Go Configure
Some Karabiner Basics

By Chris Cowell

Often used, often misunderstood! Karabiners (also spelled "carabiners") are a common component of climbing and rigging systems. Everyone who works aloft is used to handling karabiners, but how widely understood are the fundamentals of these connectors?

This article is the first in a series titled "Go Configure." The series looks at configuration and compatibility of components commonly used in tree climbing and rigging systems. It sets out to highlight the importance of understanding the tools we work with, what they are good or not so good at, and how to look after them. Here, some karabiner basics are addressed. A subsequent article will focus on some potential conflict situations that can arise when it comes to connecting karabiners to a range of objects.

First, let's go back to basics. What does the word mean? The *Oxford English Dictionary* (Burchfield 1987) gives the following definition:

> **Karabiner**. (kærăbī-nər) *Mountaineering*. Also **carabiner**, *erron.* karibiner. [Shortened form of G. *karabiner-haken* spring hook.] A coupling device consisting of a metal oval or D-shaped link with a gate protected against accidental opening. Cf. *KRAB

In a short history of the karabiner, the British Mountaineering Council (BMC 2008) suggests that the *karabiner-haken* was adopted by soldiers wanting to quickly detach their guns from carrying slings. These days, karabiners tend to have less sinister partners, but they continue to be associated with serious outcomes—hence, these articles.

There are a number of general information sources that discuss karabiners. Vines and Hudson (1999) provide a thorough overview of connectors, including design features and some standards. Merchant (2007) addresses the topic from an underground rope rescue perspective. Petzl (2008) offers an insight to a manufacturer's priorities regarding their own products, but their information can be extrapolated to a wider karabiner population.

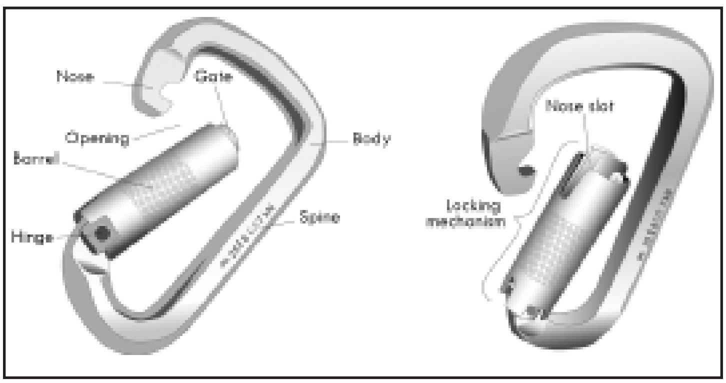

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Figure 1. Nomenclature of a karabiner.

In an attempt to ensure that we are all talking the same language in this and upcoming discussions, Figure 1 identifies and names the generic features of a karabiner.

Karabiners are produced in two broad metal groups—aluminium (also spelled "aluminum") and steel. Steel karabiners can be much stronger than aluminium, but they are also heavier. When a connector is specified in tree rigging operations, steel karabiners are the norm. Aluminium alloy karabiners are usually restricted to fall protection systems (such as in climbing applications). Steel karabiners are occasionally selected for tree climbing applications, but most climbers prefer to use aluminium connectors because they are lighter and are available in a wider range of shapes, styles, colors, and sizes. Colored aluminium karabiners have normally been anodized. Anodizing is a surface treatment that improves corrosion resistance and hardens the aluminium. Benefits for the end user include better abrasion resistance and reduced surface friction. The broad palette of aluminium karabiners can be used to differentiate manufacturer, gate mechanism, color of anodizing, and karabiner form or styling. In this way, confusion among connectors by the end user can be reduced. The discussion and images here will focus on aluminium karabiners adopted into fall protection systems.

So, it appears we have the Germans to thank for the ability to connect, disconnect, and reconnect with such ease. *Vorsprung durch technik* (advancement/development through technology) seems an appropriate phrase! But is the *technik* appropriate for the task?

