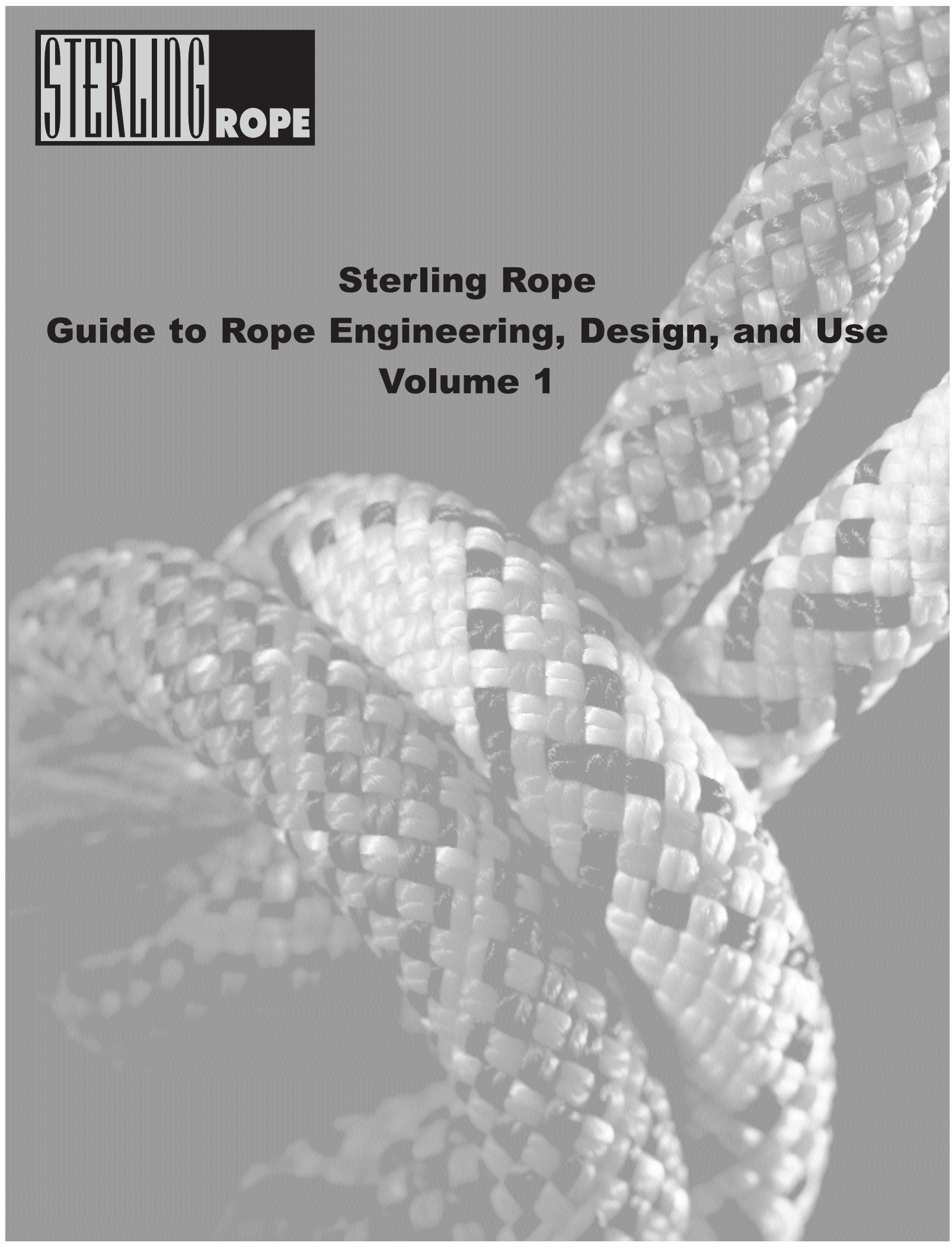
STERLING ROPE

Sterling Rope
Guide to Rope Engineering, Design, and Use
Volume 1



Tech Manual

Our goal at Sterling Rope is to make the highest quality, most technically advanced rope and cord for the rescue, climbing, life safety, and OEM markets. The purpose of this book is to help demystify the rope making process, explain how and why we make rope the way we do and hopefully answer any questions you may have.

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1. History of Rope

Evidence of early hand made ropes date back as far as 17,000 BC. Most of the early ropes were relatively short and hand twisted or braided. The expansion of shipping and the increase in ship size drove the necessity for longer ropes. Construction of ropes was done in a “rope walk”, a long alley with fixed spinning wheels at the upper end and a wheel and a capstan at the lower end.

Modern climbing ropes came about with the production of high-grade nylon in the fifties and sixties. Prior to nylon, most ropes were made from natural fiber, like manila, hemp or some times silk. These ropes we mostly a means to haul up seconds and the thought of taking an actual leader fall was absolutely horrifying. Nylon allowed construction of lighter weight ropes having great impact absorption and the ability to hold upwards of 5,000 pounds.

Early nylon ropes were twisted or double braid constructions. Compared to today’s climbing ropes, they were stiff and overly stretchy. With improvements in ropemaking equipment and nylons, climbing ropes went to a kernmantle construction. Kernmantle ropes are stronger, have a better hand, and more consistent and reliable stretch characteristic.

2. Rope Construction

Ropes come in a variety of shapes and sizes. Rope constructions have evolved over the years to become more task specific, with higher levels of safety incorporated into the construction. Improvements in fiber and rope-making processes have allowed rope manufacturers greater flexibility in rope design. Below are a few types of commonly found rope constructions. By no means is this a complete list or exhaustive in nature, but it is a sampling of some ropes found on the market today.

3-strand rope: This twisted or laid rope construction uses three strands of twisted filaments and lays them into a spiral, creating a single rope. “3-strand” rope is used for everything from generic utility rope to high strength marine line. Climbers might remember Goldline™ Rope, common in the 60’s and 70’s, which was a three-strand climbing rope.

Double Braid Ropes: Double Braid rope has a braided core surrounded by a braided sheath. It was the predominant construction used for dynamic ropes before the benefits of kernmantle rope making techniques were discovered. Current applications for double braid still include Cordelette Cord, Accessory Cord, Utility Rope and Marine and Industrial Applications.

Eight Strand or Plaited Rope: Eight strand ropes consists of four strands twisted to the right and four strands twisted to the left which are then braided together, alternating the pairs over one another. If braided while maintaining the original twist in each strand, it is called a plaited rope. Both types of ropes are most commonly utilized for heavy marine applications.

Kernmantle Rope: The type of rope most commonly used for recreational climbing and rescue. Kernmantle ropes have a tightly braided sheath (mantle) around twisted parallel core (Kern). Kernmantle constructions are very suitable for applications where a high level of safety is demanded. The core provides the majority of the strength, while the sheath protects the core from abrasion. Sterling Rope utilizes Better Braid Technology™ to produce a supple smooth running kernmantle rope.

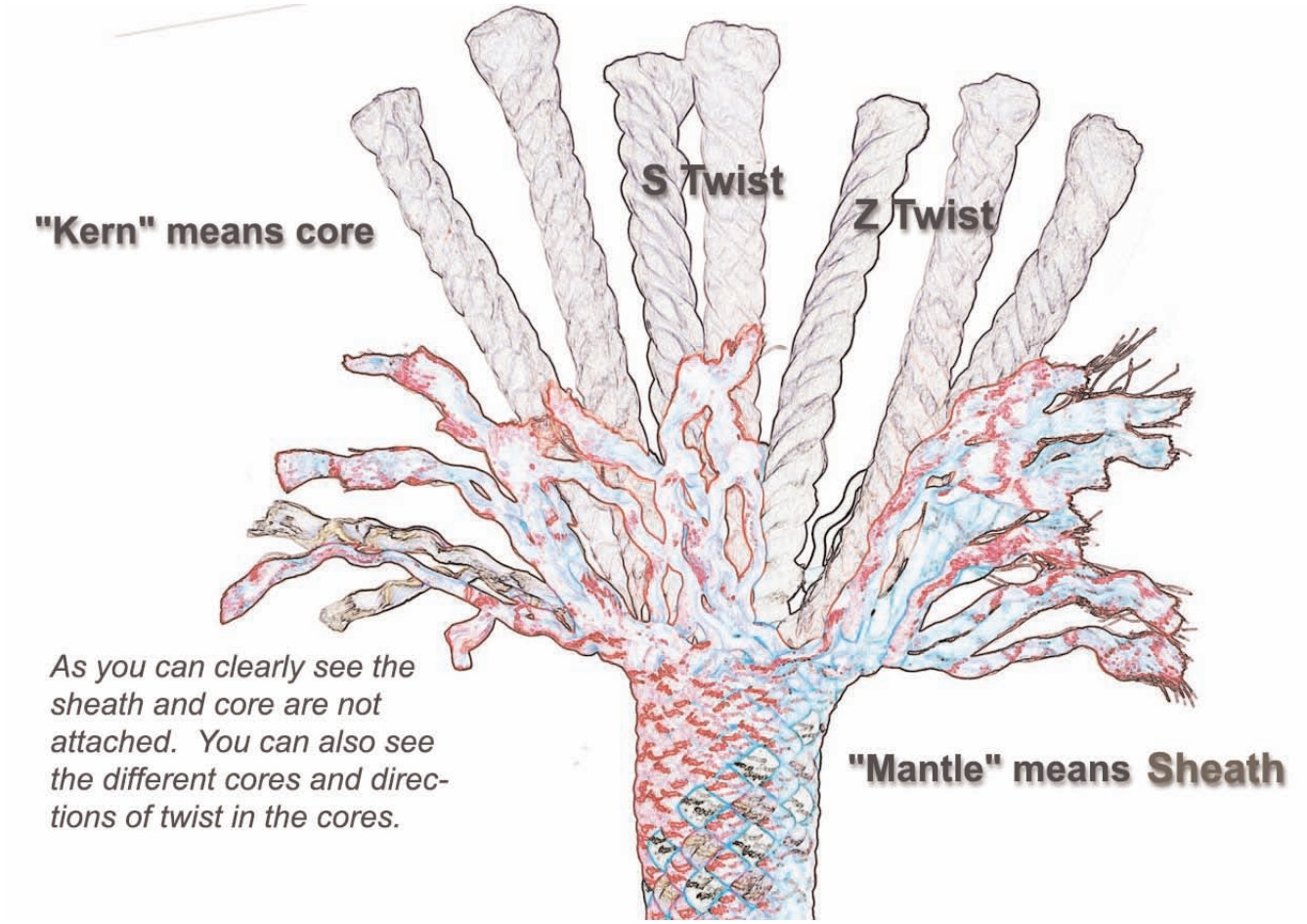


Figure 1: Exploded view of kernmantle rope

3. Yarn Types

Most of our static and dynamic ropes use nylon or polyester as the main ingredient. They are both polymeric fibers. A polymeric fiber is a polymer, or a chemical compound formed by polymerization and consisting essentially of repeating structural units whose chains are stretched out straight (or close to straight) and lined up next to each other, all along the same axis.

Polymeric fibers are extremely strong along their longitudinal axis. The measure of this strength is commonly referred to as “tensile strength”. They have low flexural strength, meaning they are not strong along their horizontal axis, which is why ropes loose significant amounts of strength when tied in knots.

Nylon

The generic name for nylon is “polyamide”. Climbing and life safety ropes are made primarily with either nylon 6 or nylon 6,6. Wallace Carothers at the Dupont Institute developed nylon 6,6 in 1935.

Nylon 6 has slightly better elongation characteristics making it more suitable for dynamic ropes. The high tenacity and relatively low weight made nylon extremely suitable for constructing military parachutes, ropes and cords. Today's nylons are far superior to the early versions. The nylon used in life safety ropes are strong and light with great elongation and impact absorption qualities. Nylon is the superior yarn to use in recreational climbing ropes because of this impact absorption. There is no better product for that purpose at this time.

Polyester

Polyester is another popular fiber used in rope construction. Wallace Carothers first researched polyester during his years with Dupont, but Dupont choose to focus production on nylon. English chemists, John Rex Whinfield and James Tennant Dickson, employees of the Calico Printer's Association of Manchester, patented polyester in 1941. Polyester has since made its way into a multitude of products including soda bottles and reflective balloons.

Polyester fibers come in varying qualities. Sterling only uses virgin high quality polyester developed in the last ten years specifically for high strength applications in our HTP™ Static Ropes and in some accessory cord products.

HTP Static Ropes are a Sterling Innovation. HTP Static's were the only 100% polyester ropes available in the life safety market for the last five years. Polyester is a superior fiber to nylon for several reasons. Polyester is hydrophobic, meaning it doesn't absorb water. Polyester has slightly better resistance to ultra violet and is slightly more abrasion resistant. Polyester also has better resistance to many chemicals. The major field applicable difference between polyester and nylon is that polyester has very little stretch. Therefore, ropes made from polyester are not intended for applications where there is potential for generating high impact forces. However, this low elongation makes polyester extraordinarily efficient for use with raises, lowers, rappelling, jugging, highlines and mechanical advantage systems.

Polypropylene

This low strength olefin fiber has a specific gravity less than one allowing it to float. For this reason, polypropylene is used as the sheath in all of our Waterline™ protecting and floating our nylon or spectra core. What makes it perfect for our float rope is it's hydrophobic and is very lightweight. In certain applications, polypropylene is very durable (why it is used in outdoor carpets). It has a low resistance to heat, UV and many chemicals. There are many different grade and filament levels to polypropylene. Ski tow ropes and generic (hardware store) utility rope often use a low quality monofilament fiber. All our Waterline™ products use a high quality, high filament count fiber suitable for life safety use.

Aramids

Aramids are a polyamide as well. The difference is in their molecular structure. The molecules in aramids align into more crystalline formations. The result is a very straight fiber with incredible strength and low elongation. Trade names for aramids are Twaron® Technora® and Kevlar®. We use TWARON in our RIT™ Series ropes because of its high abrasion resistance and its ability to withstand heat up to 900º F. We braid Technora into a supple core for use in our 6mm PowerCord™ High Tenacity Cordelette Cord.

Ultra High Molecular Weight Polyethylene

Spectra® is an Ultra High Molecular Weight Polyethylene Fiber that has an extraordinarily high tensile strength and relatively low stretch. Pound for pound, Spectra is stronger than steel. It has a specific

gravity of less than one making it float. We use Spectra in our Spec1000 Waterline and in our 24" and 48" sewn runners because of this high tenacity and light weight. Spectra has a relatively low melting point of between 220-255º F and a high lubricity (i.e. it is very slippery) often causing knots to slip.

4. Rope Design and Construction

Product Design

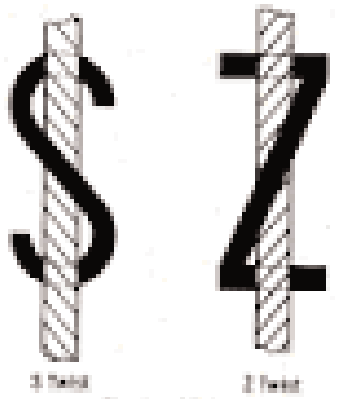
Each and every product developed at Sterling is designed using our total quality management three part process. This process begins with the planning stage in which we outline the product objectives and requirements. Here we seek input from customers, market managers, and our research and development staff. Next we begin prototype development and testing. The rope is engineered through fiber and construction analysis, then assembled. The prototype is tested in-house to meet our standards and then sent for field-testing. Field-testing is carried out by our select group of Product Development Testing Personnel (PDPT Team) where it is put through the rigors of practical use. Depending upon the feedback from the PDPT team and our in-house testing, we will make minor adjustments to the design of the rope as necessary. Once it meets our customer's or our own requirements, the product is sent out for third party testing and certification to the necessary standards.

Construction

Rope construction is a balancing act among many considerations; elongation, impact absorbtion, great handling, strength, and durability must all be considered. Rope performance cannot be quantified in test numbers. Ropes prove themselves in the field and on the rock. There are several important phases of construction.

4a. Twisting

Twisting begins by balancing the fiber. Twisting creates the strands that make up the core and sheath. We twist the fiber in the core to add mechanical elongation and determine strength. We twist our sheath yarns to aid abrasion resistance, obtain uniformity and enhance the handling performance of the rope.



There are two directions of twist, "S" twist or counterclockwise and "Z" twist or clockwise.

Incorporating two directions of twist gives the rope balance. This balance translates into a rope that won't cause a climber or rescuer to spin when they load the rope by climbing or falling on it.

Twisting of Core and Sheath Yarns

Core yarns: receive two levels of twist. The first twist dictates the rope's level of elongation. It also affects the overall strength of the rope. The second twist combines several yarn bundles producing a finished core. The level of second twist greatly affects the overall hand and knotability of the finished rope. It is important to remember that the core of a kernmantle rope is upwards of 80% of the total strength of the rope and also handles the majority of impact absorbtion in static and dynamic ropes. Dynamic ropes have high levels of twist in the cores, acting like a spring when shock loaded, increasing the elongation and impact absorption. Conversely static ropes have much lower twist in the cores creating a rope with much less elongation.

Sheath yarns: Sterling's innovative Better Twist Technology™ is incorporated all our sheath yarns. Better Twist Technology™ utilizes the most advanced twisting machinery, leading to awesome abrasion resistance and a rope that runs smoothly through gear. What is crucial to sheath twisting is aligning the load bearing direction of the yarn with the longitudinal axis of the rope. This takes advantage of the fiber's tensile strength as well as reducing the abrasion of the sheath as it runs over obstacles. In other words, sheath yarns are S- and Z-twisted, then braided into the sheath so the fibers of the sheath are aligned in the direction of load and abrasion for maximum strength and minimum snagging.

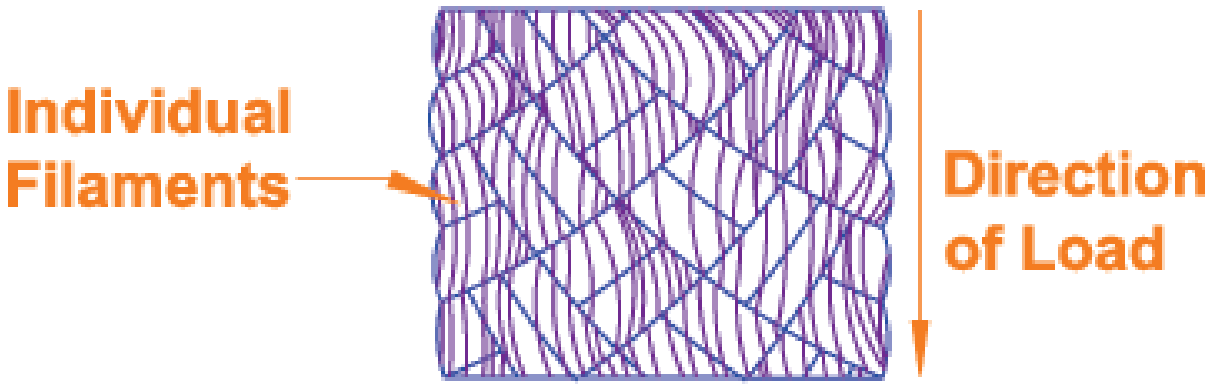


Figure 2: Close up of filaments twisted in line with the direction of load

4b. Braiding

The process of incorporating all of the twisted raw material, core and sheath, into the final rope product happens at the braiders. A rope-braiding machine will braid a sheath around a core bundle. The sheath and core in a kernmantle rope are not connected.

There are several common types of braiding constructions. Sterling mostly uses a two-over-two construction (two yarns braided over two yarns) for its ropes from 9mm up. We believe this construction, combined with our twist levels, create the most desirable and durable sheath. This construction also helps to lower sheath slippage and add firmness to the rope. Pick angle, which is the angle of the sheath yarn, is adjusted to provide the right stiffness and feel of the rope.

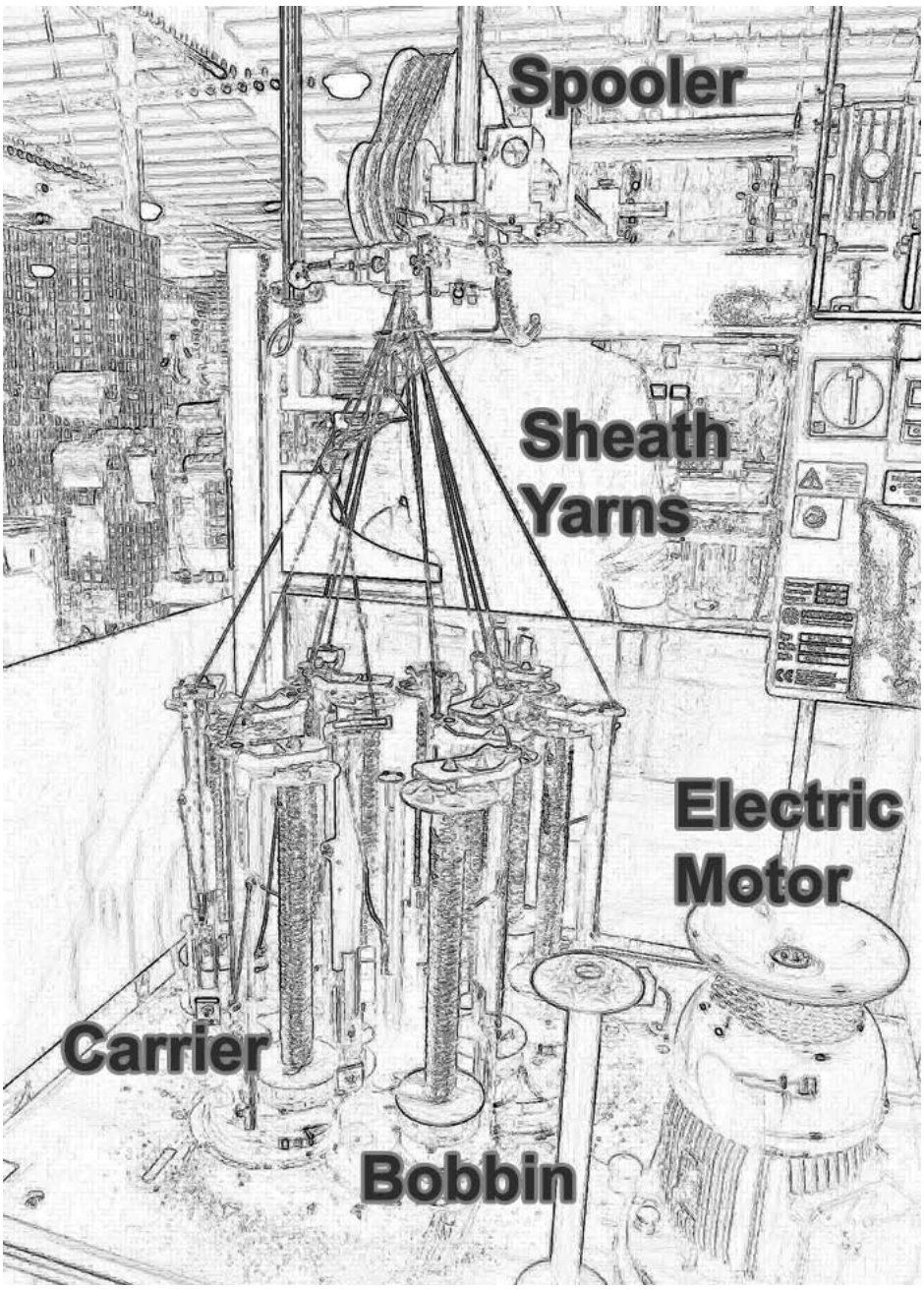


Figure 3: Braider

4c. **Thermo-Dynamic Balancing™**

Heat stabilization is important because it controls yarn shrinkage, helps the rope remain supple over time, limits sheath slippage, and helps maintain elongation properties. Because of fibers natural tendency to shrink at some point during manufacturing nylon and polyester yarn must be heat stabilized. At Sterling, we have developed a proprietary process called Thermo-Dynamic Balancing™ to achieve equilibrium in all of our rope constructions. Heat applied to yarns affects the inherent modulus of the yarn. In practical terms when referring to fibers, modulus is the ease at which a fiber is deformed and regains it shape. Fibers with high modulus resist deformity, but once deformed do not regain their shape. Lower modulus fibers are easily deformed, but come back to their original shape.

4d. **Final hand inspection**

Every single inch of Sterling rope and cord is hand inspected to back up individual inspections at each stage of the manufacturing process. At this stage, ropes are inspected, cut to length, bagged, labeled and prepared for shipment.

Every Sterling rope or cord has a very important quality control number attached to it. This number is called the “lot number” and can be found on the hangtag of the rope. The lot number allows us to track the rope all the way through construction and to the raw material source. The hangtag gives you important information on how to care for your rope. All retailers and customers should endeavor to keep this hangtag and lot number until the rope is retired.

Sterling Rope’s ID Label on all hangtags for all life-safety products.

4e. **Quality Control**

Whether it’s your climbing rope, a lifeline for rescue or an accessory cord for stringing your drum, we are committed to continually providing a superior level of quality in all our products. Sterling utilizes a Quality Management System certified to ISO 9001 Standards. Our QMS assures our customers are receiving products from a company that does what it says and says what it does. Our commitment is to continually improve our process, our products and our service.

4f. **“Third party” Certification**

An outside body, or third party, certifies all of our life safety products to the applicable standard. Outside testing guarantees a superior level of quality for each and every Sterling product. At Sterling, we utilize two testing agencies. Our dynamic ropes are tested and certified to UIAA (Union Internationale des Associations d' Alpinisme) and CE (Certified for Europe) standards by any one of the three UIAA approved testing facilities. In the United States, we use Underwriters Laboratories to test our static ropes to NFPA standards. UL is well known around the world as an established and reliable third party certifier of everything from toasters to air bags. Outside certification guarantees that our products meet and exceed the safety requirements of the industry they address.

5. **Dynamic Ropes**

What makes ropes dynamic? Dynamic ropes are designed with the intention of absorbing impact that may result from a lead climbing fall. When a climber falls a well-balanced rope will stop the fall in the shortest distance, while also lessening the impact felt by the climber and reducing force on equipment. As mentioned in the construction section, dynamic ropes have much higher levels of twist in the sheath and core yarns creating mechanical elongation to act like a spring absorbing the

energy created during a fall. A careful balance is needed in rope construction to create a rope that will catch the fall with minimal impact, yet not be so stretchy as to allow the climber to hit a ledge or ground.

5a. **Testing / Standards For Dynamic Ropes**

UIAA 101 is the standard to which all dynamic ropes are tested. There are five areas of testing; Construction, Sheath Slippage, Static Elongation, Impact Force on first fall, and Number of falls held. UIAA breaks up dynamic ropes into three categories; Single Ropes, Twin Ropes and Half Ropes.

- Single Ropes: One rope used independently and clipped into every piece of protection. Mainly found in diameters from 9.5mm to 11mm.
- Twin Ropes: Two ropes used in tandem where each rope must be clipped into every protection similarly to single ropes. These are generally smaller diameters from 7.5mm to 8.5mm. They have the added safety factor of a two-rope system and can be useful when doing long rappels
- Half Ropes: Two ropes used together, clipped through gear individually. Generally smaller diameters from 8mm to 9mm, this system reduces rope drag, allows for longer rappels, offers better safety for the “second” and greater versatility in the field.

The basics of UIAA 101 testing requirements:

Construction: Kernmantle with core having a greater mass than the sheath
Sheath Slippage: Must be less than 20mm over a 200mm sample or no more than 10%
Static Elongation: Tested using an 80kg weight for single and twin ropes and a 55kg weight for half ropes

- Single and Twin Ropes (using both strands): Must be less than 8%.
- Half Ropes: Must be less than 10%

Impact Force: Tested during the first factor 1.739 fall (4meter fall on 2.3meters of rope).

- Single Ropes: Impact must be less 12 kilonewtons (kN) using an 80kilogram mass.
- Twin Ropes: Same as Single ropes, but using both strands during the test.
- Half Ropes: Impact must be less than 8kN, tested using a 55 kilogram mass.

Falls Held: Number of falls rope holds before breaking.

- Single Ropes: Must hold 5 falls of an 80kg mass.
- Twin: Must hold 12 falls of an 80kg mass.
- Half: Must hold 5 falls of a 55kg mass.

6. Static Ropes

The term static rope is a generic description and sometimes misleading. Static ropes do actually have some elongation. Static ropes are utilized in many areas of rope access, rescue and recreational climbing. The term static rope encompasses a variety of rope constructions and materials. Certain standards make the distinction between low stretch and static kernmantle ropes because some applications require some level of impact absorption, but not the high elongation of a dynamic rope. Some applications of rope rescue require no stretch or a very low level of elongation to provide the most efficient system. Our HTP Static™ is designed for applications where a very low level of elongation is desired, while the nylon SuperStatic™ is more suitable for circumstances that could demand impact absorption. Static ropes are generally used in rescues, rigging, rappelling, ascending, mechanical advantage/haul systems, fall restraint, and travel restraint applications.

6a. **Testing/Standards For Static Rope**

In Europe Static Ropes are tested to European Norm (EN) 1891. In the United States, static ropes

are usually tested to the National Fire Protection Association Standard “NFPA 1983”, the standard for Fire Service Life Safety Rope and System Components. For testing procedures, the NFPA cites several standards written by the Cordage Institute. The Cordage Institute writes standards that cover a wide variety of rope and cord products in the United States. It is worth mentioning that the NFPA does not test ropes, they only write the standard. A third party organization (like Underwriters Laboratories) tests all ropes to NFPA specifications. Standard 1983 divides rope into three major types.

Personal Escape Rope: This standard requires that these ropes are a one-time use. Minimum Break Strength (MBS) must not be less than 13.5kN, elongation must be between 1% and 10% when tested using a mass of 10% of the MBS, and the rope must have a diameter between 7.5mm and 9.5mm.

Light Use (formerly single person load): MBS of not less than 20kN (4496lbs), an elongation between 1% and 10% under load at 10% of MBS, and a diameter between 9.5mm and 13mm when measured under load.

General Use (formerly two person load): MBS of not less than 40kN (8992lbs), an elongation between 1% and 10% under load at 10% of MBS, and a diameter between 13mm and 16mm when measured under load.

All Life Safety ropes must be labeled according to NFPA standards and must maintain their color-fastness over a specified period of time. Labeling includes an inside ID tape, proper end labels and a lot number on the hangtag.

7. Frequently Asked Questions

1. **What is a Marathon Sheath anyway?**
The Marathon Sheath is a Sterling Innovation. This sheath uses heavier denier nylon than any other dynamic rope on the market. We do this to enhance the rope’s durability and longevity.

2. **What is DryCore™?**
DryCore is our unique nylon core construction that reduces yarn on yarn abrasion of wet nylon fibers, helping to maintain the original strength and elongation characteristics of our ropes. Only Sterling ropes have DryCore™. Please note that DryCore™ does not guarantee you rope will stay dry, but that when the rope is wet the fibers will maintain more of their strength and stretch.

3. **What happens to my nylon rope when it’s wet**?
Nylon fiber is affected by the absorbtion of water. Nylon is hydrophilic meaning it will absorb water. The overall strength and stretch can be greatly affected by moisture in the fiber. Whenever possible try and keep your ropes away from water and as dry as possible. Our in-house testing shows that loss of strength in wet ropes may be as high as 70% in nylon ropes without DryCore™ but only 40% in ropes with DryCore™. A 11mm Drycore™ rope that holds 11 falls dry, holds 7 falls wet. That same rope without DryCore™ may hold only 3 falls when wet. In general the data shows that the loss of strength through the presence of water in nylon ropes is significant. The good news is that nylon’s original strength and elongation returns when the rope dries.

4. **What happens to my polyester rope when it’s wet?**
Remember that polyester is hydrophobic (literally “scared of water”) and does not absorb nearly as

much water as nylon and therefore is not greatly affected by being wet.

5. **How should I wash my rope?**
To clean rope use Sterling's Wicked Good Rope Wash™ or rinse in warm to hot water. Machine washing is acceptable. Best is to use a front-load machine. We do not recommend using a top-loading machine as the rope could damage the agitator or vice versa. The temperature of the water is not a major concern as nylon or polyester are not much affected by heat until around 300 degrees and it would be difficult to get a machine that hot.

6. **How should I coil my rope?**
To minimize twists and kinking, the best method for coiling your rope is a butterfly coil over your neck or hand or leg. It is important that each coil is alternatively laid down from left to right without twisting. At the end of the coil belly wrap the left and right sides together and pull a bight through the hole in the top of the coil and push the loose ends of the rope through the bight. If the ends are left long enough you can wear the butterfly coil like a backpack.

7. **How should I uncoil my rope?**
Ropes are hanked twist free at the factory. In order to avoid unnecessary and annoying kinking during its first use it is necessary to properly unhank the rope. To do this, hold the coil of rope in one hand and take one free end. Begin uncoiling that free end three or four twists and drop to the ground. After you have taken three or four coils off the hank, move the remainder of the rope to the other hand and begin uncoiling from the other direction. After three or four coils on that side, switch again. Repeat until the entire rope has been uncoiled. After uncoiling run the rope through your hands meter by meter two or three times to remove excess twist. This will also help you inspect the rope. Now the rope is ready to be used or flaked into a rope bag.

8. **How should I store my rope?**
Store your ropes in a cool dry place away from chemicals and direct sunlight. Do not hang your rope from a coil; use a piece of webbing or cord girth hitched around the entire coil.

9. **How do I know if I should still be using my rope?**

v **Inspect your rope often and thoroughly**.

It is important to inspect your rope thoroughly before and after each use. This should be done both visually and by sliding the rope through your hands meter by meter. If your rope is excessively abraded or you have core coming through the sheath it is time to retire that rope. Often ropes wear faster on the ends from repeated short falls and tying and untying. It may be possible to cut out the damaged section of the rope and continue using the good section.

- **Do not step on your rope**

Stepping on a rope, while not so bad in itself, can cause dirt and crystals to get forced through the sheath, abrading the core with each use.

- **Keep your rope clean**

Use a rope bag and wash your rope every 30 to 40 uses.

- **Know the condition of your rope and be wary of lending it out.**

It is important to inspect the rope when new and continually inspect it during use. We recommend keeping a rope log in order to track the uses and abuses to your rope. Remember that every fall lessens the amount of impact a rope can later absorb. Often a rope used for sport climbing will be subjected to repeated shorter falls. While the rope may not show as much wear from these falls, the cores are being frequently loaded and its ability to cushion your falls will be affected. It is important to inspect the ends of a rope and remove them if they are soft. Please be aware that during each fall the entire rope is being loaded and just cutting off the ends does not give you a new rope.

10. **What chemicals are bad for my rope?**
It is best to assume that all chemicals are bad for your rope. Do not expose your nylon or polyester ropes to chemicals. That said, much recent data has been collected regarding how substances affect rope life. Data available from Honeywell Corporation (makers of nylon 6, polyester and Spectra®) shows that nylon's strength is not greatly affected by motor oil, mineral oil, salt water, Freon, gasoline, kerosene, benzene, chloroform, paints, pine oils, or insect repellents containing DEET. Chemicals that should be avoided at all costs are bleach and sulfuric acid. Still even with this reassurance it is best to protect your rope from any exposure to any acids or alkalis and to store your rope in a cool dry environment.

11. **How much strength does my rope loose when I tie it in a knot?**
There are a lot of publications available that contain information about knots and knot strength. For that reason we will not include much information here, except to say that knots reduce the overall strength of a rope. Therefore, whenever possible use a tensionless knot around a cylindrical object with at least a 4'' diameter. Four inches is the magic number for maintaining full strength in a rope up to 5/8''. Any bend tighter than 4'' reduces the strength of rope because they stress the rope in flexure, the fibers' weaker direction. Here is a list of some common knots and the translating remaining rope strength.

Knot Strength	
NO Knot	100%
Double Fisherman's	65-70%
Bowline	70-75%
Water Knot	60-70%
Figure 8	75-80%
Clove Hitch	60-65%
Fisherman's	60-65%
Overhand	60-65%

12. What is Impact Force?
Impact force is the force felt by the climber or rescuer and equipment at the termination of a fall. It is also the number that is used to show a rope's ability to absorb the energy created during that fall. A fall on static rope with little elongation and a fixed anchor point will generate much higher impact forces than a fall on dynamic rope using a running belay. There are two measures of impact force.Theoretical impact force is the impact force without any extraneous variables. Actual impact force is the force created when you take into account a dynamic belay and friction developed over both the carabiners and rock. The UIAA mandates that the impact force generated on the first fall must be less than 12kN for a single rope. This test uses a static belay with a fall factor of approximately 1.8 or a 4.6meter (15') fall on 2.5 meters (8') of rope. This test demonstrates a very severe fall and generally is not applicable for real world climbing situation but does give a good basis for comparing the relative elongation characteristics of different ropes. Real world experience has shown that rarely are impact forces higher than 10kN generated during a climbing fall. Again, in order to limit the impact force is it important to place protection whenever possible and to utilize a dynamic belay.

13. **What is Fall Factor?**
Fall Factors are something that every rescuer and climber should understand. Understanding fall factor will help a climber/rescuer determine when and how often to place anchor points. Because it is impossible to fall farther than twice the length of the rope the highest possible fall factor is 2 (except via ferrate). A fall of 8 meters on 4 meters of rope (8 divided by 4) is a fall factor 2. So is a fall of 40m on 20m of rope (40 divided by 20, fall factor 2). It is important to remember that fall factor is not the only determinant when calculating impact force; overall length of the fall, friction from anchors, weight

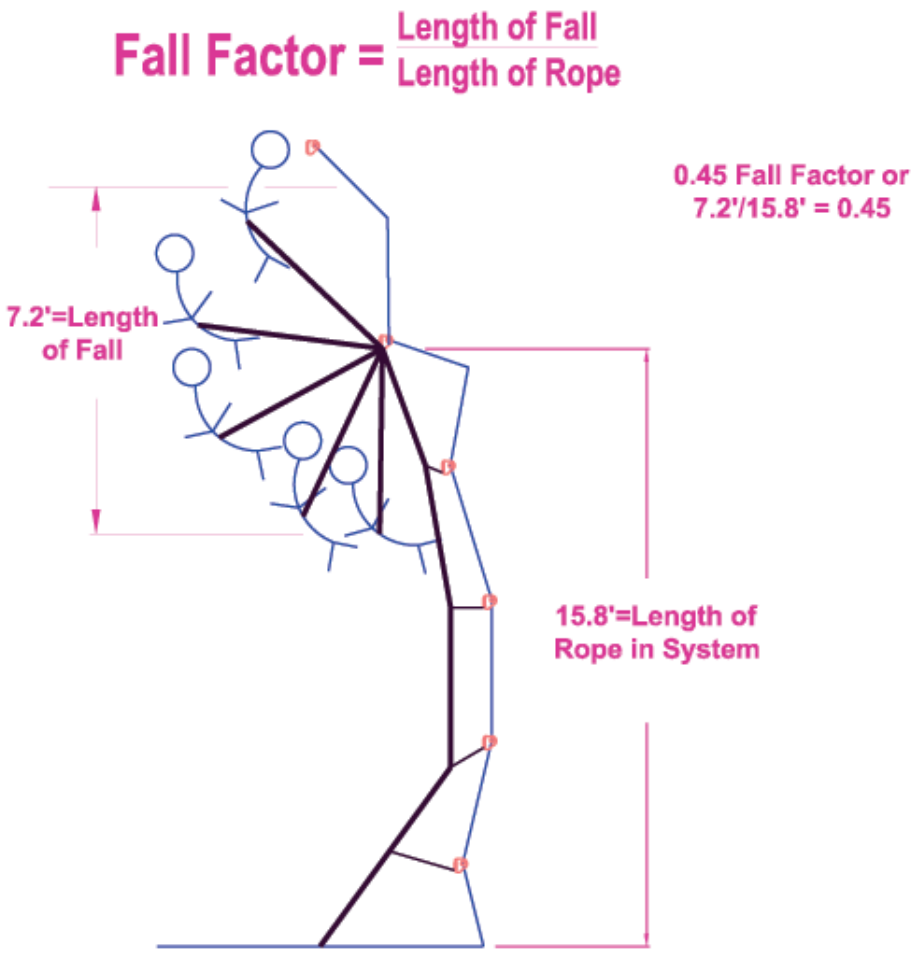


Figure 4: Fall Factor

of load, as wellas the manner of belay (whether dynamic or static) also greatly affects the impact force. In order to limit the impact force created is it important to place protection whenever possible and to utilize a dynamic belay.

14. **How many meters to feet?**
1 meter = 3.28ft

15. **How much is a Kilonewton?**
1 kilonewton = 224.82 Lbs Force

16. **What is "sharp edge resistance"?**
There are no documented cases of a rope breaking under "normal use". The documented occurrences of rope breakages in the field are attributed to pre-exposure to sulfuric acid or by being cut by a sharp edge. UIAA just recently added an optional test to UIAA 101 for testing to sharp edge resistance (UIAA 108). Many manufacturers are claiming sharp edge resistance for their ropes. The designation of sharp edge resistance is not a guarantee of safety. These ropes can still be cut. Our in-house testing shows that slight variables in the testing procedure can cause even "edge safe resistant" ropes to break on the first fall. We have recently received a letter from APAVE, the UIAA Approved Lab that we use for testing, that their "insurance company strongly recommend us to inform our customers that this test does not reproduce the reality and that the behavior of a rope in contact with a sharp edge can be radically different from the UIAA 108 test conditions and results."

17. Average vs. Minimum Break Strength
Average breaking strength is determined by averaging the samples in a given test. Minimum breaking strength can be figured several ways, either using the true minimum number that was recorded during a testing sample or more commonly by using a statistical method such as 3-Sigma.

18. **What is a 3-Sigma Rating?**
3-Sigma ratings are used throughout the climbing and rescue industries to determine a level of accuracy in the breaking strength numbers that we report. A 3-sigma rating is much more reliable than, say, an average strength where 50% of a sample could be below that strength. 3-sigma ratings are based on a statistical analysis of the breaking strengths of a given sample of rope. Statistically speaking a 3-sigma rating means that 99.9% of the products are stronger than the reported MBS rating. What this means is a 3-sigma rated MBS is three standard deviations below the average breaking strength. Standard deviation helps to define the spread in the distribution of a given test sample. It is not the mean. Reporting 3 sigma ratings more accurately represents a rope's strength to be at least the MBS reported.

19. **What are Safe Working Loads (SWL)?**
Safe working loads for rope are usually described as a ratio of the MBS to load of a rope. Depending on industry the SWL varies. The NFPA recommends a 10 to 1 SWL for life safety rope. The National Association of Tower Erectors recommends a SWL of around 15 to 1. OSHA recommends a 10 to 1 ratio as well.

20. **What's the difference between a bipattern and bicolor?**
Bipattern ropes are a pattern shift in the middle of the rope. Neither the color nor yarns change. Bicolors are produced by changing the yarns in the pattern to a different color yarn at the middle of the rope by using an air splice technique.

21. **Why does my BiColor rope have fuzzy bumpy yarns at the middle mark?**
Air Splices.are those fuzzy bumpy spots. An air splice is the joining of two yarn ends by means of high-pressure air forced around the ends causing them to entwine and snarl together. Air splices are essential to join strands into usable lengths. From a life safety perspective two yarns air spliced together test out to be 50% stronger than continuous straight fibers because they have twice as much yarn in the section that is air spliced.

22. **What length rope should I buy?**
A 50m rope was the standard for most ropes until about 10 years ago. Changes in sport climbing route development created the need for longer ropes and the advancements in yarn technology allowed for longer lighter, skinnier ropes. These attributes have led to need for longer (70M, 80M, and in some cases 100M ropes) and skinnier (9.6mm, 9.5mm, 9.3mm, 8.3mm, 8.2mm, 7.6mm) single, half, and twin ropes.
Also longer ropes allow for the worn ends to be cut and still be a useful rope – i.e. 60M rope shortened to 55m, due to the abuse from repeated short sport climbing falls.

- **50 meter**: Shorter crags or alpine terrain where a lead rope is necessary without the weight of a 60meter.
- **60 meter**: This is the standard length for a rope today. Great all around versatility for longer trad and sport routes. More advanced climbers are using skinny (9.7mm and below) 60 meter ropes on long multi-pitch and trad routes for light and fast ascents.
- **70 meter**: Slowly becoming a more common size. Great for long sport routes where a 60 isn't quite enough for the lower or for linking shorter pitches on trad climbs.

23. **Should I mark my rope with a permanent marker?**
The UIAA recently conducted a limited amount of testing using the standard UIAA 101 drop testing procedures with ropes marked with a several different permanent markers. The results of those tests are summarized as follows:

Notification concerning Rope Marking issued: April 2002

Tests done by the UIAA Safety Commission and by some rope manufacturers have shown that rope marking with liquids such as those provided by felt-tipped pens can be dangerous, even with those markers, sold specifically for marking ropes. The test results showed a decrease up to approximately 50% of the rope strength, more correctly: of the energy absorption capacity of the rope (expressed by the number of falls in the standard test method in accordance with the European Standard EN 892) Therefore the UIAA Safety Commission warns against marking a rope with any substance that has not been specifically approved by the rope manufacturer of that rope. It is not possible for the UIAA Safety Commission to test all markers that are commercially available and can be used for marking ropes. Furthermore it would be impossible for the UIAA Safety Commission to keep such information up-to-date. In addition, the effect of any rope marker seems to vary with the make of rope. Hence, all the UIAA Safety Commission can do at the moment is to warn mountaineers and climbers. The UIAA Safety Commission will carry out further research into this problem to provide practical advice to climbers. Sterling Rope stands with the UIAA in this stance and therefore recommends that you do not mark your rope with a permanent marker. That said, Pit Shubert, President of the UIAA, has also published this notice: "…A damaged rope by marking is not a big problem, because such a marked rope can not break in practice (only when tested on the test machine according to the standards, UIAA and EN (CEN)), such a marked rope can only break in practice when the two or three centimeters (about one inch), which are marked, are placed over a sharp rock edge when the rope is loaded by a fall. The probability that this will happen is nearly zero…There is only one danger, when during mountain rescue one or two people are lowered down and the rope is running over a sharp rock edge, then the two or three centimeters will run over this edge, and then there is a danger." So again and as usual, you are the best judge of your own comfort level. If you have been marking your rope for years with a pen and have never had a problem, then use your own judgment to decide if the new UIAA stance is going to alter your opinion.

24. **Do High Tenacity Aramid Fibers (Twaron®, Technora®, Kevlar®) Break Down?**
There is a lot of discussion concerning aramid fiber (such as Kevlar®) flex fatiguing over time. Most of the data available has been acquired through testing conducted for the sailing industry where a cord is excessively cycled through pulleys and blocks. The data shows that with time and cycling aramid fibers do break down. However, the level of cycling in sailing applications is far greater than of applications a climber or rescuer using aramid fibers for anchors might employ.

25. **What is Denier? What is Tex?**
In the United States yarn weight is classified by the term "denier". Denier is the weight in grams per 9000 meters of yarn. In Europe, they use a base ten system called "tex". Tex is the weight in grams per 10,000 meters of yarn. More and more US manufacturers are using the tex instead of denier, as it is much easier to convert.