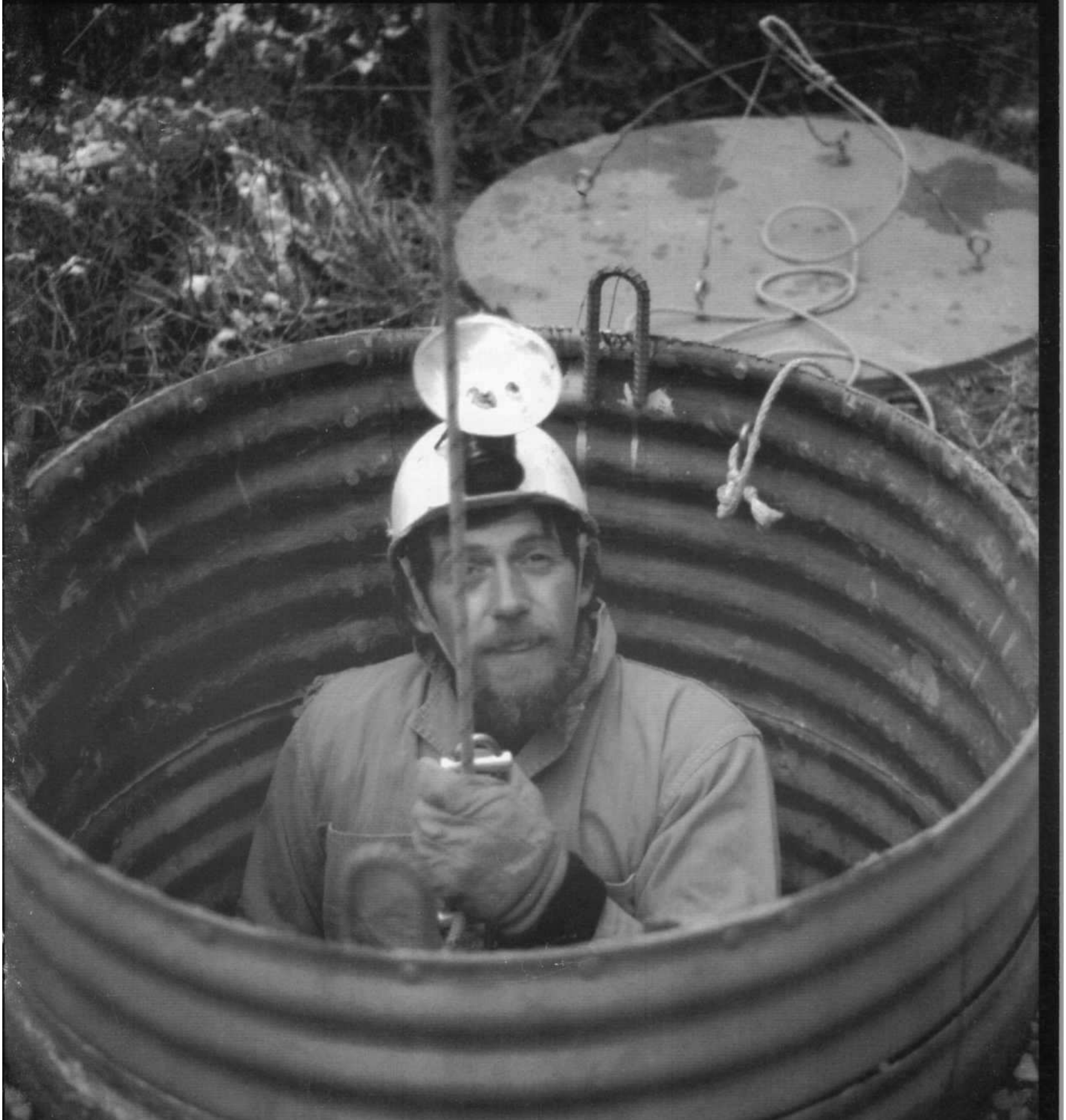
NYLON HIGHWAY

NO. 40



... ESPECIALLY FOR THE VERTICAL CAVER

NYLON HIGHWAY

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Gary Taylor
2736 Haverknoll Drive
Cincinnati, OH 45231-1053

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Co-Editors
John L. Hickman
Geary M. Schindel

Assistant Editors
Jodi Bailey
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THE NYLON HIGHWAY

The Nylon Highway is published by the Vertical Section of the National Speleological Society on a semi-annual basis pending sufficient material. It is the intent of this publication to provide a vehicle for papers on vertical work. All submitted articles containing unsafe practices will be returned to the author.

Opinions expressed herein are credited to the author and do not necessarily agree with those of the Vertical Section, its members or its Executive Committee. Reprinted material must credit the author and the source.

Message from the Editors

Geary M. Schindel, NSS#15827F
John L. Hickman, NSS#28619,
Guest Editors

Issue number 40 of *Nylon Highway* is finally completed. We thank those authors who contributed materials to this issue for helping making it possible. We especially say thanks to *Climbing* Magazine and *Rock & Ice* Magazine for allowing us to reprint a number of fine articles. Both of these magazines publish technical articles in every issue with most having an application to vertical caving. For those cavers who want to stay on the technical cutting edge, these magazines are among the best sources of available technical material.

The *Nylon Highway* needs your help. The quality of this publication is directly related to the material submitted. If you have an article you've been thinking about, some test data, or a new technique, write it up and send it in. Through the interchange of ideas, we all become safer and more proficient cavers.

Thanks,

Geary & John

Geary Schindel descending Valhalla PIt, Alabama, during a Summer, 1993 trip. (Photo by John Hickman)

• Front Cover

Fits Like a Glove - Bob Rowe at the Doyle Valley Entrance to the Mammoth Cave System. This is a drilled entrance which is 56 feet deep. The first 24 feet was 26 inches in diameter and the remaining 32 feet was 17 inches in diameter. It was later drilled out to 24 inches in diameter. (Photo by Geary Schindel)

• Back Cover

Views of Pits - Three pictures illustrate different angles of Neversink and Stephens Gaps Pits, Jackson County Alabama.

top left- John Gunn in Neversink. (Photo by John Hickman). lower left- caver descends Neversink (Photo by Geary Schindel). bottom left- Sue Schindel ascending Stephens Gap (Photo by Geary Schindel).

THE CARABINER-BRAKE RAPPEL SYSTEM REVISITED

by Geary M. Schindel

This article originally appeared in Response Magazine in the Winter 1983 issue. It has been revisited to address this system for caving.

Introduction

The carabiner-brake rappel system was a common system used by rock climbers and search and rescue personnel until the Figure-8 descender came along in the mid 1970s. The carabiner-brake rappel system and its variations are depicted in a number of climbing and caving instruction manuals (Montgomery, 1977; Setnicka, 1980; Loughman, 1981; March, 1985; Martin, 1985; and Padgett and Smith, 1987); however, these publications generally do not discuss the specifics of the system.

Climbers liked the carabiner-brake system because it could be fabricated from carabiners (materials at hand) and minimized the need for specialized single function rappelling equipment. Since climbers use relatively clean ropes, abrasion of the carabiners was rarely a problem. The system was never very popular with cavers because of excessive wear on carabiners from the typical caving rope (read rat tail file). This system is discussed here to show that a serviceable rappel device can be fabricated from carabiners and for its historical interest. It is important that attention be paid to detail in rigging the system as it can very easily be rigged incorrectly and could result in a severe case of death.

The carabiner-brake rappel system has the following advantages: it can be built using most oval or D-shaped carabiners, will accept either single or double ropes, is relatively easy to rig, and the device can be customized for your friction (load) requirements before the rappel by adding additional braking carabiners. The main disadvantages to the system are that dirty caving ropes can quickly cause severe damage to the carabiners and the system can be rigged incorrectly resulting in release from the rope. The system is a fixed or non-variable friction device which would require feeding of rope for long rappels due to excessive rope weight.

How to Rig the system

The carabiner-brake rappel system requires four to five carabiners to complete depending upon the amount of friction desired. The system is formed with two "body" carabiners and one to three brake (friction) carabiners (Figure 1). The body carabiners should be oval carabiners; however, D-carabiners will work.

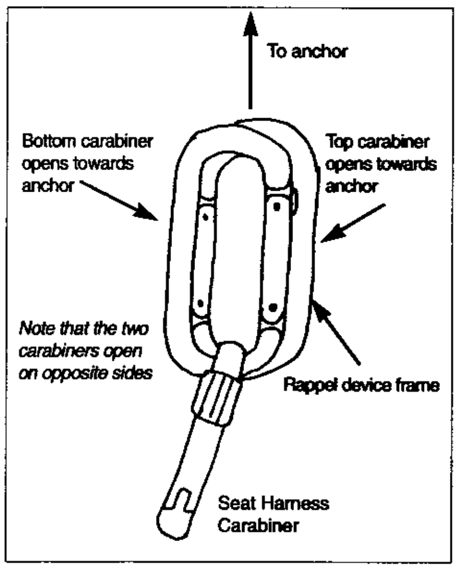

Figure 1

Some of the more exotic shaped carabiners should not be used for the body. The body carabiners should be clipped to a locking carabiner or Quick Link which is attached to the seat harness. The body carabiners should be placed on top of each other with both gates opening closest to the anchor and the locking carabiner at the opposite end. The carabiner gates should open on opposite sides of each other so that the solid metal side of one carabiner is on top of the gate of the matching carabiner to prevent the brake carabiners from sliding to the side and popping out of the system. Rigged in this fashion, the body carabiners form a continuous loop of metal. This is a critical aspect of the system so make sure it's done right. Locking carabiners can be used for body carabiners and they do add a little additional security and strength to the system. However, they tend to interfere with the function of the brake carabiners. A single locking carabiner should never be substituted for two body carabiners.

With the body carabiners attached to the seat harness with a locking carabiner, the rope should be pulled through the body carabiners and a brake carabiner clipped across the two body carabiners so that the gate is down. (figure 2)

Additional brake carabiners should be clipped next to the original brake carabiner. I would recommend that two brake carabiners be used for double rope rappels and that three carabiners be used for single rope rappels. After rappelling with this system, it is important to inspect your carabiners for excessive wear from the rope.

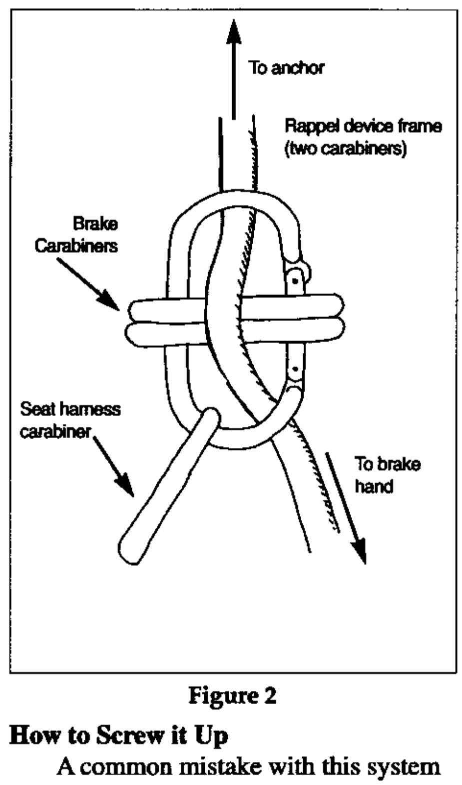

Figure 2

How to Screw it Up

A common mistake with this system is to point the body carabiner gates toward the seat harness rather than toward the anchor. Under load, the gates can open, jam into the rope and be forced

(Continued on next page)

up and into the brake carabiners. This can cause severe damage to the rope, destroy carabiners, jam the system, and strand the user in a precarious situation.

If the body carabiner gates are pointed away from the user, and the gate opens, the rope can only force the gates down and out of the way. The gate might be bent, but the likelihood of rope damage is smaller and the rappel system will still be able to function.

Some other considerations:

The system can be constructed with most oval or D-shaped carabiners, but some ultralights do not fit into the system. The system can be chained in series with other carabiner rappel systems for additional friction. This should not be needed for body weight but has been used for lowering of stretchers, etc.

A modified form of the carabiner-brake rappel system is presented in *On Rope* (page 133, Figure 5h) as a "Mountaineer's Six-Biner Rappel.." (figure 3) However, the diagram is fatally flawed (no pun intended, just a statement of fact). The use of the Mountaineer's Six Carabiner system as depicted in Figure 3 would most likely result in a

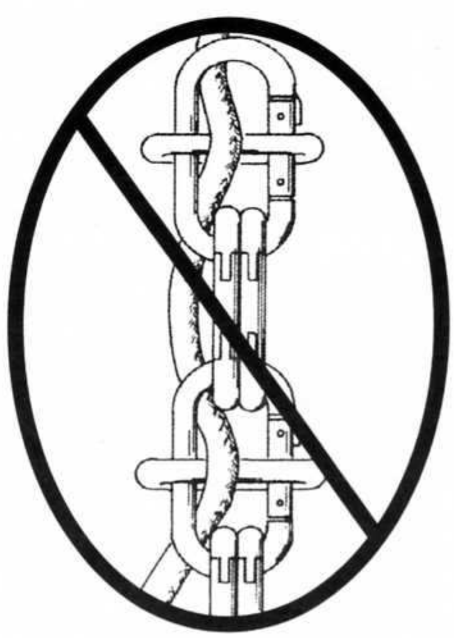

Figure 3
Mountaineer's six carabiner rig.
(Reprinted from *On Rope.*)

release from the rope. A close evaluation of the system indicates that two single non-locking body carabiner are used in series. This figure should be modified to include two body carabiners and two or three braking carabiners. The second carabiner-brake system in series is not necessary under normal body weight. The connection of the two carabiner-brakes in series with two carabiners will result in binding of the system as the rope is forced between them during loading.

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HOW TO BOLT A SPORT ROUTE

Responsible bolting is everybody's business

by David Prall

Reprinted with permission from Rock & Ice, #68, July/August 1995

Bolts have been protecting climbers for many years, yet never have they been subjected to the stress they must endure today. The dramatic increase in the number of climbers on sport routes, combined with the widely accepted practice of repeated falling and hanging, is resulting in an unprecedented demand on bolts. Anyone who places a bolt on an accessible crag today must assume direct responsibility for ensuring that the bolt is as strong as it can possibly be.