Standards and Minimum Strengths

Karabiners used in industrial fall protection systems are manufactured to defined standards (for example, EN in the European market, ANSI in the United States, CSA in Canada). Keeping on top of all these diverse standards is difficult for manufacturers and end users alike. Thankfully, PenSafe, a hardware manufacturer based in Ontario, Canada, provides in their online catalog a very useful table that summarizes the minimum requirements for a number of standards (PenSafe 2008). The catalog also presents images of some of the common test configurations.

In contrast to other product groups, karabiner strengths tend to be given in kilonewtons (kN), a measurement of force. 1 kN is approximately equal to 100 kgf (225 lbf). Three strengths are marked on most karabiners. An example of the markings required by the EN standards is shown in Figure 2. The numbers refer to the minimum breaking strength in kilonewtons when the product is new. Figure 3 summarizes the test configurations that assess major and minor axis strength.

The big differences between those strengths highlights very clearly how important it is that karabiners are loaded correctly (that is, along the major axis) and that the gate is closed and locked. If a karabiner rotates to the minor axis position during a fall, the forces generated when arresting the fall may be close to the strength of the connector, leaving a small safety factor, even when the connector is new. Likewise, it is much easier for a rope or webbing to escape from a karabiner whose gate is not correctly closed or locked. So how do we ensure correct orientation and gate locking? By taking a few proactive measures!

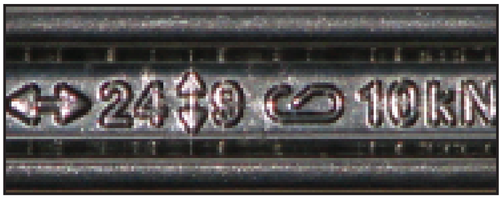

Figure 2. Typical karabiner markings showing three strengths. Left to right: Major axis 24 kN, minor axis 9 kN, gate open major axis 10 kN.

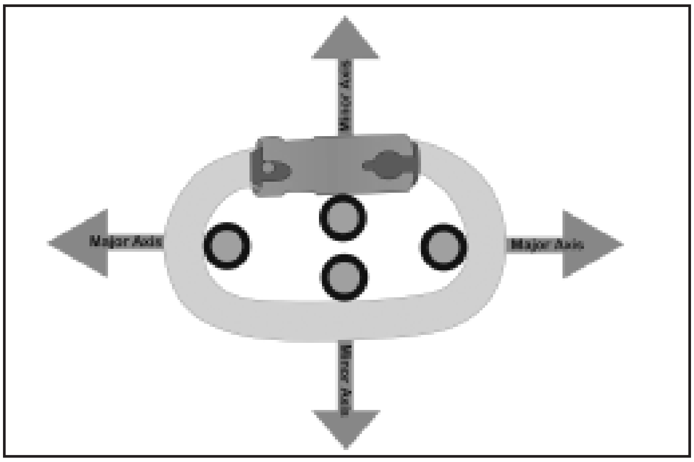

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Figure 3. Major and minor axis test configurations. Load is applied via 12-mm-diameter steel bars (represented by black circles).

Karabiner Orientation

Time spent designing a well-thought-out climbing system will increase the probability that karabiners will be loaded along the major axis. Good planning will also reduce the chance of a gate mechanism opening or failing to lock completely (for example, by contacting an object such as a branch, stem or rope).

Directional or termination connectors allow the fixing of webbing or rope in such a way that the loading is in a predetermined direction. These karabiners come in a number of formats such as locking pin and captive eye; some have a swivel feature. There are many applications for these connectors. However, because they are often spliced or stitched into a system, there can be a reluctance to remove them from service when, for instance, the locking mechanism becomes unreliable.

There are a number of other ways to ensure a karabiner is oriented along the major axis (Figure 4). Constriction knots can be very effective if the rope is soft and pliable enough to grip reliably. The knot must, of course, be appropriate (for example, buntline hitch, anchor bend or scaffold knot) and correctly tied, dressed, and set. There are also specially made products for the job such as the Petzl String, Beal Pinch, SherrillTree's Blue Bandits, and fasts made from leather, elastomers, plastics, and metals. Old bicycle inner tubes cut into short lengths, castration rings, and lobster bands can come in handy, too! All have their area of application. Some work better with webbing than rope and vice versa. It is up to the end user to ensure that he or she chooses the correct tool for the job, which may require some cautious and considered "trial and error" along the way. A very tight eye splice is the favored technique for some.

Figure 4. Examples of techniques used to maintain correct karabiner orientation. Clockwise from top left: Blue Bandit (SherrillTree), String L (Petzl) and castration ring, scaffold knot in captive-eye karabiner (note band of whipping that increases rope stiffness and, when correctly positioned, minimizes knot creep), captive-pin karabiner, nylon fast (Kong), Pinch (Beal), karabiner with clip-on cover over the locked mechanism (DMM), plastic sheath (Petzl), certified small-stitched eye.

Gate Mechanisms—Maintenance and Lubrication

With the karabiner now held in the correct orientation, the next key point is to make sure the gate is locked closed each and every time we use it. In most countries, it is suggested that autolock gate mechanisms are most suitable for tree care; that is, when an open gate is released, the gate closes and fully locks without assistance from the user. Personally, I have my doubts!

For the most common three-action (see sidebar on action versus locking) autolock gate mechanism to lock fully, the following operations need to complete successfully:

the gate must swing across with the nose locating correctly within the nose slot;

the barrel must rotate; and

the barrel must slide in to the locked position.

These actions require the free movement of working parts including three springs. We work in an environment where dust, mud, freezing rain, snow, leaves, bark, and other impediments conspire to test the operation of even the best mechanisms.

Experience in thoroughly inspecting large quantities of connectors (Figure 5) has given me an understanding of the maintenance demands of autolock karabiners. Climbing arborists don't normally want to spend their time maintaining gate mechanisms! A quick squirt with WD-40 is what substitutes for maintenance in many companies. It is necessary to keep locking mechanisms fully functional. To do that, maintenance will often have to start with a thorough cleaning, perhaps involving warm water, a mild cleansing agent ►

Action Versus Locking

In English, the term "action" is used to describe the movements of the gate mechanism of a karabiner (for example, three-action autolock). The term "locking" is used in the United States (for example, double locking).

An "action" describes a single movement, or combination of movements, by components of the locking mechanism that comprise a single "step" in the unlocking and opening or closing and locking of a karabiner. For example, when the barrel of the most common karabiner locking mechanism is rotated, the tension on at least one spring is also changed (that is, two or more components move in the process of a single action).

It may be possible to avoid confusion by comparing the two terminologies as shown in this chart.

US	English	Description
Non-locking	Non-locking	A spring in the gate is the only mechanism for maintaining gate closure—push the gate and they open. These karabiners are sprung loaded to the closed position but do not lock. Examples include straight-, bent-, and wire-gate karabiners used for rock climbing.
Single locking	Two action	To open or close the gate to/from "locked," a single locking action is required in addition to the swinging action of gate closure. Examples include twist-lock and screw gate karabiners.
Double locking	Three action	Two locking actions and the swinging action of the gate are required to fully operate the mechanism. Examples include Petzl Ball Lock and "pull-rotate-swing" mechanisms.

and a brush, followed by a blast with compressed air. Karabiners will need to be dry for lubrication to be most effective, which may mean waiting overnight. Correct maintenance and lubrication takes time. In the world of production tree work, I have the feeling it doesn't often happen!

Figure 5. Examples of a range of connector types. Clockwise from top left: D-shape, D-shape with sheave, HMS, symmetrical oval, half round, captive eye, captive eye with swivel, captive pin D-shape, Klettersteig, large symmetrical oval screw link.

A related point: I have read more than one accident report where the climber stated that he or she heard the karabiner close. That can't be good! Autolock mechanisms tend not to be visually assessed for correct closure around the desired object. In difficult situations, perhaps especially where fatigue is an element, could it be that we rely more often on that audible "clack" to confirm what we want to know? The absence of a visual check is a by-product of the autolock function. And that is bad for safety.

Safety in our industry would benefit if an improved mechanism could be developed. Correct operation cannot be reliable without a visual check. I believe that karabiners would be connected to the correct object more often, and that gates would be closed correctly more often, if climbers became more involved in the locking of the gate by means of a manual mechanism.

Making the gate more difficult to open inadvertently is an important objective. The British Health and Safety Executive (Stratham and Roebuck 2004) has researched issues surrounding "roll-out" — where a lightly loaded rope, running over the locking mechanism, opens the gate. Not all mechanisms performed equally. One mechanism, which is no longer in production, (Petzl Ball Lock with plastic barrel; Figure 6) could not be opened at all by the tests and was therefore regarded as more secure. Based on my personal observations, however, this locking mechanism gives comparatively poor results when assessed for loading from the outside. To my knowledge, the revised Petzl Ball Lock gate mechanism with an aluminium barrel has not been assessed for roll-out by the same laboratory (Figure 6).

Figure 6. Petzl Ball Lock locking mechanisms. A: Plastic barrel (2006 and earlier) as tested for roll-out by Stratham and Roebuck. B: Aluminium barrel (2006 onward).

There are two points to be made here:

improvement in safety is possible; and

before a full verdict can be given, gate mechanism test scenarios should define and assess all performance criteria for the product (such as roll-out, outside strength, reliability of closure and locking etc.).

Until such time that further advances in karabiner locking mechanisms have been made, it is important to spend time on suitable and sufficient maintenance and lubrication that is compatible with the manufacturer's guidance.

The UK Gate and Locking Mechanism Function Test

The following test was drawn up with the aid of two UK karabiner manufacturers with the aim of providing end users and equipment inspectors with objective assessment criteria when considering karabiner gate and locking mechanism function. The test is contained in a course workbook issued by Lantra Awards for those being trained in the thorough examination of arboricultural equipment (Lantra 2005). A number of checks are outlined for the karabiners. This test is valid for three-action autolock gate mechanisms:

- using thumb and forefinger, open the gate at least 15 mm (~5/8 inch), then fully bias the [gate and] mechanism towards the locking position;
- slowly bring the gate mechanism (barrel) forward until contact is made with the nose of the karabiner;
- slowly release pressure from the thumb and forefinger;
- the mechanism must close and lock [the mechanism is functioning correctly];
- if no contact is made, and the mechanism moves straight to the closed and locked position, the gate mechanism is functioning correctly;
- test is to be carried out when the karabiner is unloaded;
- [repeat 10 times to assess consistency of operation.]

I added the last step about repeated testing for consistency because mechanical tools can suffer from variability. A mechanism that works one minute may not function the next. When considering gate closure and locking, consistency is an important criterion that is both difficult to define and to assess. Discussion with colleagues and manufacturers may be necessary.

With any luck, we now have a karabiner that is attached to rope or webbing in such a way that its orientation is predetermined along the major axis. The gate is functioning reliably, so it's time to connect to something. That, unfortunately, will have to wait for the next article. The implications for karabiner strength when applying the load in ways that differ from those specified in the standards tests will be discussed (for example, where the point of contact is much wider than the 12-mm steel bars and when the karabiner is "choked" around a stem or branch). In the meantime, I would like to make one further important point . . .

Quality? Quality!

When it comes to buying climbing PPE, don't be cheap! For more than one reason, it pays to stay with quality. A higher price can be an indicator of research and development levels, the presence of a meaningful quality assurance process, an innovative manufacturing process, or higher quality materials. These inputs are often visible in the finished product. Take time to look and compare.

Anyone who has ever visited the factory of a rope or karabiner manufacturer will know how much energy and commitment it takes to bring a reliable and good-quality product, through a well-managed quality assurance process, to the market place. A quality product is an expression of company culture and all the people who had input. Not all cultures are the same. A bit of brand loyalty may make sense.

Climbers must be confident in their equipment. The consequence of a fall can be serious and long lasting for climbers and their families. Buy the very best quality you can afford, and don't barter too hard on price. This point is also very valid for wholesalers and retailers in their discussions with manufacturers. We all need manufacturers of good-quality products to be financially healthy enough to innovate!

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