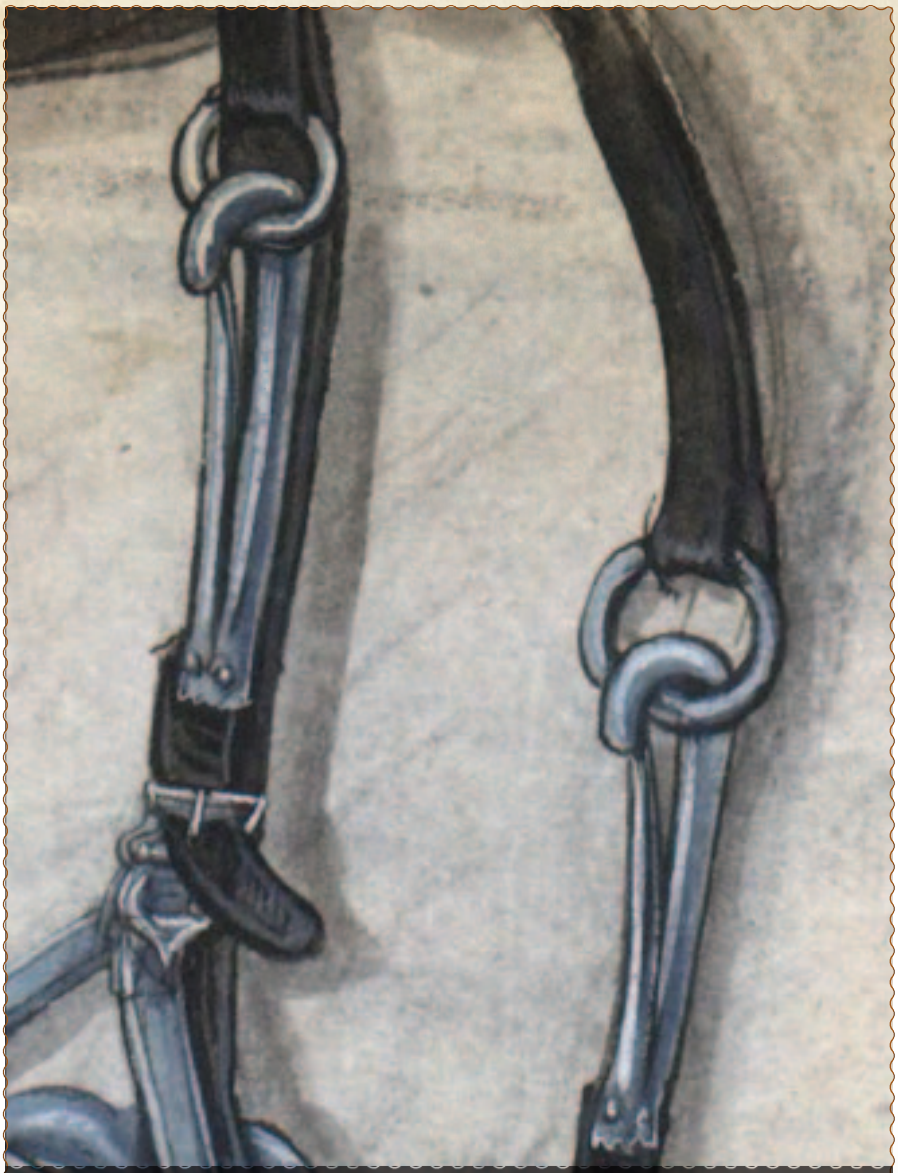
The carabiner



Hooks with a sprung, hinged gate, depicted on a horse's muzzle in the Codex Löffelholz folio 38v, about 1505

A carabiner or karabiner often shortened to biner or to crab, colloquially known as a (climbing) clip, is a specialised type of shackle, a metal loop with a spring-loaded gate used to quickly and reversibly connect components, most notably in safety-critical systems. The word comes from the German Karabiner, short for Karabinerhaken, German for 'carbine hook', used by a carbine rifleman or carabinier, to attach his carbine to a belt or bandolier.

The first known hooks that had a sprung, hinged gate where the spring kept it closed, characteristics expected of a carabiner, were depicted by Nuremberg patrician Martin Löffelholz von Kolberg in about 1505 in the Codex Löffelholz, in the Holy Roman Empire. These then became the clip used to hold a cavalry carbine or arquebus, with the earliest known mention of them being in 1616 by Johann Jacob von Wallhausen, in the Holy Roman Empire.

They were widely used in many European countries during the 17th Century and typically had a belt attachment and swivel joint, much like a modern luggage strap or handbag strap.

The load bearing latch was added in the 1790s, for the British cavalry design. They were used for many other purposes during the 19th Century, such as for luggage straps, mining and connecting ropes.

Some common designs first appeared during that time, including S-carabiners. Oval links, which had also appeared in 1485, also reappeared as carabiners. Screw gates and internal springs were developed.

Prussian fire brigades began to use carabiners for connecting themselves to ladders in 1847 and this became the modern gourd-shaped design by 1868.

German and Austrian mountaineers started using them during the late 19th Century, with a mention of their use from 1879 and their continued use for climbing by climbers in Saxon Switzerland. The majority used gourd shaped carabiners, which

were created for mining or other utility purposes.

The common myth suggesting that they were invented, created, designed, made or developed by German climber Otto "Rambo" Herzog has no basis in fact. However, like many climbers before him, he did use them for some challenging climbs and some new techniques. However, it is worth noting that he did not invent them or develop any designs and he was born long after other climbers were already using them.

University of Heidelberg 1485 sketch of a insertable link, called "hooks". Source: Deutsch Digitale Bibliothek

More designs were used by climbers during the 1920s, such as narrow pear shapes, mostly sold for general hardware. During the late 1920s and early 1930s, carabiners were being sold for climbing, with oval designs being popular during the 1930s.

Hardened steel carabiners appeared in the 1930s.

Prototype aluminium carabiners, the first dedicated climbing carabiners, were made first by Pierre Allain during the 1930s, which were also the first offset D-shaped carabiner. Aluminium carabiners were first sold to the military in 1941, which were the first commercial carabiners designed specifically for climbing.

Slightly-offset D-shaped carabiners were sold in the late 1940s, which became the standard offset D-shape which is now the most common in the 1950s.

Chouinard Equipment introduced the 22kN aluminium carabiner in 1968, though this strength had already been far surpassed by steel carabiners.

Wiregate carabiners were first patented in 1969 and were sold for maritime use. They were first sold for climbing in 1996.

The popular keylock, which avoids snagging, was developed around 1984-1987.

Shape

Carabiners come in four characteristic shapes:

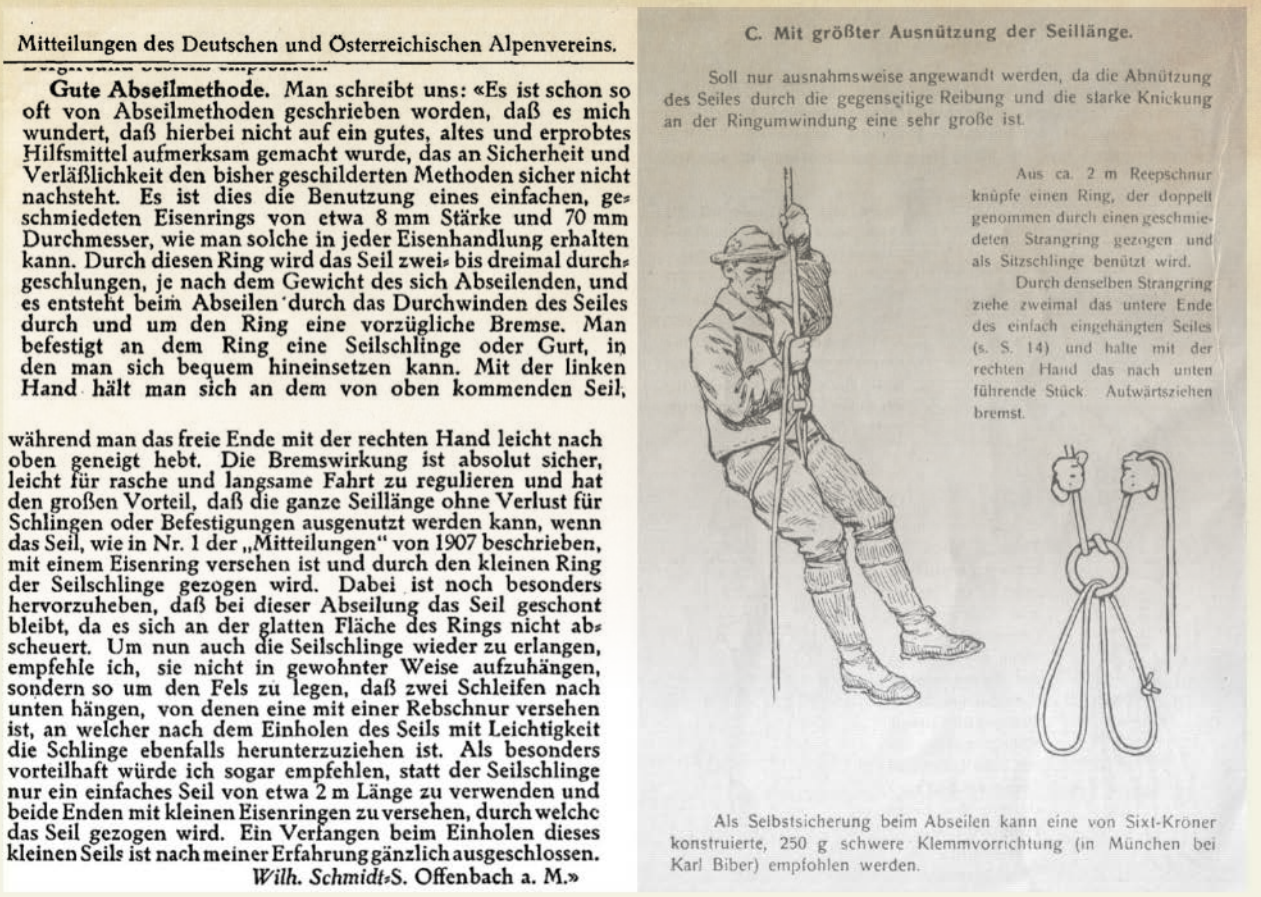
Oval: Symmetric, most basic and utilitarian. Smooth regular curves are gentle on equipment and allow easy repositioning of loads. Their greatest disadvantage is that a load is shared equally on both the strong solid spine and the weaker gated axis. Often preferred type for racking biners due to their symmetric shape.

D: Asymmetric shape transfers the majority of the load on to the spine, the carabiner's strongest axis.

Offset-D: Variant of a D with a greater asymmetry, allowing for a wider gate opening.

Pear/HMS: Wider and rounder shape at the top than offset-Ds and typically larger. Used for belaying with a munter hitch and with some types of belay device.

Cassin steel carabiner, dated c.1950. Maker's mark "CASSIN ITALY" stamped on one side, reverse side stamped "CARICO. MINIMO ROTTURA KG.1800." Richard K. Irvin Collection



Mitteilungen des Deutschen und Österreichischen Alpenvereins.

Gute Abseilmethode. Man schreibt uns: «Es ist schon so oft von Abseilmethoden geschrieben worden, daß es mich wundert, daß hierbei nicht auf ein gutes, altes und erprobtes Hilfsmittel aufmerksam gemacht wurde, das an Sicherheit und Verläßlichkeit den bisher geschilderten Methoden sicher nicht nachsteht. Es ist dies die Benutzung eines einfachen, geschmiedeten Eisenrings von etwa 8 mm Stärke und 70 mm Durchmesser, wie man solche in jeder Eisenhandlung erhalten kann. Durch diesen Ring wird das Seil zwei- bis dreimal durchgeschlungen, je nach dem Gewicht des sich Abseilenden, und es entsteht beim Abseilen durch das Durchwinden des Seiles durch und um den Ring eine vorzügliche Bremse. Man befestigt an dem Ring eine Seilschlinge oder Gurt, in den man sich bequem hineinsetzen kann. Mit der linken Hand hält man sich an dem von oben kommenden Seil, während man das freie Ende mit der rechten Hand leicht nach oben geneigt hebt. Die Bremswirkung ist absolut sicher, leicht für rasche und langsame Fahrt zu regulieren und hat den großen Vorteil, daß die ganze Seillänge ohne Verlust für Schlingen oder Befestigungen ausgenutzt werden kann, wenn das Seil, wie in Nr. 1 der „Mitteilungen" von 1907 beschrieben, mit einem Eisenring versehen ist und durch den kleinen Ring der Seilschlinge gezogen wird. Dabei ist noch besonders hervorzuheben, daß bei dieser Abseilung das Seil geschont bleibt, da es sich an der glatten Fläche des Rings nicht abscheuert. Um nun auch die Seilschlinge wieder zu erlangen, empfehle ich, sie nicht in gewohnter Weise aufzuhängen, sondern so um den Fels zu legen, daß zwei Schleifen nach unten hängen, von denen eine mit einer Rebschnur versehen ist, an welcher nach dem Einholen des Seils mit Leichtigkeit die Schlinge ebenfalls herunterzuziehen ist. Als besonders vorteilhaft würde ich sogar empfehlen, statt der Seilschlinge nur ein einfaches Seil von etwa 2 m Länge zu verwenden und beide Enden mit kleinen Eisenringen zu versehen, durch welche das Seil gezogen wird. Ein Verfangen beim Einholen dieses kleinen Seils ist nach meiner Erfahrung gänzlich ausgeschlossen.

Wilh. Schmidt-S. Offenbach a. M.»

C. Mit größter Ausnützung der Seillänge.

Soll nur ausnahmsweise angewandt werden, da die Abnützung des Seiles durch die gegenseitige Reibung und die starke Knickung an der Ringumwindung eine sehr große ist.

Aus ca. 2 m Reepschnur knüpfe einen Ring, der doppelt genommen durch einen geschmiedeten Strangring gezogen und als Sitzschlinge benützt wird.

Durch denselben Strangring ziehe zweimal das untere Ende des einfach eingehängten Seiles (s. S. 14) und halte mit der rechten Hand das nach unten führende Stück. Aufwärtsziehen bremst.

Als Selbstsicherung beim Abseilen kann eine von Sixt-Kröner konstruierte, 250 g schwere Klemmvorrichtung (in München bei Karl Biber) empfohlen werden.

Left: 1910 description of abseil method with strong forged "iron" rings that were readily available (these are most certainly forged steel rings). Right: Anwendung des Seiles, 1913

- The largest HMS carabiners can also be used for rappelling with a munter hitch (the size is needed to accommodate the hitch with two strands of rope). These are usually the heaviest carabiners.

Locking mechanisms

Carabiners fall into three broad locking categories: non-locking, manual locking and auto locking.

Non-locking

Non-locking carabiners (or snaplinks) have a sprung swinging gate that accepts a rope, webbing sling or other hardware. Rock climbers frequently connect two non-locking carabiners with a short length of webbing to create a quickdraw (an extender).

Two gate types are common

Solid gate: The more traditional carabiner design, incorporating a solid metal gate with separate pin and spring mechanisms. Most modern carabiners feature a 'key-lock nose shape and gate opening, which is less prone to snagging than traditional notch and pin design. Most locking carabiners are based on the solid gate design.

Wire gate: A single piece of bent spring-steel wire forms the gate. Wire gate carabiners are significantly lighter than solid gates, with roughly the same strength. Wire gates are less prone to icing up than solid gates, an advantage in Alpine mountaineering and ice climbing. The reduced gate mass makes their wire bales less prone to "gate flutter", a dangerous condition created when the carabiner suddenly impacts rock or other hard surfaces during a fall and the gate opens momentarily due to momentum and both lowers the breaking strength of the carabiner when open and potentially allows the rope

to escape. Simple wiregate designs feature a notch that can snag objects (similar to original solid gate designs) but newer designs feature a shroud or guide wires around the "hooked" part of the carabiner nose to prevent snagging.

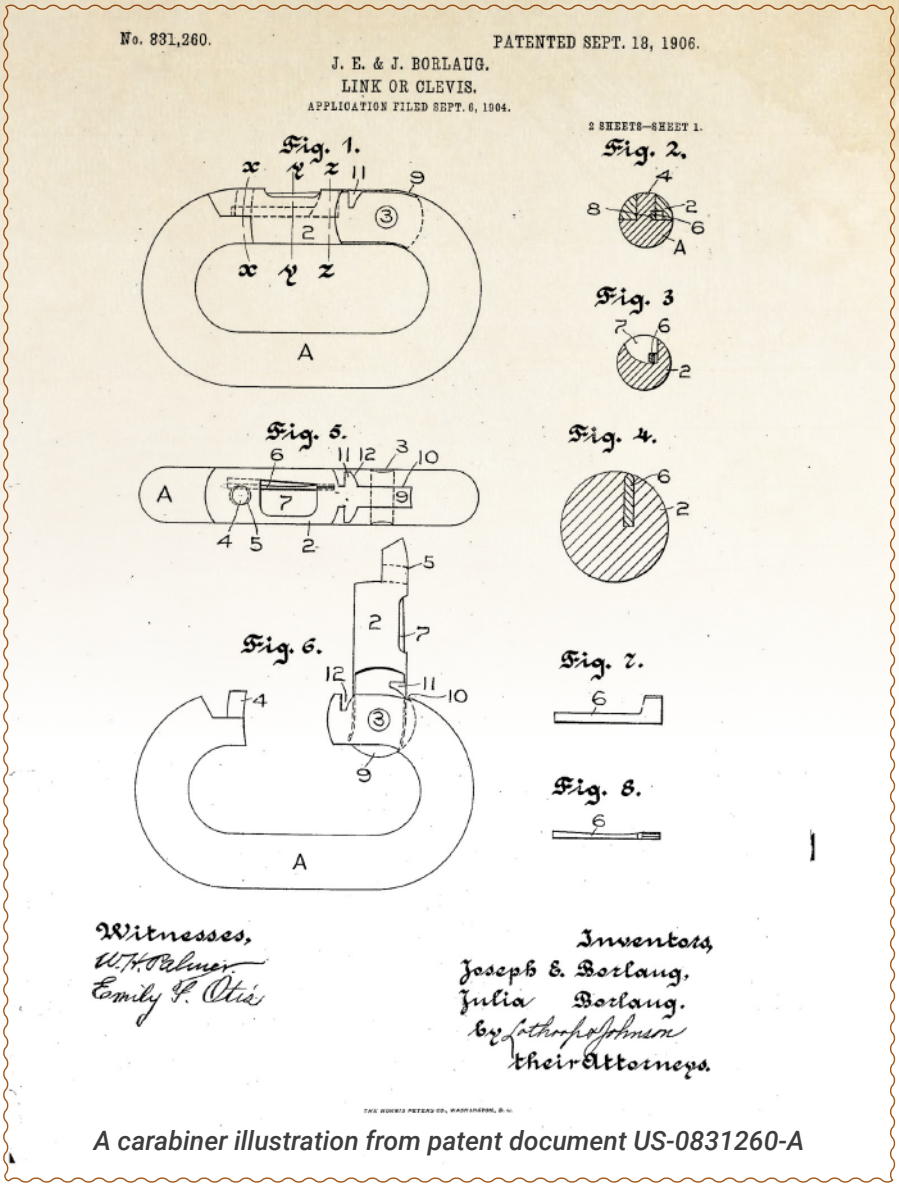
Both solid and wire gate carabiners can be either "straight gate" or "bent gate". Bent-gate carabiners are easier to clip a rope into using only one hand, and so are often used for the rope-end carabiner of quickdraws and alpine draws used for lead climbing.

Locking

Locking carabiners have the same general shape as non-locking carabiners but have an additional mechanism securing the gate to prevent unintentional opening during use. These mechanisms may be either threaded sleeves (screw-lock), spring-loaded sleeves (twist-lock), magnetic levers (Magnetron), other spring loaded unlocking levers or opposing double spring loaded gates (twin-gate).

Manual

Screw-lock (or screw gate): Have a threaded sleeve over the gate which must be engaged and disengaged manually. They have fewer moving parts than spring-loaded mechanisms, are less prone to malfunctioning due to contamination or component fatigue and are easier to employ one-handed. They, however, require more total effort and are more time-consuming than pull-lock, twist-lock or lever-lock.



A carabiner illustration from patent document US-0831260-A

Auto-locking

Twist-lock, push-lock, twist-and-push-lock: Have a security sleeve over the gate which must be manually rotated and/or pulled to disengage but which springs automatically to locked position upon release. They offer the advantage of re-engaging without additional user input but being spring-loaded are prone to both spring fatigue and their more complex mechanisms becoming balky from dirt, ice, or other contamination. They are also difficult to open one-handed and with gloves on and sometimes jam, getting stuck after being tightened under load and being very hard to undo once the load is removed.

Multiple-levers: Having at least two spring loaded levers that are each operated with one hand.

Magnetic: Have two small levers with embedded magnets on either side of the locking gate, which must be pushed towards each other or pinched simultaneously to unlock. Upon release the levers pull shut


verfertigtes Musterstück habe ich nun seit drei Jahren im Gebrauch und es hat sich als vorzüglich bewährt. Die Abmessungen sind so gehalten, daß der Hammer leicht in einer Tasche untergebracht werden kann. Zug und Griff sind vortrefflich, die pyramidenförmige Spitze des Vorderteiles leistet bei Vereisung oder auf hartem Schnee gute Dienste.

Ist nun der Mauerhaken eingetrieben, so wird das Seil nicht unmittelbar durch den Ring gezogen, was ein Losseilen beider Teilnehmer erfordern würde, sondern es wird durch einen starken Karabiner aus Stahl mit dem Ringe verbunden: Sehr geeignet hiezu sind sogenannte Feuerwehrkarabiner (Fig. 3); noch vorteilhafter wäre eine ovale

Fig. 3.

- and into the locked position against a small steel insert in the carabiner nose. With the gate open the magnets in the two levers repel each other so they do not lock or stick together, which might prevent the gate from closing properly. Advantages are very easy one-handed operation, re-engaging without additional user input and few mechanical parts that can fail.

Double-gate: Have two opposed overlapping gates at the opening which prevent a rope or anchor from inadvertently passing through the gate in either direction. Gates may only be opened by pushing outwards from in between towards either direction. The carabiner can therefore be opened by splitting the gates with a fingertip, allowing easy one hand operation. The likelihood of a rope under tension to split the gates is therefore practically none. The lack of a rotating lock prevents a rolling knot, such as the Munter hitch, from unlocking the gate and passing through, giving a measure of inherent safety in use and reducing mechanical complexity.

Certification: Europe

Recreation: Carabiners sold for use in climbing in Europe must conform to standard EN 12275:1998 "Mountaineering equipment – connectors – safety requirements and test methods", which governs testing protocols, rated strengths and markings. A breaking strength of at least 20kN (20 000 Newtons = approximately 2 040 kilograms of force, which is significantly more than the weight of a small car) with the gate closed and 7kN with the gate open is the standard for most climbing applications, although requirements vary depending on the activity. Carabiners are marked on the side with single letters showing their intended area of use, for example, K (via ferrata), B (base) and H (for belaying with an Italian or Munter hitch).

Industry: Carabiners used for access in commercial and industrial environments within Europe must comply with EN 362:2004 "Personal protective equipment against falls from a height. Connectors." The minimum gate closed breaking strength of a carabiner conforming with EN 362:2004 is nominally the same as that of EN 12275:1998 at around 20kN. Carabiners complying with both EN 12275:1998 and EN 362:2004 are available.

Certification: United States

Climbing and mountaineering: Minimum breaking strength (MBS) requirements and calculations for climbing and mountaineering carabiners in the USA are set out in ASTM Standard F1774. This standard calls for a MBS of 20kN on the long axis and 7kN on the short axis (cross load).

Rescue: Carabiners used for rescue are addressed in ASTM F1956. This document addresses two classifications of carabiners, light use and heavy-duty. Light use carabiners are the most widely used and are commonly found in applications including technical rope rescue, mountain rescue, cave rescue, cliff rescue, military, SWAT and even by some non-NFPA fire departments. ASTM requirements for light use carabiners are 27kN MBS on the long axis, 7kN on the short axis. Requirements for the lesser-used heavy duty rescue carabiners are 40kN MBS long axis, 10.68kN short axis.

Fire rescue: Minimum breaking strength requirements and

calculations for rescue carabiners used by NFPA compliant agencies are set out in National Fire Protection Association standard 1983-2012 edition Fire Service Life Safety Rope and Equipment. The standard defines two classes of rescue carabiners. Technical use rescue carabiners are required to have minimum breaking strengths of 27kN gate closed, 7kN gate open and 7kN minor axis. General use rescue carabiners are required to have minimum breaking strengths of 40kN gate closed, 11kN gate open and 11kN minor axis. Testing procedures for rescue carabiners are set out in ASTM International standard F 1956 Standard Specification of Rescue Carabiners.

Fall protection: Carabiners used for fall protection in US industry are classified as "connectors" and are required to meet Occupational Safety and Health Administration standard 1910.66 App C Personal Fall Arrest System which specifies "drop forged, pressed or formed steel or made of equivalent materials" and a minimum breaking strength of 22kN.

American National Standards Institute/American Society of Safety Engineers standard ANSI Z359.1-2007 Safety Requirement for Personal Fall Arrest Systems, Subsystems and Components, section 3.2.1.4 (for snap hooks and carabiners) is a voluntary consensus standard. This standard requires that all connectors/carabiners support a minimum breaking strength (MBS) of (22kN) and feature an auto-locking gate mechanism which supports a minimum breaking strength (MBS) of 16kN.

Understand the standards

A kiloNewton is the unit used to measure carabiner strength and it can be tricky to understand in climbing scenarios as it is not a static force. Instead, it means mass times acceleration or how much weight is moving times the accelerating force of gravity. For a better real-world understanding of this measurement, you can think of 1kN as approximately 225 pounds.

The major axis is the long side of the carabiner, which runs parallel to the spine, while the minor axis is perpendicular to that. The strongest orientation is always along the major axis with the gate closed. Applying force on the minor axis is called cross-loading, a dangerous situation since this axis is much weaker.

Modern climbing biners are rated to at least 20kN along the major axis with the gate closed and 7kN along the minor axis and with the gate open. But how did companies arrive at these numbers for industry standards?

The German military found that parachuters jumping out of planes could withstand up to 12kN in a full-body harness, so this became a standard for harnesses and ropes.

When determining how strong a biner needed to be, engineers took into account the force from the rope on the biner and found that the belay side had to hold 8kN. This breaks down to 12kN on the climber's side and 8kN on the belay side, so 20kN total. The 7kN rating was determined after a series of field accidents where carabiners were failing at a rating of 6kN, so the regulation was upped to 7kN.

Sources: Climbing, Wikipedia, High Snobiety

Pierre Allain aluminium carabiner, unknown exact date but likely between 1950s–1960s. Maker's mark "P. ALLAIN 1600KG" stamped on one side, reverse side stamped "BREVETE S.G.D.G." (sans garantie du gouvernement), which translates from French to "Patent without government guarantee." