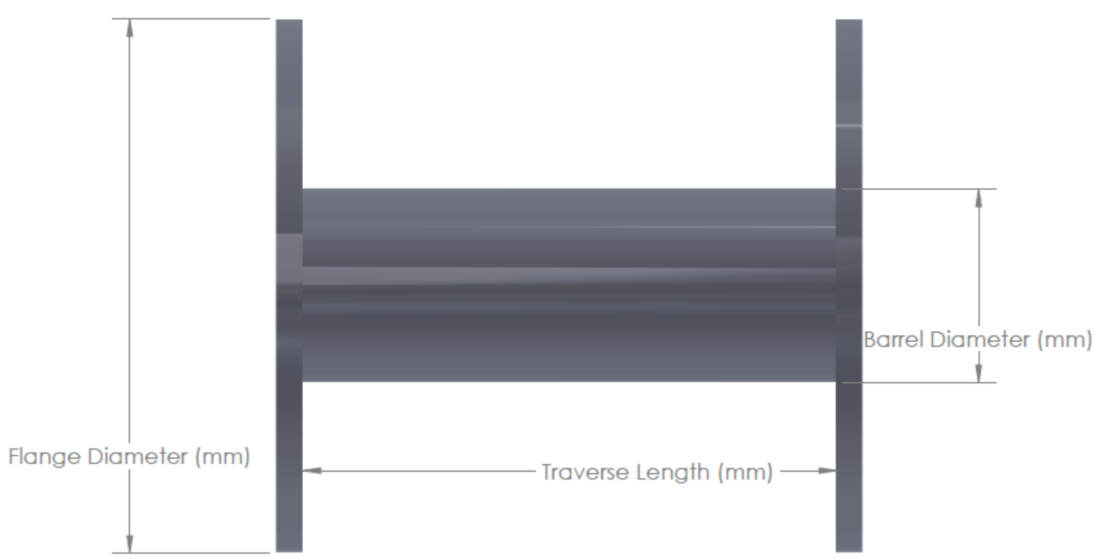
It is important to arrange the spooling systems in such a way such that they do not impart twist in the rope during the spooling process. Minimizing twist will enhance the ropes longevity and performance.

Winch grooves should ideally be U-shaped with a 10-degree flare out. Groove diameters should be 10% larger than the rope's nominal diameter if no splice is expected to pass through the sheave. If end-for-end splices are expected to pass through sheave grooves, then the groove diameter should be 50% larger than the nominal rope diameter.

The maximum rope length which can be stored on the drum can be calculated using the following formula:

$$\text{Max Rope Length} = \left(\frac{\text{PF x Traverse Length x (Flange Dia.}^2 \text{ - Barrel Dia.}^2\text{)}}{\text{1000 x Nominal Rope Dia.}^2} \right)$$

Where the Max Rope Length is measured in meters. Flange Diameter, Barrel Diameter and Nominal Rope Diameter are measured in millimeters. PF (packing factor) depends on the state of the rope. For new unused rope PF is approximately 0.75. For worked rope PF will increase to a value closer to 0.8.



5a. Inspection Points

All new, altered, or repaired ropes must be inspected to ensure compliance with relevant application, regulatory, and statutory requirements. Additionally, rope slings must be inspected for damage before and after every use. Areas of concern must be reviewed by a qualified person to determine if the fiber rope sling should be removed from service.

Within a calendar year after the first time the sling is put into service, a thorough inspection must be conducted by a Cortland, or Cortland-approved, representative. Following this, an annual logbook review and sling inspection must also be conducted by a Cortland, or Cortland-approved representative.

 # 1 – Inspect the tag

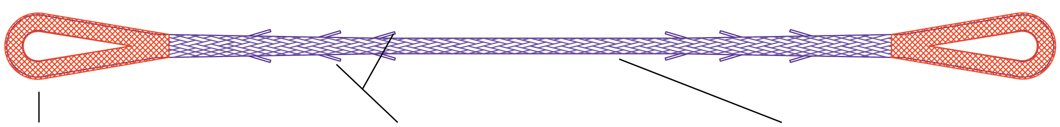
- Make sure the tag is in place and the mandatory information on the tag is legible.

 # 2 – Inspect the wear protection

- Begin at the bearing surface of the eye, and work your way down the fiber rope sling
- Inspect the sling protection for cuts, snags, compression, abrasion and/or other damage.
  – If damage is detected on the protection, further inspection of the fiber rope strength member is required

 # 3 – Inspect the fiber rope strength member

- Splice termination—refer to applicable Cortland splice procedure for the rope type
- Inspect the rope for abrasion, visible cuts or pulls in strands, inconsistencies in rope diameter, and glazed or heat-damaged (melted) fiber.
- “Hand-compress” the braid to open up the construction. By compressing the braided rope, both strand and internal wear/damage can be assessed (e.g. mass volume loss to abrasion, cutting or heat damage).



If a rope has several different modes of damage, their effects could be cumulative. Even if they do not individually meet the removal from service criteria, the combined effect must be considered.

Synthetic fiber rope being hand-compressed.

The rope can be inspected for internal wear / damage with the construction opened.

5a.i Abrasion

Abrasion is the wearing of fiber from frictional contact, resulting in a loss of load-bearing material. Abrasion is readily identified by the fuzzy appearance of the damaged fiber (i.e., broken filaments).

There are two primary types of abrasion which happen to a fiber rope when used:

1. External abrasion
2. Internal abrasion

External abrasion is the most common type of damage. External abrasion is caused by movement of the rope against another object. This type of abrasion is typically localized and not consistent through the entire length of the rope.

Internal abrasion is caused from movement between rope strands—also referred to as strand-on-strand abrasion. This type of abrasion is typically more indicative of a fiber rope which has been heavily used and is normally consistent throughout the length of the rope.

Visual inspection chart on Cortland UHMWPE rope		
Rating	External Abrasion	Internal Abrasion
1 **Like new** (good to use)		
2 **Light to moderate abrasion** (good to use)		
3 **Moderate abrasion** (remove rope from service)		
4 **Moderate to severe abrasion** (remove rope from service)		
5 **Severe abrasion** (remove rope from service)		

5a.ii Cuts

Cuts represent a significant potential hazard to user safety and overall fiber rope performance. Cuts may be identified by the even, squared-off ends at the point of damage.

While broken filaments have very little effect, partial cutting of strands and/or primary braids can create an imbalance in load-sharing, leading to significantly lower strength.

As a general rule of thumb during inspection:

1. For a 12x12 rope, cut primary braid strands do not have as much impact on strength as cut primary braids. However, all cuts should be thoroughly inspected to determine the severity of the cut.
2. One cut of 50% or more of a 12x1 strand, or a 12x12 primary braid, is cause for immediate removal from service.

For more information, see removal from service criteria on page 33.

The image above shows a cut primary braid. The cut can be readily identified by the squared off ends of the cut material. In this example 12 primary braid strands were severed.

5a.iii Pulled Primary Braids or Primary Strands

A pulled primary braid or strand occurs when a part of the rope gets snagged on something external, causing it to become caught and partially pull out, forming a loop.

Generally, when the rope is under tension it is very difficult to pull a loop of material. Most pulled braids or strands occur when the rope is relaxed. ⚠ WARNING In addition to unbalancing the rope structure, pulled braids or strands can create a dangerous situation if the loop becomes entangled on an object while the rope is being handled.

A pulled primary braid strand or primary braid is not cause to remove the rope from service unless the affected strand cannot be "worked" back into the rope construction by hand flexing and compressing the rope. If it cannot be worked back into the rope structure, the damaged section should be removed and the rope re-spliced or removed from service. ⚠ WARNING A pulled primary braid should never be cut.

Pulled primary braid

Pulled primary braid strand

5a.iv Burns

Virtually all synthetic fibers can be melted or charred due to exposure to elevated temperatures. This can be caused by excessive heat due to high frictional contact between the rope and a fixed surface or through exposure to some heat source such as a welding, open flame, etc.

Burns can be identified by a glassy fused area on the surface of the rope and a black color.

Example of burned and excessively melted fiber

Example of burned and partially melted fiber

5a.v Structural Deformation

The surface of the rope must be checked for any change in the shape of the rope or variations in the cycle length or diameter.

Change in shape
Although very rare, it is possible for one or more of the primary strands to partially or totally fail inside the rope, with the broken ends remaining trapped inside the structure of the final braid. When this happens, the diameter of the rope at the point of failure will reduce, producing an hourglass shape along the surface of the rope. If this happens the rope must be removed from service.

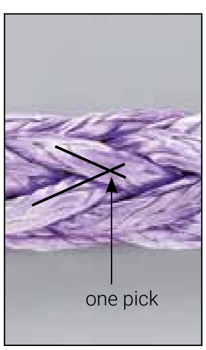
Cycle length and diameter
Cycle length and diameter of the final braid must be measured at periodic intervals along the length of the rope to make sure that there are no irregularities in the construction. The cycle length is determined by measuring the length of six consecutive picks along the longitudinal axis of the rope. Pronounced differences in either measurement (cycle length or diameter) at some location indicate a structural abnormality. The fiber rope must be inspected thoroughly, including inside the final braid structure, if any variations in these measurements are found.

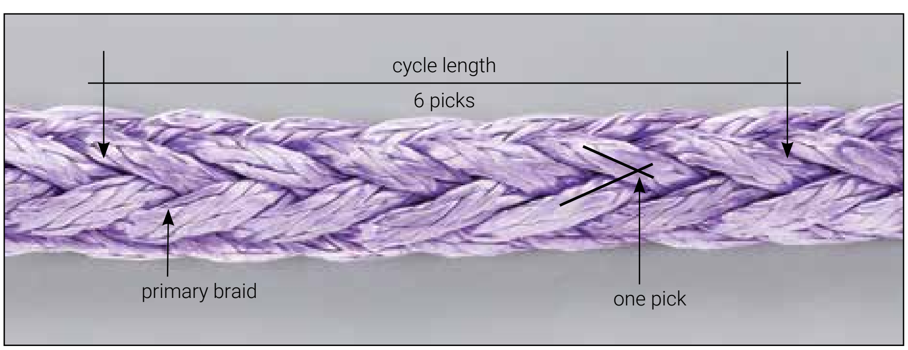
The diameter (or circumference) can be measured with a diameter tape, standard tape measure or by wrapping a piece of twine around the rope and then measuring the length of twine. It must be noted that as the rope is used, the diameter will decrease slightly, and the cycle length will increase uniformly. But if an isolated location of the fiber rope is drastically different, it must be investigated further.

Example of structural deformation

Picks and cycle lengths:
Picks refers to the point at which one strand running in one direction, crosses over or under a strand running in the opposite direction. Pick density is expressed as picks per unit length.

The cycle length is the distance along the axis of the rope in which one strand makes one complete revolution around the circumference of the rope. A length of six consecutive picks running along the longitudinal axis of the final braid is the cycle length for a 12-strand rope.





5b. Removal from Service

The following is an inspection guideline for fiber rope, and conditions that dictate that the rope be removed from service.

	Type	Condition	Action
1	**Tagging**	Tag is illegible or missing	Remove from service
2	**External abrasion**	Moderate and above (see page 34)	Remove from service
3	**Internal abrasion**	Melted or fused braids and strands; powdery or brittle fibers; moderate abrasion and above (see page 34)	Remove from service
4	**Cuts**	12x12 construction: three (3) or more cut primary braid strands within a primary strand cycle length, OR six (6) or more cut primary braid strands within a secondary braid cycle length, OR two (2) or more adjacent primary braid strands in a primary braid, OR 1/2-cut primary braid	Remove from service
		12x1 construction: 1/2-cut strand or more	Remove from service
5	**Pulls**	**Primary braid strand (see page 30):**	
		3 or less strands per primary braid per 3 cycle lengths	Work back into rope if possible. If not, then remove from service.
		More than 3 strands per primary braid per 3 cycle lengths	Remove from service
		Primary braid (see page 30):	
		1 primary braid per 3 cycle lengths	Work back into rope if possible. If not then remove from service.
		More than 1 primary braid	Remove from service
6	**Burns or heat damage**	Localized areas of fused and melted fibers	Remove from service
7	**Structural deformation and/or distortion**	Temporary compression	Work out compression
		Localized diameter area reduction, stiff and flat areas on rope unable to be flexed back into shape; any other permanent deformation	Remove from service
8	**Splices**	Exposed tucking tails	Re-tuck tails in body of rope
		Loose tucks	Repair splice if possible. If not, re-splice immediately or remove from service.
9	**Contamination**	Dirt or grit	If moderately or heavily contaminated externally, wash material off of rope. If moderately or heavily contaminated internally, repair or remove from service.
		Chemicals	If any suspicion of chemical contamination then consult Cortland International.
		Oil or grease	If moderate to heavy then wash rope surface with mild detergent or liquid soap. If it cannot be washed then remove from service.
10	**Discoloration**	Discoloration caused by unknown source	Remove from service
11	**Wear Protection**	Damaged/cut wear protection	Replace protection and inspect rope for associated damage

Notes

Notes

Cortland International operates the world's largest synthetic rope manufacturing organization with capacity to produce over 70,000 metric tons of rope and netting solutions per year. Collaborating with customers, our team uses its experience in high-performance materials and market knowledge to transform ideas into proven products.

For more than 40 years, our custom-built solutions have been engineered to perform in the toughest environments and tackle some of the world's most demanding challenges. Trusted across aquaculture, marine and shipping, offshore energy, aerospace, defense and industrial sectors, they consistently empower our customers to meet and exceed mission-critical demands.

cortlandinternational.com

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