Step-by-Step Bolting

Once you've found the line of your dreams, your first questions will probably be, how many bolts does this thing need, and what should I rate it? Slowdown; first you'll need to make sure it's as classic-and safe-as a new line should be.

Using natural or traditional gear, set up a temporary top anchor before placing any bolts. Rappel the route and remove dangerously loose rock. Climb the route several times, paying close attention to the availability of solid rock for good bolts every six to eight feet. If even your best line crosses one or two unprotectable, unboltable sections, choose another route.

If you decide the route is viable, place two bolts for permanent top anchors. On many crags, the quality of rock decreases as you climb higher. Plan your route so the permanent top anchor is well below any dubious rock. On overhanging climbs, make sure the lowering rings of the top anchors are not above the point at which the angle eases back toward vertical. Anchors higher than this point can cause excessive rope drag and may be impossible to see from the ground and/or route.

Top anchors should be 12 to 18 inches apart. Unless long extensions [chains or webbing) are used, greater horizontal spacing increases the load on each bolt. Anchors set closer than 12 inches could fracture the rock. You needn't place the bolts side-by-side; a diagonal or vertical arrangement may take better advantage of rock quality. As long as they're equalized, these configurations are fine.

Toprope the route several times, concentrating on potential clip locations. Bolt placements must be in good rock and reachable from a relatively comfortable climbing position that utilizes solid holds. Look for rock that receives the least amount of exposure to the elements; a basketball-sized area of smooth, dense-looking rock is ideal. Avoid pocketed, hollow or fragile rock.

The best clipping stances are also rests. Minimally, you'll need one solid foothold. On vertical and overhanging routes, a large, solid handhold will also be desirable.

The safest location for any clip is at the climber's waist. On slabs, this reference point works well, but on steeper routes, clipping that low is awkward and therefore less safe. On these routes, the safest clip is near the head or shoulders. Avoid clips higher than a foot or so above the head-a lot of energy is spent pulling up rope to clip, and extra rope out adds to the potential fall distance. Most people will have better control if the clips are slightly to one side.

> ***Chains attached to bolts with spacer washers might be the most lethal anchor idea ever conceived.***

Mark placements with blackboard chalk or lumber crayons. Crayon lasts longer; both wipe off easily. Place your first bolt as high off the ground as is safe for the leader to reach without protection-you want to get as much rope out as possible to minimize fall impact on that bolt.

Place the second bolt close enough to the first to minimize impact to the first bolt and prevent a ground fall. Space the rest of the bolts at distances appropriate for the terrain. (Pay attention to ledges or other obstacles the leader could hit.)

Before you drill, have friends of varying abilities and heights climb the route. Can they make the proposed clips easily, or is the route too specific to one type of climber? Gather as much input as you can. You'll enjoy your route more if others like it as well.

Drill on rappel if the route is difficult or on toprope if it's more moderate. The angle between the drill bit and rock surface should be as close to 90 degrees as possible; a 90-degree angle improves hanger contact and bolt durability. Practice on concrete or large stones until you can drill efficiently.

Clean the rock dust from the holes. An aerosol can of compressed air or blowing through small diameter flexible tubing works well for this.

If you're using glue-in bolts, follow the glue manufacturer's instructions religiously. For mechanical bolts, tap the bolt all the way into the hole, then twist it around a little. Most manufacturers supply the recommended torque setting. Practice tightening bolts with the correct torque ahead of time; use the wrench you'll use at the crag to develop a feel for the correct torque. You can check your accuracy with a torque wrench; if convenient, bring the torque wrench to the crag as well. Up to five pounds away from correct torque will not affect strength, but significant under- or over-tightening will.

Never use silicon caulk to seal mechanical bolts. One problem is that the seal breaks down quickly and leaks. More serious, however, is the fact that many sedimentary formations, especially limestone, soak up and seep water like a sponge, so water leaks into bolt holes from inside the rock. If a hole is even partially sealed, the moisture doesn't evaporate quickly. Leave holes unsealed in all types of rock to allow drainage.

Clean the placement markings from the rock.

Why Bolts Fail

Bolts fail either because the metal fails, or because the rock in contact with the anchor fails and the anchor pulls out when loaded. The way a bolt is installed will affect its strength.

When manufacturers rate the strengths of their bolts, they usually express the figures in terms of pull-out, shear and tensile strengths. Shear and tensile strength are virtually meaningless when evaluating climbing anchors; bolts used for climbing almost never fail due to these conditions. Pull-out is a concern in very soft rock, so comparing rated pull-out strengths is useful.

Bending is the real enemy of climbing bolts. A bending load (a fall or a swing after a fall) produces higher stresses to the bolt than the same-magnitude load applied in any other manner. Additionally, climbing falls cause several loading conditions to occur simultaneously. These stresses are additive and potentially very destructive.

Applying these loads to a bolt once is bad enough; repeatedly applying them eventually results in severe metal fatigue. When bolts are strength-tested, loads are applied singly, independently and statically (slowly and smoothly in increasing magnitude until the specimen being tested fails). This is not how a falling climber impacts a bolt. A component loaded by repeated back-and-forth bending will fail at much smaller loads than one that is statically loaded. During routine tests, steel components subjected to repeated bending have failed at as little as 10 percent of the rated strength. This metal fatigue is what helps you remove tabs from beer cans.

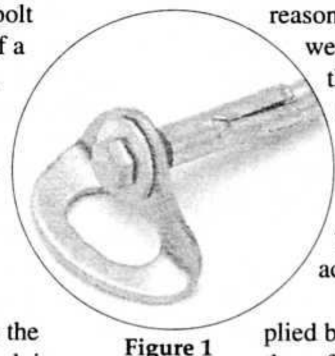


Figure 1

Stress can also be concentrated, and thus, anchor strength reduced, by applying loads to sharp corners or other geometric irregularities on the bolt. For this reason, stud-type [including wedge) bolts, in which the threaded portion protrudes from the hole, and threaded rods are weaker than shaft-type ('sleeve") bolts. Furthermore, exposed threaded areas attract and accelerate corrosion.

Strength ratings supplied by manufactures do not take these factors into account; thus, stated strengths are typically higher than performance strengths. Bolts rated with "working loads" are more representative of reality, because they are tested in ways that simulate real conditions. In addition, not every bolt in a batch of thousands is tested. If you were to buy 100 bolts and test them all, not only would they fail at loads different from those stated by the manufacturer, but it's also possible that some would fail at drastically smaller loads.

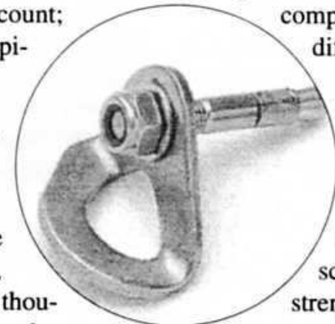


Figure 2

Which Hardware?

Proper hardware is vital to the strength and life of an anchor. The choice for hangers is simple-buy from an established company that has had its equipment in use for several years without incident. One-piece, glue-in, ring-type bolts from an established manufacturer are also strong. Coldshut hangers are positively suicidal. Welded coldshuts are suspect; welding has to be of sufficient strength and accompanied by heat treatment to be effective and how many people are doing that in their garages?! Additionally, the extra thickness of a coldshut forces the bolt to produce farther from the hole, subjecting it to greater leverage and bending.

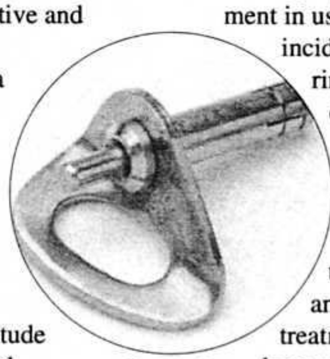


Figure 3

You have more choices for bolts. Mechanical (expansion/compression) bolts come in a variety of styles, and each is available as a stud or shaft. Compression bolts and poorly performing "pseudo" expansion bolts, which tighten as you hammer them into the rock, pale in comparison to expansion bolts that you tap into a hole and tighten with a torque wrench.

The expansion mechanisms of shafts bolts *(figure 1)* are variations of a cone-and-sleeve design. Stud bolts *(figure 2)* use cone-and-ring or opposing-wedge mechanisms. Both perform comparably with respect to pull- out strength; shaft bolts (sleeve design) are far easier to remove and replace. The stainless-steel Petzl Longlife *(figure 3)* is a "psuedo" expansion bolt; it's strong in compact rock such as granite, yet difficult to remove.

Regardless of the type of bolt you choose, it should be made from steel. Steel offers a few variations:

Grade. Structural bolts are graded on a variety of scales; all are related to strength and hardness. Very hard steels with high ultimate strengths are poor choices for bolts, they tend to be more brittle and break more easily in repeated loading situations. Low-grade steels are inadequate due to lack of strength.

Medium-grade (mild) steels offer the best blend of durability and overall strength for climbing and possess higher resistance to fatigue than high- or low-grade steels.

Corrosion resistance. In wet, salty or polluted environments, stainless-steel bolts and hangers last much longer. Limestone often seeps and can constitute a wet environment, even in semi-arid climates. However, in most situations, anchors will need to be replaced long before corrosion becomes a critical strength factor.

Even if you don't use stainless steel, never use non-galvanized bolts outside; they won't last a season, even on your bird feeder. Beware, however, that not all galvanizing treatments are equal. Hot-dipped galvanizing involves dipping components in molten zinc, then cooling; this leaves a somewhat-fragile coating. A vastly superior process is zinc-plating, in which an electro-chemical process is

(Continued on page 6)

(Continued from page 5)

used to plate zinc to the steel. It's easy to distinguish between the two. Plated bolt will look bright and shiny, as if they were spray-painted silver, and show no inconsistencies. Dipped bolts will appear duller and mottled.

Galvanic corrosion occurs when two metals or allays having different compositions and galvanic potentials are placed in direct contact while exposed to an electrolyte. Contrary to statements made in *Rock & Ice* #62, the galvanic difference between steel and stainless steel is not great enough to matter, and rain is not a significant electrolyte.

Therefore, the galvanic-corrosion effects on a climbing anchor's strength are negligible.

Critical corrosion or weakening will not be slowed by the addition of paint. Paint to reduce visual impact, not to protect the hardware.

Top Anchors

For lowering and rappel stations, it's hard to come up with anything that beats two Metolius Rap Hangers. An adequate alternative consist of two regular hangers fitted with 3/8-inch diameter or larger quick links with screw closures.

The most dubious anchor setups I've seen use chains. Chains attached to bolts with spacer washers might be the most lethal anchor idea ever conceived -- because the bolt might stick farther out of the hole, bending forces on the bolt can be increased by a factor of 10. Not to mention that the quality of the chain, even when new, is anybody's guess. Some companies make chains with hangers permanently attached. This is a sound idea, as long as the chains are high-quality, ASTM-tested and certified. If you have to extend an anchor, use new, rock-colored nylon webbing. At around 25 cents a foot, webbing is cheap life insurance. A rope-bearing sling or link should be replaced before 25 percent of its diameter is worn away.

Bolt Size

It's important to measure a bolt's true diameter when comparing bolt strength; different manufacturers size bolts differently. For example, the 3/8-inch Rawl *(sometimes referred to as the five-piece) is not a true 3/8-inch bolt. Its shaft is only 5/16-inch in diameter and is not as strong as a 3/8-inch diameter shaft. The sleeve makes up the difference, so a 3/8-inch hole is required to accept the complete assembly. However, the sleeve adds no significant strength to the bolt.

The stated diameter of stud-type bolts and threaded rods are not true sizes either. Three-eighths- or 1/2-inch threaded stock is not as strong as 3/8- or 1/2-inch shaft stock. The threads are cut in the stock, which reduces the diameter of the bolt where the leads are strongest. Always compare certified test strengths rather than stated sizes.

Increasing a bolt's diameter improves the bolts grip and strength; it also decreases the potential for rock failure. If the rock is more likely to fail than the bolt, a longer bolt (more than 2-1/2 inches) can help too, but only if drilling deeper exposes rock of equal or greater strength. In some types of rock, especially hole-riddled limestone or sandstone, strength can actually decrease as bolt lengths increase. In very soft rock, longer bolts coupled with glue-in techniques will improve the rock's durability.

Glue-in Versus Mechanical Bolts

Mechanical bolts, with some exceptions, are less expensive, easer and faster to install, and easier to remove and replace than glue-in bolts. They're also performance-tested and certified, and, assuming proper placement in sound rock, more durable and fatique-resistant. Mechanical bolts lose strength dramatically, however, when improperly installed -- drilling errors, over-or-under-tightening and improper sizing all diminish their strength.

Glue-ins are superior when very large diameters and lengths are required, as in soft and/or loose rock or on crags that receive a lot of runoff. Glue-ins are not affected by moisture, even while the glue is setting. Quality glue-ins, available from Ramset/Redhead, Hilti, Rawl and Petzl, are generally stronger than the rock in which they're used. Glue-ins also work well in the irregular holes that can result from the removal of old mechanical bolts or from poor drilling techniques; these bolts can eliminate the need for reboring with larger diameters or in new locations.

Glue-ins have their disadvantages: They're more expensive than mechanical bolts; proper installment is often tedious and difficult; and glues can be messy. The effects of glue-in anchors also tend to be more difficult to erase.

If you use threaded rods with glue-in anchors, strength is further compromised; it's best to use machine bolts with an unthreaded shaft near the bolt head. Contrary to popular belief, glued bolts with threads are no more resistant to pull-out than those without.When using machine bolts, the bolt head and the hanger must be held tightly against the rock, and the shaft must be surrounded uniformly by glue while the glue sets. To facilitate these, use a hacksaw to cut a diametric slot into the tip of the bolt about a 1/4-inch deep. Slide the hanger onto the bolt, and spread the tip of the bolt slightly. (Hammer a chisel or screwdriver into the slot.) You'll need to experiment to find the amount of spread that allows entry into the hole and still holds the bolt tightly while the glue sets. The hanger remains on the bolt. To install, fill the hole with glue as per manufacturer's directions, and insert the bolt/hanger unit by tapping lightly. Taking the time to do this leaves a stronger anchor.

How to Drill

Even the strongest bolt won't be worth a damn if it's placed in a sloppy hole. It's better to use a power drill than a hand drill-unless doing so breaks local traditions or regulations.

With either tool, the larger diameter the hole, the more difficult it is to drill cleanly. if you are using the correct bolts, you should never need to exceed a 9/16-inch diameter (for a 1/2-inch glue-in) to drill a new hole. With proper technique, you can drill these sizes cleanly enough to create solid placements.

Some people remove the battery from their power drill and carry it in a backpack, connected with an extension cord, while drilling. The drill will make a faster and cleaner hole; however, if the battery is left attached, the weight transfers impact force to the tip of the drill bit and improves hole-cuffing ability.

It's a good idea to drill a pilot hole to ensure a clean bore. Drill a smaller-diameter hole, then drill the required size in the same hole. This technique will also extend the charge life of your batteries.

How long do bolts last? You've bolted your route using the best hardware and technique. The route is as safe as it is classic, yet it won't stay that way forever. To guarantee long-term quality and safety, bolts on all routes need periodic replacement. Metals are susceptible to fatigue; a significant number of bolts at popular climbing areas are prime candidates for failure right now. Fatigue is unpredictable -the bolt that held a massive screamer yesterday could break today from just a short drop.

It's impossible to say exactly how often a bolt should be replaced. At high-traffic crags, bolts on popular routes see a lot of abuse. If such crags are in areas that experience winter conditions and the rock is of medium quality (such as weathered limestone), the safe-life of a good anchor could be as little as five or six years. On the other hand, a well-placed, quality 3/8's-inch or 1/2-inch bolt in solid rock should withstand many years of moderate use.
If you don't know a bolt's age, visual inspection is all you can go by. Any bolt with obvious signs of wear or corrosion should be replaced. If a bolt feels loose when wiggled, it's a goner. Attaching a sling to the hanger and giving a few sharp jerks in various directions is a good way to check for more subtle weakness. Hammering is a poor way to test a bolt; you can make a previously adequate placement unsafe with even mild blows.

If the bolt is sound and the hanger is loose (a "spinner"), the unit is probably still safe as long as the bolt isn't protruding more than 1/4inch from the hole. It's a bad idea to tighten a spinner unless the threads are visible (stud bolt) and in good shape. Tightening a bolt with bad or hidden threads (shaft bolt) loosen the bolt's grip and start the entire unit spinning. This leaves the anchor in worse shape than before.

Removal

A mechanical shaft bolt is the easiest to remove. First, tighten it clockwise to make sure the wedging portion is engaging the rock. Then simply unscrew and remove it. Use the bolt to tap the cone and sleeve loose and a piece of bent wire to extract them.

Removing stud bolts, Petzl Longlifes and glueins is a pain. Use a hammer, chisel or hacksaw to cut or break the portion of the bolt that protrudes from the rock. With a drill bit, counter-sink the remaining material deep enough to fill it with epoxy and rock dust. The hole will no longer be usable for another bolt.

Always use as much care and thought when replacing an anchor as you would when installing a new one. For tips on replacement, see "Bolts: Bomber or Time-Bomb?" in issue #62 of *Rock & Ice*.

David Prall has a PhD in mechanical engineering. He has placed or replaced more than 500 fixed anchors in the U.S. and Europe.

Wear of Titanium Brake Bars

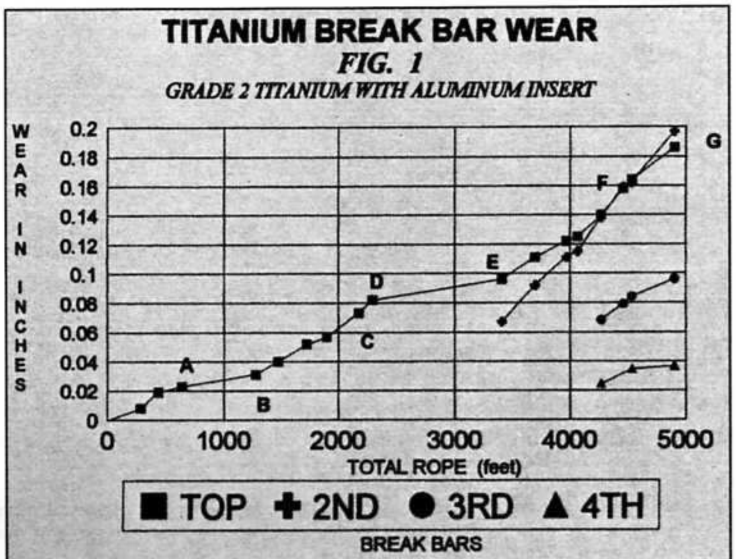
by Ron Simmons
NSS # 16894FL

After the Pendleton, Oregon convention I purchased one of the Howell N Man titanium racks. The rack that I bought was the five bar mini rack. It is as light and small as the Petzl Bobbin that I was using up until then for short drops. I didn't want to carry a rack because of the bulk and weight but after buying the titanium mini rack I started using a rack for all my vertical work both small and large drops. After getting the rack I thought that it would be interesting to measure the wear on the bars from new until they wore through. So I kept track of the rope footage going through the rack and used a micrometer to measure the wear.

The bars that I measured the wear on were made of grade 2 titanium with press fitted aluminum inserts. Table 1 gives the measurements that I made. The numbers are plotted out on fig. 1. The following discussion refers to letters shown on fig. 1 and table 1. Originally I only measured the wear on the top bar but later started measuring the wear on the other bars. First of all let me say that most of the rope going through my rack would be considered very dirty and abrasive. My normal caving area in Virginia and West Virginia has many short drops and lots of mud. This set of bars saw two trips to TAG. You can see that the slope levels out quite a bit when clean rope is run over the bars. These would be the sections from A to B and from D to E. The top bar wore through the Titanium at point C. The aluminum insert was now exposed but since there were no sharp edges I keep using the bar. A word of caution here. When the outer layer of titanium is worn through it is important to check for sharp edges. If there is even the smallest gap between the titanium and the aluminum a knife edge will result. The aluminum insert worn through at point G on the graph after 4902' of rope and a removal of .186" of metal from the bar. Another interesting item was along section F. The second brake bar started wearing faster than the top bar. In fact when the 1st bar wore all the way through the 2nd bar had more wear than the 1st.

I don't know that this information shows any new and startling facts but I thought that it was interesting to look at. This is the only time that I have ever measured the wear of a brake bar so closely. It would be interesting to have a set of numbers for stainless steel bars and aluminum but my impression is that the grade 2 titanium bars are comparable to steel bars and much better than aluminum. The newer grade 4 and 6 titanium bars which are harder will of course last much longer than the grade 2.

As far as I am concerned, the main advantage of the titanium rack is it's light weight. I find the life of the bars acceptable for the reduction in weight. Of course one could always just use the titanium rack frame and use cheaper break bars. As for me I think that I've found the rappel device I'll be using the rest of my caving career.



TITANIUM BREAK BAR WEAR

TOTAL WEAR (inch)

	TOTAL ROPE (feet)	1ST BAR	2ND BAR	3RD BAR	4TH BAR
	285	.008			
	435	.019			
A	635	.023			
B	1276	.031			
	1471	.040			
	1721	.052			
	1896	.057			
C	2176	.073			
D	2291	.082			
E	3402	.096	.067		
	3692	.111	.092		
	3967	.122	.111		
	4067	.125	.115		
	4267	.140	.138	.068	.025
F	4457	.158	.159	.079	
	4532	.164	.162	.084	.035
G	4902	.186	.197	.096	.037

NOTES:
1) Break bars used were Howell-N -Mann grade 2 titanium with aluminum inserts.
2) Almost all rope used was 10 to 11.5 mm PMI and very dirty.
A) Beginning TAG trip, used clean rope.
B) End of Tag trip.
C) Rope wore through titanium on 1st bar.
D) Beginning TAG trip, used clean rope.
E) End TAG trip.
F) Wear on 2nd bar starts to overtake wear on 1st bar.
G) Hole 1/32" in dia. wore through aluminum insert in 1st bar. Hole 1/8" in dia. wore through aluminum insert in 2nd bar.

(Table 1)

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Harrison, TN 37341
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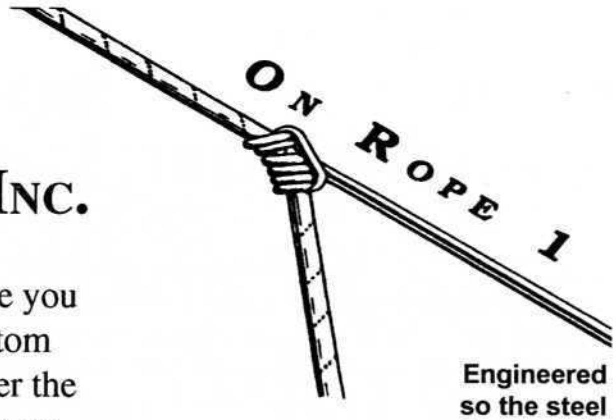
423-344-9089 Fax

On Rope 1, Inc.



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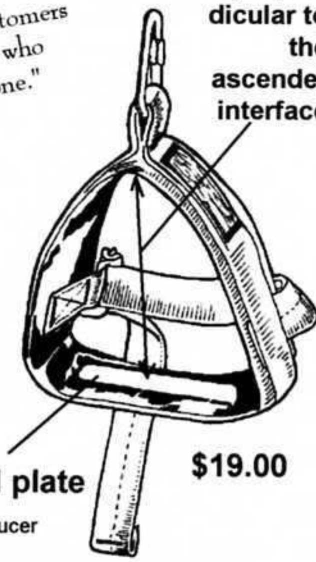

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3 colors of 9/16" tubular webbing	.25 ft.
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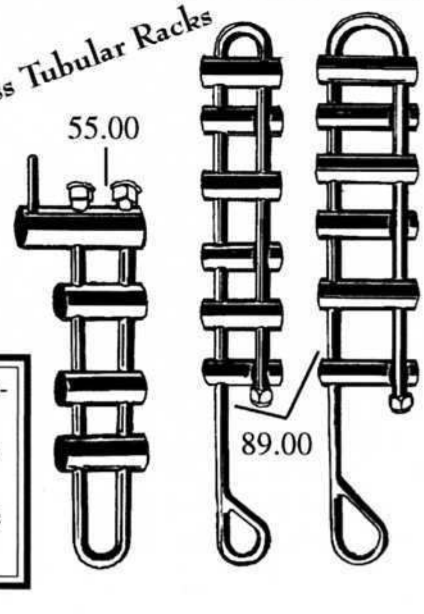

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EQUIPMENT
WORKING FOR THE CLAMPDOWN

by Duane Raleigh

Reprinted with permission from Climbing No. 140, October/November 1993

Hollywood likes to present climbers as seminal Gabe Walkers who slap — solo — for icy slopers, hand-over hand up ropes, and, in the end, win the girls. Call us pantywaists, but who among us is fool enough to lunge — rope or no — for a snowed-up hold? And, to the further disappointment of the misinformed hordes, climbers know that skiers get the girls. Maybe it's because us weaklings need ascenders to scale ropes.

We at *Climbing* can't offer advice on landing a mate — ask Dr. Ruth or Sly for that — but if you're in the market for a pair of ascenders and don't know a Jumar from a Clog, step into our office. Over the course of several years we used every full-size, handled ascender on ropes strung from Mount Huntington to the Kingfisher.

Among other things, we learned that while every model performs well for several tasks, none is ideal for all situations. For example, the Petzl Ascender works like a champ for motoring up straight shots of fixed rope and hauling bags, and grips an icy rope like a dog on a ham bone. The cam-release on the Petzl, though, is tough to manipulate, making it a poor choice for cleaning aid pitches, where you can remove and reset the top ascender up to 50 times on a single pitch. In comparison, you can whip a Jumar off and back on the rope faster than Verm can snap another picture of himself, but then Jumars slip on icy ropes. The solution is to home in on your priorities — big walls, mountaineering, glacier travel — and buy accordingly. (Our recommendations pertain to standard climbing situations only; they do not apply to rescue, industrial, or other types of work, where strength need and features required are much different.)

Price

$25 separate the least expensive ascenders, the Petzls, from the highest priced ones, the Jumars. Sure, that price difference can represent a day's take-home, but you are still wiser to cough up the extra dough and get what you really need.

Rope Compatibility

All the ascenders we tried grip 9- to 11-mm climbing ropes. the Petzl and Clog ascenders also latch onto 8-mm ropes, a common size for fixing on mountains, and the Jumar works on ropes as skimpy as 6-mm, just in case you're brave enough to trust that twine. But beware, merely because ascenders work on small-diameter ropes doesn't mean you're safe. These size ropes not only cut easier, but are more prone to slip through the gap between the ascender cam and frame, a real and deadly treat when the rope runs diagonally or horizontally. This danger is most pronounced with the Kong Modular, which shockingly, can pop off a 9-mm rope under a less-than-body-weight load. With any ascender and rope combination, stay alive by tying frequent back-up knots, and on traverses and roofs, clip the ascender frame to the rope.

Strength and Durability

Not even King Kong Bundy could break any ascender using his body weight alone, but it still pays to be cautious. (In the worst case an ascender should have to hold you, your partner, and the haul bags, or about 500 pounds.)

As an extra measure you might think to look for UIAA approval. Don't kid yourself. The UIAA tests are so mild (in a nutshell, an ascender has to withstand an 880-pound static load five times on each rope without damage) that approval can mislead you into thinking you've bought a safe product.

The UIAA-approved Kong Modular, for instance, is the most dangerous piece of gear we've seen — its cam safety can release unexpectedly (we just avoided a serious mishap while testing this model), or it locks down so tight you have to tap it with a hammer to make it open. We were stunned that such a frightening product could get UIAA approval. (Since our test, Advanced Base Camp, Kong's U.S. distributor, has recalled this ascender.)

The Petzl ascender is also UIAA approved. None of the other manufacturers bother submitting their ascenders for testing, although all would pass.

Most manufacturers list ascender strength in terms of frame strength (see chart), a poor reality check. A few companies also list a much lower number, the one that tells how much load an ascender will bear before its toothed cam tears the rope. Ascender strength on a rope; however, varies wildly depending on the rope, brand and its condition. As a rough gauge, *Climbing* tested each ascender on a new 9-mm rope. All held 1,000 pounds without damage to the rope or ascender itself. At 1,100 pounds the incisored Petzl ripped the sheath, and all other models soon followed suit with none holding over 1,800 pounds.

Petzl does go one step further and subjects their ascender to dynamic tests, including factor one falls on 10- and 11-mm ropes. Impressively, their ascender holds although rope damage is severe. The test shows that the ascender is made of strong stuff, but don't misconstrue it to mean that you can use the Petzl as a self belay.

Another point worth noting is whether the ascenders are pretested at the factor for defects. The chart lists models that are.

Finally, long-term dependability is an issue, but once again all the ascenders we've used are about equal and you'll have a hard time even wearing out any pair. The exception might be the Jumars, which have some-what fragile cast-aluminum frames (all others use more resilient stamped or extruded aluminum) that could crack under a misguided hammer blow. Just in case, rig Jumars with a back-up sling threaded through the top ascender eye and the clip-in loop. Also, discard any ascender that's been dropped, begins to slip on a dry rope, or shows any sign of wear or damage including cracks, loose rivets, or, more likely, weakened springs.

Function

It boils down to this: can the ascender do what you need it to?

Mountaineers want an ascender that holds on an icy rope, is easy to operate with a gloved or mitted hand, and is compatible with standard 8- to 9-mm fixed ropes. The Jumar and CMI ascenders grip icy ropes about as well as bald tires do a slick road, so forget them. The Clog and Petzl models fit the whole bill, but overall our testers preferred the Clog, stating that it was the easiest to get off and on the rope, and its shorter cam teeth don't snag the rope. A small inconvenience to the Clog is its lack of a bottom clip-in hole, an oversight that necessitates slinging the handle with webbing.

The needs for glacier travel are similar to mountaineering, but because here you'll manipulate the ascenders less than if you were actually climbing, operational ease isn't as important, and any of the two previous models work fine.

As stated earlier you can remove an ascender dozens of times when cleaning an aid pitch, so for big-wall climbing a model that is easy to operate with one hand is preferred to one that tests your finger dexterity. And because you'll end up yarding on the ascenders more than you'd like, handle-grip comfort is a priority as well.

The venerable Jumar is far and away the easiest ascender to operate, making it the big-wall standard. The Jumar's handle is a bit uncomfortable, a situation you can remedy by wrapping the bottom of the handle with a generous pad of cloth tape. The Clog ascender is another popular wall ascender. Its advantages are that it is initially more comfortable than the Jumar and latches onto icy ropes, a real attribute in case you encounter winter conditions. The Clog's disadvantage is that its trigger is harder to manipulate, although most climbers develop a knack for it.

CMI's Ultra Ascender is similar to the Jumar, but has a sturdier frame- a feature that alone makes it worth big-wall consideration — and a comfortable molded grip. Its drawbacks are a knurled safety trigger that can rub your thumbs raw, and when you take the ascender off, the cam, by design, catches on the underside of the trigger, an annoying trait.

Serious big-wall enthusiasts will want to avoid the Petzl ascenders. These work well in the mountains, but their fang-like cam teeth make down-jugging difficult, and snag the rope if you don't swing the cam fully open when removing the ascender, something you're bound to do.

Warning

There are a lot of ways to buy it, and using an ascender as a self belay on a fixed top rope is one of the most sure fire. Excluding Petzl, none of the manufactures covered in this review recommend using their ascenders for any sort of self-belaying. The Petzl catalog gives their ascender a "good" rating for self belaying on a fixed rope. We, however, would never dare use it that way. Instead, we would opt for a real solo device, like the Rock Exotica Soloist (review in *Climbing* , #131), or dredge up a partner.

Getting a Handle on It (Handleless ascenders)

Wall and alpine climbers need handleless ascenders like they need handleless hammers or ice tools. Those uses aside, these succinct ascenders do offer advantages in some situations, like slogging up endless fixed ropes on a mountainside and crevasse self rescue.

The spring-loaded Gibbs, a popular model among cavers, and the Rock Exotica Microscender are the top two handleless ascenders, and both grip on icy ropes, a big plus on the mountain. But their best feature is their on-rope security. You have to take the units apart and reassemble them around the rope (a two-handed procedure), making the risk of having the rope pop free virtually nil — a feature you'll praise while slogging up a thousand feet of fixed rope strung along a snowfield.

Another hot selling point, but one of less real concern, are the Gibbs' and Microscender's cam design. Both ascenders use ribbed cams that squeeze the rope for purchase, rather than bite into it as do standard toothed cams. Until you fall, the difference between cams means little or nothing. But should a stone crack you on the head and you slip and shock load the fixed rope, the ribbed cam is less likely to skin the sheath off, making you more likely to stay alive.

The Microscender only weighs five ounces, but is expensive at $60. Rock Exotica also makes a larger version, the Rescuscender for the same price. The Gibbs are less expensive at around $36 apiece.

EDITOR'S NOTE

by Geary Schindel

Use of a Handled Ascender as a Safety

Duane Raleigh brings up an interesting point regarding the use of handled ascenders for top rope belaying. Cavers commonly use a handled ascender for self belaying with a fixed rope around lips, on cable ladders and when "rock climbing" in caves. This practice should be done with extreme caution (whenever a factor one fall can occur).

Deicing Jumars

Duane's comments on the use of Jumars on icy ropes brings back fond memories of a mid 70s January trip to Crookshank Pit (105 feet) in Friar's Hole, West Virginia. Tom Vines, Mike Kedda, Doug Jacoby, Dave Gambrill and myself decided to drop the open air pit. The surface stream entering the drop was a little higher then usual; temperatures were in the mid 20s and dropping. We rigged the pit and explored the cave for a couple of hours. Returning to the rope at dark, we found it frozen to the rock. The temperature had dropped to just above zero and water was swirling down the pit. Mike, Tom, and Doug had rope walker systems and managed to break the rope loose from the rock and slug up it. Tom ended up with a good case of frostbite on one of his fingers. Dave was relatively inexperienced and didn't know enough to be scared; so he had no real problems. Somehow I go stuck being last. I pulled out the old Mitchell System and started up. About 50 feet off the floor, both of my two Jumars slid about 2

(Continued on page 12)

(Continued from page 11)

feet down the rope before they grabbed. I pulled out my safety ascender and clipped it onto the rope. It held. I then slid one of my Jumars up and found it wouldn't grip the rope. I removed it from the rope and found that the teeth were completely covered with ice. (Note, this is where it helps to have nerves of steel i.e., I surprisingly still had some spit in my mouth after the 2 foot slide). Figuring I needed to defrost the cam and quick, I put it in my mouth. This was like putting your tongue on a sled runner on a cold winter day, not real pleasant. However, it did defrost the cam and I no longer have a problem with hair growing on my tongue. I placed the Jumar back on the rope and found it held. I then removed the second cam and also defrosted it and placed it back on the rope. However, when I went to slide the first Jumar up the rope, it again iced up. I found that I had to defrost each cam every time I needed to move it. Needless to say, it was a long climb that night. On a good note, necessity IS the mother of invention and I'm thinking about applying for a patent on this technique.

Ascender Comparison Chart

Model	Price (pair)	Rope Diameter	Strength (frame)	Comfort	Ease of Operation	Works on Ice Rope	Comments
Clog Expedition	$95	8-11 mm	1500 lbs.	A	B	✓	Suitable for Mountainering glacier travel, and big walls; large handle and molded grip is comfortable and accepts mittens; awkward trigger; no bottom clip in hole.
CMI Ultra	$99	9-12 mm	5,000 lbs.	B	B		Suitable for big walls; knurled trigger rubs thumb; hold open feature on cam is a hassle.
Jumar	$115	6-14 mm	1,800 lbs.	C	A		Suitable for big walls; easiest ascender to operate; pre-tested; grip requires padding; cast aluminum frame requres webbing back up.
Petzl	$90	8-13 mm	4,400 lbs.	A	C	✓	Suitable for mountaineering and glacier travel; large handle and molded grip is comfortable and accepts mittens; UIAA approved; pre-tested; tiring to remove from rope; cam teeth can snag rope; difficult to downclimb with.

Rope Hypocrisy

.... *continued from page 23*

been exposed to acid. The rope had been transported in a large unprotected coil in a van during the trip. The van was reportedly used to transport a car battery some weeks before the trip. However, the acid source could not positively be identified. Maybe the acid source was a caver's wheat lamp. We'll never know.

2) While looking for a friend at a recent SERA, I walked over to the area where he was camping and thought I found his car. I looked in the car to see if it was his, and saw a caving rope on the back seat with a pair of jumper cables on top of it. It turned out that it wasn't my friends car but he knew who's it was. When the issue of the jumper cables came up later, the caver said they were new and hadn't been used. Was he trying to save face or was he being honest. Are you willing to bet your life on it. The caver was a member of a long standing grotto at a large Virginia University. He should have known better.

Single Rope Buyers Guide

.... *continued from page 21*

inside the core that states the year of manufacture.

Rivory Joanny

With nearly 50 years of experience building dynamic ropes, this French company has a good reputation for durable products. The only other company that makes a braided core (Climb Axe is the other), Rivory Joanny chose not to switch to twisted cores because their ropes were holding up well to gym use. The sheath fibers' low twist rate allows the ropes to fuzz more quickly, yet they wear well and have a good hand.

Sterling

Sterling ropes all have a good hand and, for the most part, tested reasonably well. The exception was their Dynamic Gym rope, which had sheath problems (severe slippage in the gym and premature failure during drop tests). Features such as water-resistant cores and whipped ends are nice.

Buyers Guide

Advanced Base Camp 503-685-9600
Beal (Climb High) 802-985-5056
Black Diamond 801-278-5533
BlueWater 800-533-7673
Climb Axe 360-734-8433
Climb High 802-985-5056
Cousin 303-581 -9177
Edelweiss (Bergsport) 303-939-9665
Mammut (Climb High) 802-985-5056
Mammut (Metolius) 503-382-7585
Marlow 303-384-9148
New England Ropes 508-678-8200
PMI 706-764-1437
Rivory Joanny (Trango) 303-443-8438
SMC 206-883-0334
Sterling 508-921 -5500

Clyde Soles is products editor for Rock & Ice. His e-mail address is Clyde_Soles@nile.com.

Many thanks to BlueWater for the use of their testing facilities and to Dent Nelson, rope breaker, who climbed up and down a 30-foot ladder 1,000 times for this article.

Single-Rope Buyers Guide

Everything you always wanted to know about ropes but didn't know to ask

Article and Photos by Clyde Soles

Reprinted with Permission fromRock and Ice Magazine, Vol. 117, No. 68

FAAAALLIIIING!

The 1.6 seconds it takes you to fall 40 feet is not the time to be wondering whether or not your rope will hold. In another 1.6 seconds, you could fall an additional 130 feet and be traveling 70 miles per hour. And knowing that you'll top out at 155 miles per hour-terminal velocity-is, somehow, not very reassuring.

No other piece of equipment is more important to climbers than the skinny nylon line that separates us from eternity. Yet of all the toys on which our lives depend, climbing ropes are probably the least understood. Many climbers have only a vague concept of the testing process for ropes and therefore don't understand what those numbers on the hangtags actually mean. To complicate matters, rope manufacturers use differing terms that confuse the issue even more. Fourteen brands and more than 45 models of single dynamic ropes are currently on the US market, and that's not including models available in both standard and dry versions or indoor-gym ropes. When you walk into a store that has more than 100 ropes on display, how do you decide which is best for you?

That question is more complicated than I originally anticipated. First, the big disclaimer-this is not a rope review. The tests we conducted were on one sample of each model and are thus not statistically valid; tests should not be interpreted as contradicting manufacturers' claims. Please read this entire article, and take the chart with a large grain of salt.

History

Mountaineers have been tying themselves together with ropes for security on climbs since the mid- 1800s. These ropes were made from natural fibers-usually hemp, manila or sisal-bundled into three or four strands and twisted or laid around one another (hence the term "laid" construction). A less-common construction method was a "solid," as opposed to "tubular," braid that offered better handling at the expense of poor abrasion resistance. During the first half of this century, almost all climbing ropes came from the marine industry, as did knots and terms such as "belay."

Not only were these old ropes relatively weak, but they had little stretch-and the standard practice at the time was to use a static belay. At the alpine museum in Zermatt, I was scared just looking at the thin [approximately 7-millimeter), braided rope used by the ill-fated Whymper party on the first ascent of the Matterhorn. Little wonder that the creed of the day was, "The leader must not fall!"

It was not until the '30s that the Sierra Club introduced the dynamic belay. By allowing controlled slippage of the rope through the belayer's gloved hands, impact forces were considerably reduced. This radical development heralded the age of modern rock climbing; climbers could take falls with a reasonable chance of survival.

With the onset of World War II, natural fibers were in short supply, and DuPont introduced ropes made of a polyamide synthetic fiber called Nylon™. This laid-construction nylon rope was lightweight and very strong and it stretched a great deal to absorb the impact of a fall. One brand, Goldline (or Mountainline), became the standard climbing rope for generations.

The twisted construction was not without fault however. While dangling in mid-air, the climber would spin nauseatingly as the rope untwisted and the ropes were excessively stretchy for jumaring. Although a Goldline had no hidden core and thus could easily be inspected for major damage, once the rope became fuzzed from abrasion, it had already lost significant strength. Furthermore, Goldlines were stiff, handled poorly, created excessive rope drag, absorbed water quickly and tended to freeze easily.

In 1951, Edelrid introduced the first kernmantle climbing rope, which featured an inner, load-bearing core (kern) protected by an outer sheath (mantle). These ropes solved most of the problems associated with laid ropes and eventually became the industry standard. Kernmantles are the only ropes certified by the Union Internationale des Associations d'Alpinisme (UIAA).

Since then, ropes have undergone many minor enhancements in handling, strength and durability. In 1966, the first ropes with a water-repellent treatment were introduced (again by Edelrid). Other innovative attempts-a rope with a plastic sheath between the core and sheath, a rope that was thicker on the ends than in the middle, and a rope with a radio cable inside-have come into the market, yet no major improvements have occurred in the past 40 years.

Manufacturing Process

Today, all climbing ropes are built from essentially the same materials and in the same way. That's not to say they're all alike; large differences exist among the final products. How the rope is put together and how it is finished determine its characteristics.

Although both nylon 6 and nylon 6,6 are available, only the former is used for climbing ropes. No other material has yet been developed that combines the necessary qualities of toughness and elasticity. There are numerous suppliers of raw nylon fibers throughout the world; each has its own manufacturing and treatment

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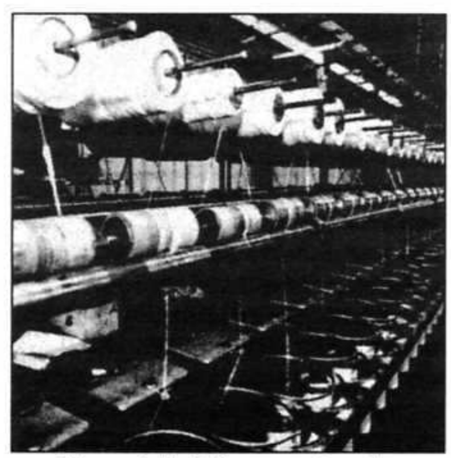

Figure 1: Twisting core strands.

(Continued from page 13)

process.

The energy absorption of a dynamic rope comes mostly from its core. Although nylon is somewhat elastic, the material alone cannot absorb the full force of a hard fall. Therefore, the core's fibers are twisted or braided; straightening under load absorbs energy by converting it into heat. When a rope finally fails in a UIAA drop test, many of the core strands melt.

For both the sheath and the core, individual nylon fibers are collected into bundles and twisted into a "ply" of yarn (figure 1). Half the plies are produced with a clockwise Z-twist; the rest are produced with a counter-clockwise S-twist.

Next, the yarns are Z- or S- twisted into a strand. The number of twists per meter significantly affects how much the rope can stretch to absorb a fall; it also

Figure 2: Braided core.

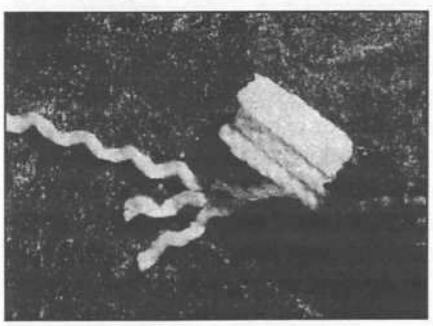

Figure 3: Twisted core. (Notice the S and Z twists in the strands.)

affects elongation under body weight. Manufacturers can also vary the thickness of the plies, the number of plies per strand and the number of strands within the core, depending upon the results they're trying to achieve. Twisting machinery is expensive, so some rope companies purchase pretwisted core materials.

Braiding and twisting are the two basic methods of making a dynamic rope's core. Braided cores (Figure 2) are made by plaiting relatively thick strands into either a single, thick bundle or three smaller bundles. These cores require more machine time to produce than twisted cores. Braided-core ropes have somewhat higher impact forces than twisted-core ropes when new, but impact forces do not go up as quickly with successive falls. Braided-core ropes are also less prone to sheath slippage than twisted ropes.

To reduce production costs and, some argue, to increase strength, almost all manufacturers now use a twisted-core (cable-core) construction, in which from 6 to 14 strands are bundled and run parallel to one another for the length of the rope (figure 3). With the proper balance of S- and Z-twist strands, the rope will be neutral (no tendency to spin and kink) and easy to handle (figure 4).

Although much of a rope's strength and shock absorption come from the core, the majority of its handling characteristics and durability comes from the sheath. As in the core, the sheathes plies and strands must be twisted. Rope companies can reduce costs by only using Z-twists; sheaths made this way wear out quickly from the rope running across rock edges (figure 5).

The type of braider a company uses also plays a part in the sheath's thickness and feel. The more bobbins the machine carries, the smoother the finish can be. Today's standard for single dynamic ropes is a 48-carrier machine (figure 6), though some are made on 32-, 36-, 40- or 44-carrier braiders.

These machines can weave different patterns, named according to the number of times the bundles go over one another. A "2-over-2" sheath is most common, but 2-over-l" and "1-over-l" patterns are also used (figures 7 and 8). Depending on the pattern, the rope has either a single- or doublepic sheath (a "pic" is an exposed bundle of fibers). Single-pic sheaths are smoother, for reduced friction and a nice hand, and generally are used on narrower-diameter ropes. Double-pic sheaths are used on ropes in which durability is a greater concern.

The amount of tension during the braiding process greatly affects the handling characteristics and durability of the sheath as well. A loose sheath makes the rope very supple, giving a nice hand,but the rope flattens in use and lacks durability. A very tightly woven sheath exhibits minimal slippage and helps keep dirt and water out, yet it tends to be stiff and difficult to handle. The trend toward very soft ropes, popular a few years ago, seems to have swung back toward stiffer ropes that wear better. One design, the Program ropes by Beal and PMI, is made on a special, variable-speed braider that forms a rope that's soft and firm in different areas.

Raw nylon is white, so fibers that will be used for the sheath are typically sent away for the application of a surface dye, a process in which strict quality control is vital. Cheaper ropes may have sheaths made from nylon that has been dyed prior to extrusion; this method can weaken chemical bonds and slightly reduce strength.

At some point during the manufacturing process, the nylon in a rope must

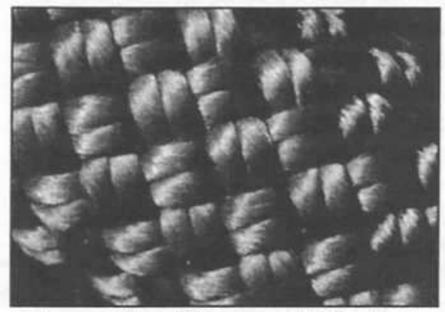

Figure 4: S and Z twists. (All the fibers are parallel or almost parallel to the rope.)

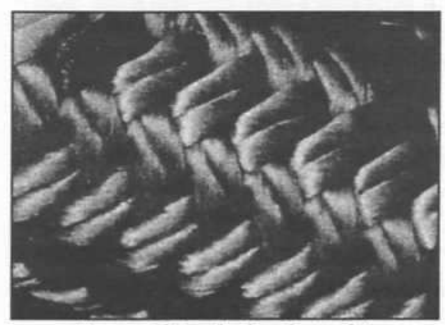

Figure 5: Look closely at this Z-twist-only sheath. (The fibers in half the strands run perpendicular to the rope.)

be stabilized with steam or dry heat.

Sheath fibers are subjected to high temperatures, and thus shrunk, when they are dyed; core fibers are usually not heated. Manufacturers must ensure that the sheath and the core have equal stretch characteristics; how each company accomplishes this is a secret held closer

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Physics of Falling

Probably one of the most confusing issues for those of us who are mathematically impaired are the actual forces involved in a fall. The concept is easy: The fall factor is merely the ratio between the length of a fall and the amount of rope available to absorb it.

The UIAA drop test is based on a theoretical, worst-case scenario-a hard fall on a short piece of rope with a static anchor. In real climbing, a number of factors help mitigate the force: These include slip through the belay device and an upward pull on the belayer's pliable body.

The term "impact force" gets thrown around a lot, but, without clarification, it has no meaning. When referring to dynamic ropes, the impact force most commonly discussed (and measured by the UIAA) is that sustained by the climber. The belayer, however, sustains an impact force as well, but it is reduced by friction in the system.

Assuming one piece of protection has been placed prior to the fall, the force on the belayer will be much less than the force on the climber. Testing has shown that the friction on a rope making a 180-degree bend over a carabiner "edge" creates an average tension ratio of only 52 percent. (The belayer feels half the impact force the climber does.) This is why a light person can hold a heavy climber on a toprope.

As always, however, there's a catch, When the leader climbs upward, clipping more points of protection, friction develops in the system. This friction reduces the efficient length of rope that absorbs the shock, because the entire length of rope that's out is no longer taking the full force of the fall. The section of rope between the falling leader and the highest protection point will feel a disproportionate share of the impact. For example, if you are 100 feet out and fall 20 feet, the (theoretical) frictionless fall factor would be .20; the actual fall factor is .58.

As mentioned earlier, UIAA uses an 80-kilogram (176 pound) weight to determine forces in its test drop-the weight of the "average" climber. But what about everyone else? The maximum impact force felt is proportional to the square root of the climber's weight. All other factors being equal, a computer model shows that, during a fall with a factor of .5 onto 20 meters of rope, a 60-kilogram (132 pound) climber will feel about 3.4 kiloNewtons, an 80-kilogram climber will feel 4 kiloNewtons and a 100-kilogram (220-pound) climber will feel 4.5 kiloNewtons. On the same length of rope, if the climber takes a screamer with a fall factor of 1.5, the 60-kilogram leader will feel 5.4 kiloNewtons, the 80-kilogram leader will feel 6.2 kiloNewtons, and the big boy will pack a wallop of 7 kiloNewtons.

The type of belay device you use also has a significant effect on impact forces. Tests have shown that a figure eight device (used in the rappel configuration, not the dangerous "sport mode") creates about 1.5 kiloNewtons of braking force, giving a very soft catch. Slot-type devices (Sticht plates, ATCs, Pyramids and some figure-eights made for belaying through the small hole) can resist loads of about 2 kiloNewtons while the Munter hitch (in its open configuration) holds about 3 kiloNewtons.

With any of these belays, falls with impact loads below this threshold will be caught statically. As the load on the device increases, slipping occurs (possibly burning the belayer's hands), making the belay dynamic. However, if a Grigri (which slips at about 9 kiloNewtons) is used, the belay is essentially static even at high loads. This can increase the chances of gear ripping out. In any case, attaching the belay device to your harness, rather than to an anchor, dampens the impact load on both the climber and anchors.

One test showed that forces are reduced from 15 to 30 percent, due to the belyaer being pulled forward or even lifted into the air.

There is a wide-spread notion that the solid block used for testing generates more force on the rope than a human body would, supposedly because of the dynamics of the harness and bag of water (i.e. person). Recent tests by the Italian Alpine Club have shown that a climber only absorbs about 66 pounds of force during a factor-1 fall of up to 13 feet.

One serious consequence of rope stretch during short falls right off the ground is the high potential of decking. To prevent a ground fall when the leader slips while about to make the next clip, use the following guidelines: If the first anchor is 13 feet off the ground, the next cannot be more than 4.2 feet above that and the third no more than 7.2 feet about the second. If the first anchor is 16 feet above the ground, the next cannot be more than 6.2 feet above that and the third no more than 9.8 feet above the second.

Clyde Soles

(Continued from page 14)

than the recipe for Coca-Cola.

Dry Treatments

As many climbers have discovered, nylon is very hygroscopic, which means it readily absorbs water from the air-not to mention in its liquid form. Wet ropes are not only heavy, but they also lose about 30 percent of their strength and ability to absorb impacts. They stretch more, are less abrasion-resistant and can freeze into solid, unmanageable cables

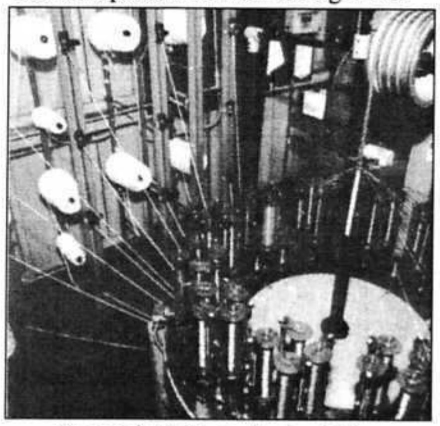

Figure 6: A 48-carrier braiding machine.

The Holy Grail of rope companies is to find a treatment that makes ropes hydrophobic, increases abrasion resistance, never wears off and cost pennies to apply. They are still looking, although the situation has improved markedly in the past five years.

Manufacturers can apply dry treatments to individual fibers prior to rope production; however, much of this wears off during the twisting and braiding processes. Many ropes made just a few years ago were treated with paraffin-based compounds-yeah, wax-that quickly wore off, turning the rope and our hands black with dirt and aluminum oxide from carabiners. Silicone treatments are cheap, but they don't last, either.

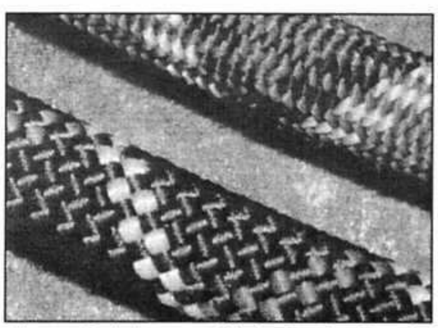

Figure 7: A "2-over-1" single-pie sheath (top) and a "1-over-l" single-pie sheath (bottom).

Considering that no modern rope in good condition has ever failed in the field, without being cut, UIAA testing has been very effective.

The current consensus holds that impregnating the entire rope with a fluoropolymer-based solution, which bonds to the fibers rather than coating them, gives the best protection and durability. In essence, the manufacturer submerges the rope in a tub until the trapped air stops bubbling, then removes it and dries it. Each company has its own special soup and is loathe to reveal it.

Every now and then, someone, shouts "Eureka!" and describes how their new treatment is best. The reality is that no industry standard exists for comparison, and none of the tests I've seen translates even remotely to the real world. Floating new ropes in water and observing how fast they sink-or soaking them to see how much water they take up- is bogus.

Several companies claim their dry treatments increase rope life by reducing friction over rock and through carabiners. This may be true at first, but surface treatments abrade off relatively quickly. It's doubtful you'll get an extra 20 percent of rope life, which is about how much extra you pay for dry treatment.

Ultimately, you should choose a rope for its other characteristics, then decide whether you need a dry treatment. Crag rats should probably save their money; alpine and ice climbers will find the extra dollars well-spent.

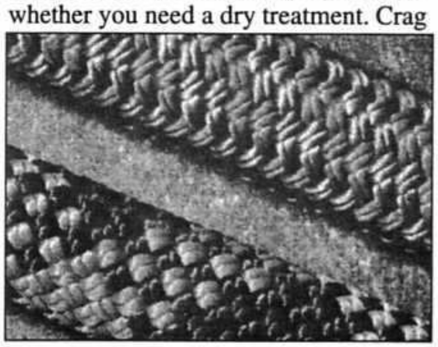

Figure 8: A"2-over-1" double-pic sheath (top) and a "2-over-2" double-pic sheath (bottom).

Many climbers want to know if they can buy an after market product to recharge a dry treatment or even to make a standard rope dry. Manufacturers are understandably reluctant to recommend any chemical treatment over which they have no control. Any type of spray-on water repellent is a waste of money; it will wear off the surface and won't penetrate to where it is most needed.

Currently, there is no recommended wash-in treatment for ropes. According to Mike Curtis of Nikwax, makers of the best waterproofing treatment on the market, their current product will not harm the rope, but they can change some characteristics (e.g., stiffness and sheath slippage). They are working on a product specifically for ropes that should be available next year.

Testing

Developed in the late '50s by Professor Dodero in France and updated several times since, UIAA standards are designed to give climbers confidence in their ropes. Considering that no modern rope in good condition has ever failed in the field--without being cut--the testing has been very effective.

UIAA standards also give a useful means for comparing ropes-if you understand the tests' limitations. What many climbers don't realize is that UIAA tests are merely performance standards, not a guarantee of quality or veracity. This means that the tests are performed on a limited sample (40 meters of each rope model, selected by the manufacturer) every two years, and the results are strictly pass/fail (except for measurement of diameter and mass). Furthermore, the rope manufacturer can choose the test lab, it may continue to resubmit samples until one passes, and it is not obligated to report results. The UIAA only certifies that the sample passed; all hangtags claims about the number of test falls held, the impact force generated, etc., are the manufacturers.

In the drop test for single ropes, an 80-kilogram (176.4- pound) weight is dropped 4.8 meters (15.7 feet) onto a 2.8-meter (8.5-foot) section of rope -a factor-1.71 fall. The rope is held statically (three wraps around a 30 millimeter bar and clamped) and passes over a

10-millimeter-radius edge, designed to approximate a carabiner, which is 30 centimeters (1 foot) from the bar (figure 10). Prior to the test, rope samples are conditioned for four days to ensure they are all the same temperature and humidity.

This is a really severe test. To pass, three samples from the same production must hold at least five consecutive falls (five minutes apart, with the weight removed from the rope within one minute); the impact force on the first drop must not exceed 12 kiloNewtons 12,698 pounds of force).

When you're looking at rope specs, the most important figure to consider is the impact force-the lower the better. A lower-impact rope means that you'll receive a softer catch, and it will be easier for the belayer to hold the fall. There will also be less force on your anchors.

During a hard fall, the typical kernmantle rope stretches 20 to 30 percent (old Goldlines stretched 40 percent or more) Stretch increases the chance of hitting ledges. At present, there is no standard to impact elongation, and no manufacturer list this figure for its ropes. Roughly, it is inversely proportional to the rope's maximum-impact force. Even though a low maximum-impact force is desirable, you don't want a rope that responds like a bungee cord.

As a rope receives repeated falls, the nylon loses elasticity. Its ability to absorb energy is diminished, and the impact forces climb. This change is most pronounced in smaller-diameter ropes. Current hangtags only list the force of impact on the first fall. To give you a better idea of the rope's energy absorbing capabilities, the chart on the following page lists the percentage increase of the impact force from the first drop to the fourth.

We also tested a few ropes after they'd been at the rock gyms for about two weeks- with sobering results. Two (a 10.5- millimeter and 11-millimeter) broke on the first fall. A 10.5 millimeter held two falls on a section near the end, but a central section that felt rather mushy held only one fall. A good section of a 10-millimeter held two falls, and an 11-millimeter held three falls. It is of interest that the ropes that held at least one fall did so with a fairly low impact force (between 6.53 and 7.0 kN). The static elongation of the 11 millimeter rope mentioned above increased from 6.4 to 7.9 percent after it had been used.The number and severity of falls endured by each of these ropes in the gyms cannot be used for any scientific comparisons.

Even though it is the only test figure currently required on hangtags, the maximum number of UIAA test falls that a given rope model can hold is provided by the manufacturer. The hang tag does not specify whether it is an average or merely the highest achieved with the given sample.

Beyond that, more is not necessarily better. All manufacturers recommend that their ropes, even "12-fall" models, be retired after one long fall.This is because the rope sustains the force for longer than it does during a UIAA test fall. The only real reason to buy a rope with a very high fall rating is if you frequent extremely long routes where retiring the rope after one long fall is not an option.

In a standard drop test, the rope survives five falls over a carabiner "edge" with a radius of 10 millimeters. If the rope runs over a 90-degree edge with a radius of .75 millimeters, virtually every rope breaks on the first drop; none survives two. In our test of a few samples, the Edelweiss Stratos passed in reasonably good shape, Black Diamond and BlueWater 1 1-millimeter ropes barely survived, and the rope with the highest mass (Sterling 10.8) failed. There is no performance standard for edge resistance, and few companies test for this although, as previously stated, the only rope failures in the field have resulted from cutting.

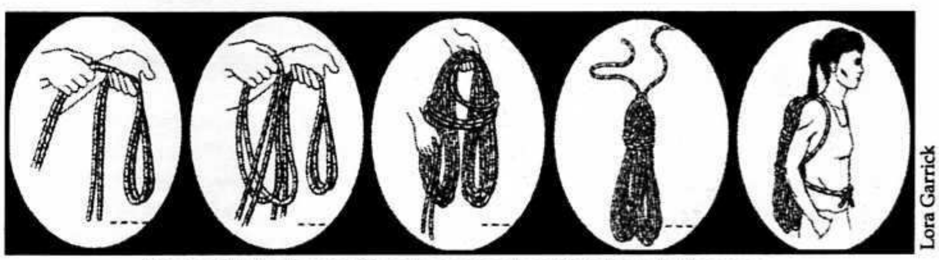

Figure 9: The butterfly coil does not put kinks into the rope.

Measuring the diameter of a rope is not as simple as it sounds, either, ropes are neither round nor constant. For single ropes, the UIAA specifies that a six foot section of rope be weighted with 22 pounds for one minute. Six measurements are then taken (two each at three points about one foot apart) and averaged.

After impact force, the most important hangtag number to compare is mass. Not only does this tell you how much the rope should weigh, but it also indicates how much nylon is in the rope. Be suspicious of a rope that claims to have a high fall rating or superb durability and low weight.

The UIAA also checks for sheath slippage by pulling six feet of rope through a squeezing device. You don't want any slippage (40 millimeters is the maximum allowed); few of us experience any in climbing situations. Unless the rope is used for an exceptional amount of jumaring, rappelling or lowering, this is a minor concern, and few manufacturers specify it.

When jumaring and rappelling, you want a rope that stretches very little. The UIAA requires that single ropes must not stretch more than 8 percent with a load of 176.4 pounds. In reality, most ropes stretch less.

Future Standards

You've heard of UIAA, but how about DIN, CEN, ASTM F-8.21, ISO9000 and PPE? All these abbreviations appear now, or will shortly, on rope hangtags. The Deutsches Institut fur Normung (DIN) is the German institute that establishes standards for all products sold in that country. DIN usually closely parallels UIAA standards, but sometimes goes beyond.

As the European Community becomes a reality, disparate regulations are being brought under the umbrella of the Comite Europeen de Normalisation (CEN). Like DIN, CEN is generally adopting existing UIAA standards for climbing equipment. However, one significant change in the most recent draft of the dynamic-rope standard is a requirement for comprehensive labels with documented and certified test data.

Currently, the ASTM is drafting new standards that will cover equipment sold

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in the US. The committee overseeing the development of performance standards for climbing equipment is called F-8.21. ASTM membership, which costs $65 per year, is open to all interested parties and includes voting privileges. Using UIAA standards as a starting point, the ASTM is our best opportunity to improve upon gear design and testing requirements. Call 215-299-5400 for more information.

ISO 9000 is a series of standards that relate to the quality-control systems of every company in the world. Base level certification is 9003, which ensures a reliable system for final inspection and testing of products. The 9002 level covers quality control during production as well. The highest level is 9001, which means there is documentation for every business aspect from design to management to customer service. To achieve ISO certification is an expensive, time-consuming process -companies who commit to this should be commended and supported.

The Personal Protective Equipment (PPE) directive of the European Community requires that work products meet performance and quality guidelines. Last summer, they decided that climbing equipment falls under the strictest category (group 3). For the most part, if a company wants to sell a product in Europe, its designs and products must be certified by authorized test centers, and the company must submit to an annual quality audit (unless it is ISO 9003 or higher). Considering the financial clout of the EC, this will affect products made in the US as well.

Rope Characteristics

Discussing rope characteristics (handling, durability and resistance to kinking) is like talking about modern art: Everybody has an opinion, nobody can agree, and everyone is right.

The handling and feel of a rope can change considerably with use. Ideally, the rope should be very soft and supple, so it runs easily through carabiners and is easy to knot. Yet such a rope will wear out more quickly than a stiffer one. Very stiff ropes are more durable, but they create greater rope drag on meandering pitches and are harder to coil.

After experimenting with each extreme, most manufacturers have settled on a moderately stiff rope that loosens up a bit with use (assuming you keep it clean).

One useful measure of stiffness is the UIAA knotability test, where an overhand knot is tied in a rope that is then weighted with 22 pounds for one minute. The weight is reduced to 2.2 pounds, and the inside diameter of the knot is measured with a conical taper. The test is performed with the knot tied in both S and Z configurations, and the numbers are averaged and divided by the diameter of the rope. Although this is a pass/fail test (the ratio must be less than 1.1), we reported the figures in the chart. The lower the number, the more supple the rope. Bear in mind, however-this number is for a new rope.

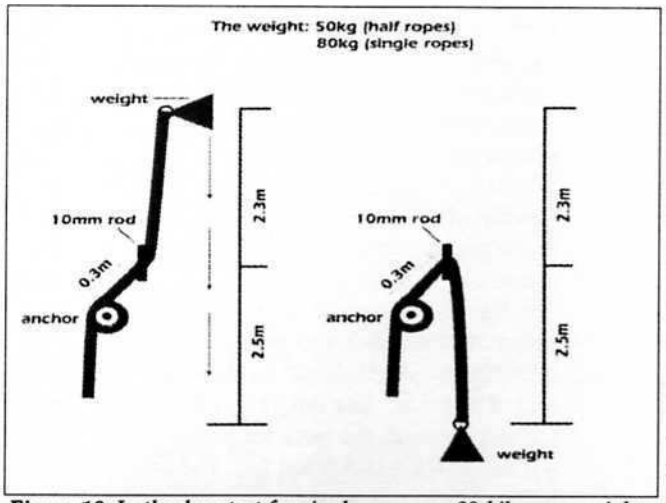

Figure 10: In the drop test for single ropes, an 80-kilogram weight is dropped 4.8 meters ont a 2.8 -meter section of rope -- a factor-1.71 fall. The rope is held statically and passes over a 10-millimeter-radius edge, designed to approximate a carabiner, which is 30 3centimeters from the bar.

The big question about any rope remains, How durable is it? At first glance, a test of abrasion resistance would seem to answer the question. However, there is no consensus on how to design an abrasion test or measure the results. So far, no lab test has proven accurate for indicating how a rope wears in the field.

Sheath plies having a low twist rate tend to fuzz fairly quickly. The low twist rate means that individual yarns only reach the surface every few inches,as opposed to every quarter inch on ropes with a high twist rate. When cut by abrasion, the shorter strands are shed (that pile of fluff you see after a rappel); longer strands are held in place. The argument goes, and field testing confirms, that fuzz helps protect the remaining fibers from further abrasion. just because a rope fuzzes quickly doesn't mean it's less durable.

Sheath abrasion is but one of several factors that determine a rope's durability. To get a rough idea of how ropes hold up under abusive conditions, we put samples of each on the lead walls of local climbing gyms. Here they were subjected to much more falling and lowering, though less abrasion, than even the most hard-core climbers will give them in the field. This was, of course, very unscientific, but it provided interesting information.

Nearly half the ropes, including six out of eight 10-millimeter ones, were retired with blown sheaths. In all except one case, the blowout was about six and one-half feet from the end of the rope. Virtually all the ropes showed heavy wear between five and 10 feet from the ends. Sheath slippage (shrinking) was only a factor on four of the fat ropes. Basically, the skinny ropes didn't last long enough for this to be a problem.

Because of the abuse they will receive, "gym" ropes offered by several companies have a higher sheath-to-core ratio. This yields a rope that is more abrasion-resistant and has less sheath slippage. The tradeoff is that they often have high elongation (both static and impact) and relatively poor handling. Although they're great for gym owners who can't afford to replace ropes every week, gym ropes don't belong outdoors.

Your best gauges when choosing a rope remain diameter and mass-the more, the better. A fairly tight, smooth sheath will generally hold up better as well.

Few things are more aggravating than a rope that kinks. The problem isn't the rope, though; its climbers and their techniques. A rope is neutral when it comes off the sheath braider-it does not have kinks built into it. Many things we do with a rope can introduce difficult-to-remove twists into it.

The first time you use a new rope, you flake it out in a loose pile, right? Wrong! This simple act automatically puts 40 to 50 twists into it. Instead, unwind your rope end-over-end, and it will start out with no twists.

Your methods of rappelling and belaying also make a big difference in rope handling. Many people like figure-eight devices because they are smooth and easy-to-use. But did you realize they put a twist in the rope every 10 feet? In Europe, the Munter hitch is very popular for belaying, yet when used on rappel, it adds a twist every five feet.

There are two basic methods to coiling a rope: the wrong way and the right way. The wrong way is what many of us first learned; *Freedom of the Hills* calls it the "mountaineer's coil," and John Long calls it the "standing coil." Whatever you call it, this method puts twists into a rope. The better method is what *Freedom* calls the "butterfly coils" and Long calls the "mountaineer's coils" (figure 9). It's faster, easier and doesn't kink your rope. The best alternative for sport climbing and toproping is to flake the rope onto a tarp.

Rope Length

For nearly 100 years, 120 feet was the standard length for climbing ropes. In the '60s and partway through the 70s, most people used 150-foot (45-meter) ropes; climbs put up in that era often have belays spaced accordingly. Now the most common length is 165 feet (50 meters); many modern bolted routes require the extra 15 feet.

A recent trend has been toward 200-foot (60-meter) ropes. For a 1,000-meter big wall, the extra length can eliminate four or five belays, speeding things considerably. Because the ends of the rope usually get trashed first when sport climbing, you can trim several meters from each end of a 200-foot rope and still have a serviceable (but not new!) rope. Drawbacks to a 60-meter rope are a large, heavy rack at the start of each pitch and a lot of rope drag and poor communication at the pitch's end. Ropes of this length are heavy, bulky and a pain to coil.

Many climbers are surprised to find that rope lengths are approximations and that they change sometimes considerably. Because the rope is braided under tension, it shrinks after coming off the machine. The manufacturer should let it rest before cutting, then allow for continued shrinkage after that. So your 50-meter rope may actually be 52 meters when you purchase it, but, after you've climbed on the rope for a season, it may end up measuring 48 meters or less.

Prior to their going into service in the rock gyms, I measured off 100 feet of each rope. Following their retirement, I measured the ropes again and discovered shrinkage that ranged from two to seven percent.

T L C

You can maximize your rope's useful life with some care and knowledge. To start, always protect your rope from sharp edges-nothing destroys rope faster. When leading, use slings to extend protection points to reduce rope drag or edge contact. Use rope pads when toproping.

Always use at least two locking carabiners for the anchor on a toprope, both for safety and to minimize wear and tear. Make sure the carabiners are hanging below the up edge of the cliff for both rappels and topropes-even a rounded edge can do considerable damage if the weighted rope runs over it.

Some belay and rappel devices have relatively sharp bends that are not very rope-friendly. And some may have metal burrs or seams that will pick at your rope; if there are, carefully file them down. For the same reason, avoid using carabiners with a small rope-bearing thickness (less than 9 millimeters). Some ascenders, such as Jumars, have sharp teeth that are very hard on a rope's sheath.

Choose the right rope for the job-a good 10-millimeter is nice and light, but it is not going to last as long as an inexpensive 11-millimeter rope. Consider using a static rope for hauling and lugging; it will save you work and last longer. It should be obvious that you should never use your rope for towing a car, but I'll say it anyway.

According to tests by Mammut, peoples' fears of rope damage from ultraviolet light are unfounded -unless you leave your rope as a fixed line or in a window. UV exposure does degrade nylon, but the effect during normal use are minimal.

A clean rope is a happy rope . . . and the sign of a smart climber. Dirt particles work their way into the rope and slowly cut both sheath and core fibers-and decrease suppleness. Using a rope tarp can really help with cleanliness. When your rope is not in use, store it in a cool, dry place-ideally, in a rope bag.

The best way to remove dirt is with water and an inexpensive rope washer from SMC or PMI. Air dry your rope in the shade by loosely looping it around the rope washer.

If you insist on machine-washing your rope, use a front-loader on gentle cycle and cold water. (Never use a top-loading washer with a central agitator; these have been known to destroy ropes. Chain-braid the rope, and put it in a large mesh bag, pillow case or sleeping-bag storage sack.

Most manufacturers recommend that you wash with water only-avoid detergents, fabric softeners or anything that contains bleach or bleach substitutes. If you can't resist soap, try Ivory Snow or Woolite and rinse thoroughly. If your rope has a dry treatment, definitely stick to water.

The most deadly of sins is to store your rope near chemicals. Especially harmful are acids, alkalis, oxidizing agents and bleaching compounds. The scariest is battery acid-the fumes alone can destroy a rope's core with no visible effect. Pure gasoline and petroleum produce will not harm nylon, but that is not necessarily true of the additives in those products. One lab test showed that DEET, the active ingredient in many insect repellents, did not appreciably harm nylon (although it eats a hole in some plastics).

The good news for sea-cliff climbers is that salt water has no effect on nylon. Nevertheless, give your ropes a thorough fresh-water rinse after use.

Given the danger of certain chemicals to nylon, many climbers are concerned about how to mark the middle of a rope. The question is whether the solvents in permanent markers can harm the nylon. Nobody has a definite answer, but all warn to be careful. Phenol-based markers can degrade nylon. New England Ropes notes that tests by one nylon producer showed that Carter's MARKS-A-LOT, Sanford's SHARPIE and Binney & Smith's MAJIC MARKER had no effect on the material. Larry Pickard at PMI points out that the solvent used in these products can change without notice; therefore, they do not recom-

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Individual (Rope) Retirement Account

It's not the years, it's the mileage -- Indiana Jones

"When should I retire my rope ?

The best answer is, when you don't feel comfortable on it. When you're out there on the sharp end pushing your limits, hands sweating, legs shaking, with big air below you, confidence in your lifeline is essential.

Keep tabs on the condition of your rope by inspecting it each time you belay and rappel. Feel for bumps, thin spots or changes in stiffness: these indicate it has been severely stressed. Look for signs of heavy fuzzing (50 percent of the sheath fibers are cut) and puffs or bulges of white core material showing through the sheath. Any of these indicators means the rope should be retired.

Even if your rope appears to be in good shape, if it has held a long, severe fall (fall factor greater than one), there's reason for concern. Inspect the rope carefully for irregularities, and record the fall in your logbook.

Sport climbing is especially hard on a rope. In a BlueWater test, a 10.5-millimeter rope lost 32 percent of its tensile strength after 25 short falls (176-pound weight falling 5.2 feet on 8.2 feet of rope every minute!, and the impact force climbed 25 percent. After 125 drops, the rope lost 63 percent of its tensile strength. You're better off using a fat, heavy rope for working that crux and, occasionally, alternating ends of the rope to give the nylon a chance to recover. If you use your rope daily for heavy-duty functions such as guiding or sport climbing, manufacturers recommend retirement after three to six months. Weekend warriors who also take climbing holidays should expect one to two years of use. If you only get out occasionally, your rope should be good for two to four years. Ropes that have had no obvious abuse still wear out.(Ideally, ropes would come with a freshness label, like a carton of milk, but so far only PMI and Beal have taken this step.) We tested an 11-milimeter rope that was virtually unused and had been properly stored for about 20 years. To look at it, you'd think it was in great shape, and you probably wouldn't hesitate to climb on it. The rope held one fall. To be safe, a rope that's been shelved for five years should no longer be trusted for leading.

For those who are good record keepers, Edelrid has the following advice. Multiply the number of feet climbed by .33 and the number of feet rappelled, lowered and jumared by 1.66; keep a running tally of total usage. Retire a 10-millimeter rope when it has accumulated between 5,000 and 15,000 feet; a 10.5 millimeter, after 23,000 to 33,000 feet; and for an 11-millimeter, after 36,000 to 63,000 feet. Opt for the lower number if it receives hard falls or is lightweight.

Retirement does not have to mean the end of your rope's life. Unless it's really trashed, it should be fine for toproping and rappelling, activities that usually generate small impact forces. Just keep a close eye on the condition of the sheath. In fact, toproping and rappelling are so abusive to the sheath that, if you use a rope a lot for these activities, you probably should save it for these activities only. One test by the Deutscher Alpenverein (DAY) showed that after 200 rappels on thin ropes, strength was reduced by 70 percent.

When it's really dead, cut the rope up so that you-or someone who doesn't know better-are not tempted to use it. "The Ashley Book of Knots" illustrates several way-cool floor mats you can weave from ropes.

Clyde Soles

(Continued from page 19)

mend the use of markers. BlueWater markets a marking pen that should be safe on all ropes.

If you don't want to worry about markers, you can always pay extra for a bicolor rope that changes color or pattern halfway alone the sheath.

Some climbers use tape, this has a tendency to peel off or migrate away from where it is supposed to be [dangerous when rigging a rappel). Sterling whips the ends and middles of their ropes with nylon yarn, an old sailor's trick that anyone wish patience can use.

The Bottom Line

As with rock shoes, There is no one rope that does it all. Most beginners, guides, big-wall addicts and dedicated sport climbers will want an 11-millimeter rope for its durability. At the other end of the scale are 10-millimeter ropes-light enough to help you send that 13b you've been working or to tote on an alpine climb. If you want an all-around climbing rope and are willing to accept some trade-offs, a 10.5 is a good choice.

When looking at a rope in the store, run it through your hands; the sheath and core should feel smooth, with no bumps or ridges. Flex the rope; be wary of those that are very soft or stiff. A good rope will be moderately firm; it shouldn't flatten easily when compressed. Wring a short section in your hands; if the sheath develops pronounced ridges when you twist it, it's more prone to abrasion. Look carefully at the sheath; yarns that aren't a consistent color are a sign of poor quality control.

Advanced Base Camp

The newest player in the rope market is off to a good start. The ropes are designed by ABC and built by a Washington cordage manufacturer with many years experience in the industrial market. Both the 10.5- and the 11-millimeter ropes performed well in lab and gym tests.

Beal

The excellent reputation of these French ropes was borne out in our testing. Beal's new Program ropes are among the most exciting development in the past decade. The core and other specs are the same as those of their standard ropes, but the sheath is very different. Each end is soft for five feet to make tying in easier; the next 13 feet, where the rope gets the most abuse, are stiffer for durability. The central 130 feet are soft for easy handling and minimal rope drag. After using a Program in the field, I have to admit I really like the feel. Yet, if you have to cut off the ends due to sheath damage, there won't be much of the durable section left. It's also rather difficult to evaluate the condition of the rope by feel.

Standard Beal ropes performed as well as or better than most others we received.

Black Diamond

These ropes are made to Black Diamond's specs by Beal and PMI. The 10-millimeter uses a tightly woven, single-pic sheath, which gives it a smooth feel, but it turned black and blackened hands faster than any other, and it was on the stiff side. The 10.5- and 11-millimeter ropes have double-pic sheaths that handle and wear well. Good all around ropes.

BlueWater

Completely redesigned this year, these aren't the fat ropes many of you remember. Appropriately called Slimlines, the new ropes are lighter and have a very good feel, yet remain durable. The 9.8-millimeter Lightning Pro held up better than any other in its category. My own field use has shown BlueWater's dry treatment to be as good as any I have used. BlueWater has made dynamic ropes longer than anyone in the US, and it is working toward obtaining ISO 9001 certification. This company continues to be a strong performer.

Climb Axe

These ropes, made in Spain by Roca, are another new entry in the US market. They have three braided-core strands and a relatively soft feel. Although not remarkable, they seemed a reasonable rope for the money.

Climb High

In addition to importing Beal and Mammut ropes, Climb High has ropes made for them by PMI. The 10.5-millimeter we received handled and performed much like the Black Diamond and PMI ropes- quite well.

Cousin

These French ropes had the lowest impact forces of any in the review. Many people liked the feel and handling of the Supersoft, due to its smooth, single-pic sheath, but durability is somewhat lacking. The Top Rock has a unique, very abrasion-resistant sheath and a fairly good hand. The big disappointment was the Fun. By far the worst-handling rope in the review, it also has a fairly cheap sheath.

Edelweiss

These Austrian ropes have long been among my favorites. The 10.5-millimeter Strotas with its cut-resistant core, remains unique on the market. Each strand on the outside perimeter has mono-filament braided around it for protection. This makes the rope a bit stiffer than other ropes (though not as bad as the original version), yet it's a great choice for big-wall alpine climbs or for sport climbs with sharp edges.

The conventionally built Ultralight was a solid performer in its category. The Extrem (11-millimeter) and Calanques (10.5-millimeter) were not available in time for testing.

Mammut

Another company with a long history of making excellent ropes, this Swiss manufacturer sets a high standard for quality and performance. I have used its 10.5-millimeter Flash quite a bit in the past two years and have been very pleased with its handling and durability. The 10-millimeter Galaxy did reasonably well in testing. Single ropes are also available with the unique Duodess sheath, which changes pattern at midpoint.

Marlow

This British manufacturer has been making climbing ropes for several years, and they are now becoming available in the US. They were not available in time for testing.

New England

New England is the only company that offers ropes with different sheaths: Standard models have double-pic sheaths; twill models have single-pic ones. Maxim ropes have a good feel and are hard wearing, yet have higher impact forces than any other brand reviewed here.

PMI

PMI has been making caving ropes since 1976, when several employees left BlueWater to start PMI. They began making climbing ropes in partnership with Beal, who twists the cores, about four years ago. Overall, their ropes' performance was quite good, though the ropes seemed to blacken quickly.
The PMI 9.9-millimeter has a strand of Kevlar running through the core; this gives it a low static elongation. PMI makes its own version of the 10.5-millimeter Program (see Beal). All PMI ropes now have a continuous marker

(Continued on page 12)

Testing the Testers

Several manufacturers mentioned they had seen a wide disparity in figures from UIAA-approved test labs. This presents an interesting problem for the rope buyer. If the maximum impact force and number of falls held are two of the major criteria we use for evaluating ropes, how do we know how accurate the figures are?

There are no UIAA-approved rope labs in the US. However, there are four drop towers in this country (at Bluewater, New England Ropes, PMI and REI)that meet all specifications except for independent status. I requested an extra 10.5-millimeter rope from the three manufacturers, then divided these into quarters and sent samples off to be broken.
As predicted, the initial impact force (in kiloNewtons) and number of falls held ranged quite a bit. The moral: Use numbers as guidelines only.

Drop Tower	Bluewater	New England	PMI
BW	6.94/ 8	8.17/ 6	7.11/ 5
NE	8.90/ NA	9.79/ 8	9.12/ 8
PMI	7.99/ 9	9.61/ 7	8.27/ 7
REI	NA/ 6	9.85/ 7	8.43/ 6

ropes

	Manufacturer & Model Name	Diameter (listed/tested)	Weight g/m (listed/tested)	Impact Force (listed/test avg.)	Impact force increase (% from 1st to 4th fall)	# falls (listed/test avg.)	Static Elongation (listed/tested)	Knotability (mm)	Price (50 m std/dry)
10mm ropes	**Beal Laser**	10/10.2	63/65.0	8.2/NA	NA	6/5	7/7.4	8.7	$ NA/136.75
	Black Diamond Superlight	10/9.9	64/62.4	8.5/6.74	52	6/4	7.0/6.8	8.3	$ 122.50/141.00
	BlueWater Lightning Pro	9.8/9.7	62/59.0	8/6.30	54	6/5	6.5/5.5	8.3	$ NA/140.00
	Climb High Chamonix	9.9/NT	63/NT	8.2/NT	NT	5/NT	3.7/NT	NT	$ 116.30/143.00
	Edelweiss Ultralight	9.9/9.9	64/65.3	9/6.38	56	7/6	NA/6.3	9.1	$ NA/148.00
	Mammut Galaxy	10/10	66/65.1	9/6.43	45	6-7/7	5.5/5.8	9.8	$ 136.00/160.00
	Marlow Thor	10/NT	65/NT	9.5/NT	NT	6/NT	8.0/NT	NT	$ NA
	New England Maxim	9.8/10.1	64.8/64.9	10.7/8.04	43	5-6/5	7.1/6.2	9.8	$ 120.00/141.66
	PMI 9.9 Single	9.9/10.0	63/66.6	7.5/6.30	58	6/5	7/4.4	9.4	$ 116.30/143.00
	Sterling 9.8	9.8/10.3	69.3/69.9	8.9/7.05	35	8/5	7.0/6.7	10.5	$ 123.25/146.60
10.5mm ropes	**Advanced Base Camp**	10.5/10.5	69.5/70.1	10.5/7.61	40	7-9/7	5.2/6.5	9.1	$ 121.50/138.50
	Beal Edlinger	10.5/10.7	70/70.9	8.3/7.0	37	9/8	6.8/7.2	8.6	$ 129.00/157.25
	Beal Edlinger Program	10.5/10.5*	70/70.9*	8.3/7.0*	37	9/8*	6.8/7.2*	8.6*	$ 136.15/162.00
	Black Diamond 10.5 mm	10.5/10.6	70/72.3	9.0/6.92	42	7/8	6.8/6.9	8.9	$ 125.00/148.00
	Bluewater Accelerator	10.5/10.4	70/66.4	8.5/7.0	37	9/8	6.1/5.3	7.9	$ 123.25/146.60
	Climb Axe 10.5 mm	10.5/11.1	NA/73.9	9.8/6.84	44	7-9/5	7/4.8	10.8	$ 119.95/138.95
	Climb High Aurora	10.5/10.9	70/72.6	8.9/6.79	44	7-8/7	6.5/6.5	8.5	$ 125.75/149.50
	Cousin Fun	10.3/10.5	68/69.1	8.6/5.76	59	7/6	7.2/5.7	10.3	$ 120.00/NA
	Cousin Supersoft	10.2/10.7	68/71.8	7.5/5.91	54	8/6	5.8/6.5	8.8	$ 140.00/165.00
	Cousin Top Rock	10.4/10.9	72/75.2	7.1/6.12	46	10/8	6.4/6.1	10.4	$ 140.00/168.00
	Edelweiss Stratos	10.5/10.7	76/77.3	9.00/6.30	53	10+/11	NA/5.9	13.5	$ NA/178.00
	Edelweiss Calanque	10.5/NT	70/NT	9.75/NT	NT	8/NT	NA/NT	NT	$ NA/148.00
	Mammut Flash	10.5/10.3	71/70.5	9.2/6.58	41	8-10/8	6.8/5.6	10.5	$ 138.00/164.00
	Marlow Vega	10.5/NT	72.9/NT	9.2/NT	NT	7-8/NT	7.3/NT	NT	$ NA
	New England Maxim 10.5	10.5/9.9	67.1/66.4	11.4/8.09	38	7-9/5	6.3/6.8	8.4	$ 128.33/146.67
	PMI 10.5 mm Single	10.5/10.8	70/70.2	7.8/7.11	46	10/6	6.8/6.9	8.7	$ 125.75/149.50
	PMI 10.5 mm Program	10.5/NT	70/NT	7.8/NT	NT	10/NT	6.8/NT	NT	$ 139.00/166.00
	Rivory Joanny Virus	10.2/10.6	68/70.5	9.9/7.73	43	6/6	6.6/6.7	9.3	$ 149.95/163.95
	Rivory Joanny Mystic	10.5/NT	69/NT	8.7/NT	NT	6/NT	7.8/NT	NT	$ 162.95/175.95
	Rivory Joanny Virtige	10.5/10.4	69/68.5	10.64/8.20	34	8/6	6.4/6.0	9.1	$ 137.50/147.50
	Sterling 10.2 mm	10.2/10.7	74.0/74.6	7.84/6.74	42	8/8	6.9/6.2	10.5	$ 123.25/146.60
11mm ropes	**Advanced Base Camp**	11/11.3	80.7/81.9	9.8/7.73	34	11-12/13	5.3/5.4	8.8	$ 131.50/150.00
	Beal Leader	11/11.2	77/78.3	8.5/7.08	32	11/9	5.8/7.0	8	$ 136.25/171.25
	Black Diamond 11 mm	11/11.3	78/79.9	9.4/6.77	28	11/9	5.8/6.4	9.1	$ 134.00/161.50
	BlueWater Enduro	11/10.9	77/77.3	8.5/7.05	38	10/8	6.0/5.1	10.8	$ 133.25/160.00
	Climb Axe 11 mm	11/11.4	NA/79.2	9.4/7.10	36	9-11/11	7/4.9	8.6	$ 129.95/149.95
	Climb High Ultima	11/NT	78/NT	15/NT	NT	11/NT	5.5/NT	NT	$ 136.00/160.00
	Edelweiss Extrem	11/NT	79/NT	9.0/NT	NT	12/NT	NA/NT	NT	$ NA/160.00
	Mammut Flex	11/NT	77/NT	9.7/NT	NT	12-14/NT	5.8/NT	NT	$ 149.00/179.00
	Marlow Odin	11/NT	79.9/NT	9.4/NT	NT	9-10/NT	8.0/NT	NT	$ NA
	New England Maxim 11 mm	11/11.2	74.6/74.0	10.2/7.93	37	10-12/7	7.8/5.7	9.9	$ 136.66/156.67
	PMI 11 mm Single	11/11.1	77/76.7	8.0/7.55	28	12/10	6.2/6.5	9.3	$ 136.00/160.00
	Rivory Joanny Force	11/NT	77/NT	9.8/NT	NT	8/NT	7.6/NT	NT	$ 169.95/179.95
	Sterling Dynamic Gym	10.8/11.1	NA/82.8	NA/7.88	NA	NA/4	NA/5.1	9.2	$ 132.25/160.00
	Sterling 11 mm	11/11.5	78.9/78.0	7.5/7.7	40	9/9	3.5/4.6	9.4	$ 133.25/160.00

* Soft section NT= not tested   NA= not available

ROPE HYPOCRISY

by Geary Schindel

Hypocrisy — 1. a pretense of having a virtuous character, moral, or religious beliefs or principles, etc., that one does not possess. 2. a pretense of having some desirable or publicly approved attitude (*The Random House Dictionary of the English Language*, unabridged, 1973).

Many years ago, when I was younger and dumber and just getting involved in rock climbing and caving, one of the first rules I learned was never to walk on a rope. The thought was that walking on a rope caused both external and internal abrasion decreasing its strength and service life. If you were caught stepping on a rope, you were politely then firmly told to stop. I have actually seen people who have ignored this request receive a swift and embarrassing kick in the butt.

To determine the effects of foot traffic on caving rope, I performed a couple of simple and very unscientific tests. I examined a short section of retired Bluewater III caving rope, then stepped on it wearing caving boots. I found that stepping on the rope on a hard surface did no noticeable damage to the sheath. I did find that if I purposely trapped the rope between a rock and the boot, I could fairly quickly cause some sheath damage. I did not try this test with a loaded rope. Some of the dependent variables are probably the roughness and hardness of the rock surface, surface area of the rope, weight of the caver, load on the rope, etc.

Damage does occur when a rope is stepped on. Much of the damage is submacroscopic and cumulative with cumulative being the key word. Therefore, it is worth minimizing. I have always been a student of human nature and have found that the care a caver exhibits with his vertical gear is indicative of the quality of the caver.

Tag Rap

Enter the Tag Rap. No, not the rap song. The Tag Rap, or caver's coil, is a method of coiling a rope, to minimize loose coils, for transporting it through a cave. This allows the rope to be worn over the head and under the arm like a bandoleer. Coiled ropes are usually not directly walked on; however, considering that most caves are surrounded by rock and may contain dirt, a coiled rope offers little protection from abrasion. A coiled rope is commonly rolled, dragged, crawled on, sat on, and generally abused; but rarely walked on. When you give this some thought, it's a little hypocritical to tell someone not to walk on your rope and then end up dragging it unprotected through a cave.

In addition, if you carry a rope bandoleer style as most cavers do, this places the lower coils against your hip in the same general area when a battery belt pack maybe worn. One of the other lessons taught beginning cavers and climbers is that ropes and chemicals do not mix. There are numerous documented accidents related to the failure of ropes exposed to chemicals.

Engineering Controls

In the hazardous waste business, to minimize exposure to toxic materials, we commonly use engineering controls. One of the primary methods of protection are barriers. These includes gloves, oversuits, helmets, respirators, etc. The same principle applies to vertical caving equipment. One of the best ways to protect you vertical equipment from abrasion and chemicals is to use protective barriers.

Rope Bags

Rope bags offer a number of advantages. They protect the rope from abrasion, make comfortable seats, roll pretty well through caves (having no coils to catch on a cave wall), double as a rope pad, protects the rope from ultraviolet rays and other nastiness outside the cave, and acts as an indicator if the bag is exposed to chemicals.

The disadvantages of a rope bag are few but to some, important. A rope bag does not look as macho as a coil of rope around your shoulder or placing the coil in the back window of your car. In addition, some of the stiff American caving ropes (steel cables) are more difficult to stuff into a rope bag than to coil. It's an interesting problem, many caving ropes appear to sacrifice handling characteristics for abrasion resistance and many American cavers think that because a rope reportedly has high abrasion resistance, you don't need a rope bag, or for that matter, a rope pad. Rope bags are a standard piece of caving equipment for European vertical cavers. Surprisingly, maybe they know something about vertical caving that us Americans don't.

Battery Packs

I have owned three Wheat Lamp Batteries and one MSA battery and all of them have leaked. The current Gel-Cel I am using will also leak someday. My wet cells have leaked from physical abuse and abrasion of the case (normal caving), from the vent holes, and from the terminal posts. My Gel-Cel will probably also fail by abrasion or cracking of the case or around the terminal posts. I have always carried my batteries inside a battery pack. The battery pack helps protect the battery and also acts as an indicator if acid is released. Acid will cause the pack to quickly degrade and signals the need to perform a thorough inspection of all equipment which may have been exposed. I also recommend that you inspect your batteries on a regular basis; however, note that a very small hole or crack in the battery casing can easily go unnoticed until damage has occurred.

Separation of Materials

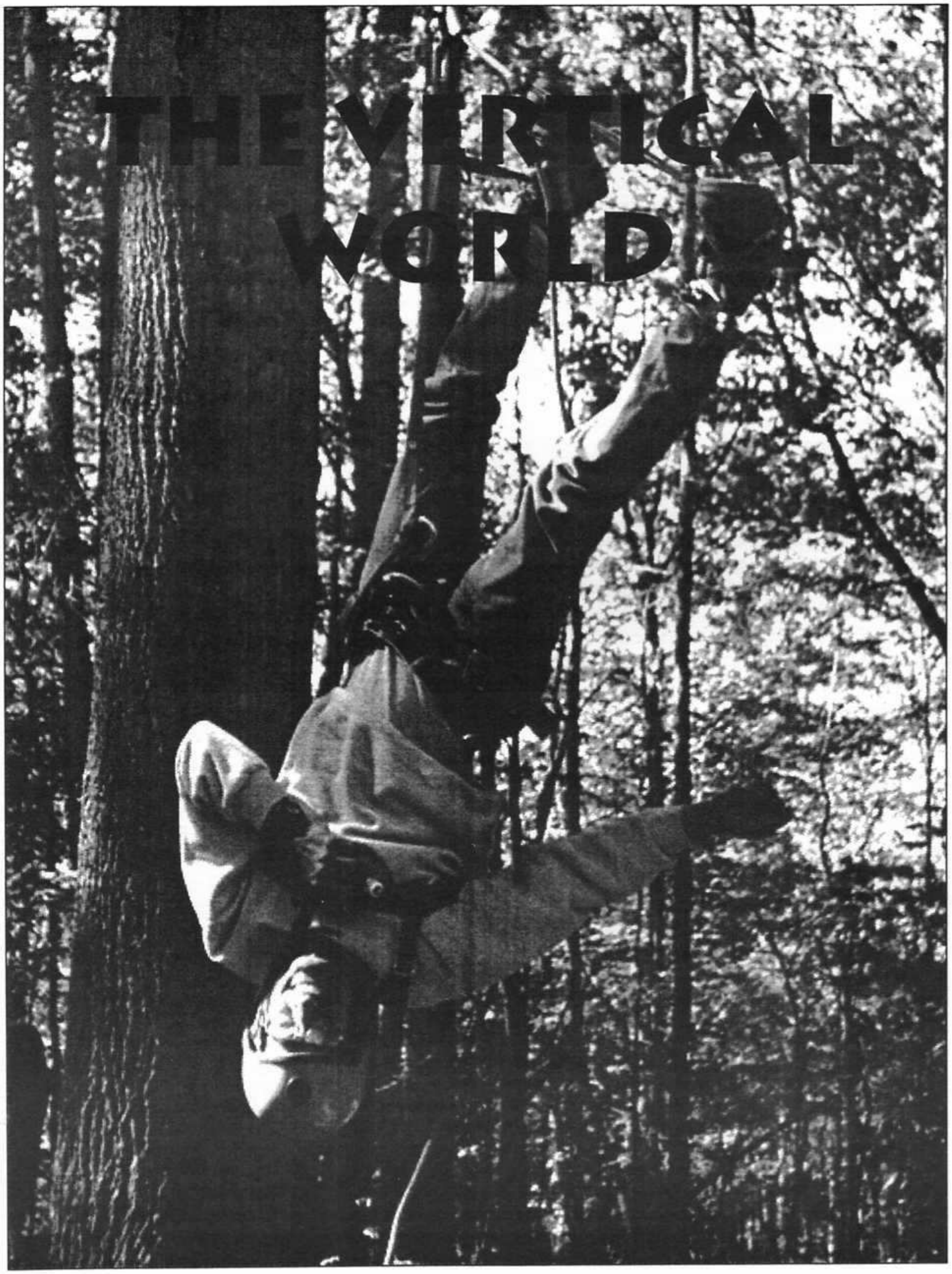
An additional engineering control is to separate incompatible materials (acids and vertical equipment). I have a standing policy that all wet cells and Gel-Cels must ride on the car floor behind the drivers seat. All ropes and vertical gear must go in the trunk inside of a gear bag. All jumper cables also are placed under the back seat of the car.

Examples

#1) A number of years ago some friends went to Mexico to do some of the big pits. They made arrangements to meet some cavers with a long rope.

After dropping El Sotano, they went to sotano de las Golondrinas. The third person down the rope had the sheath pull apart in the rappel rack. The tail of the rope was lowered to the caver and he changed rope. Later inspection and analysis of the rope indicated that it had

(Continued on page 12)



During a Nashville (TN) Grotto Vertical Training Session, Mike Felts experiences the sensation of being inverted. Who said only chickens wear those loops? *(Photo by Debby Johnson)*

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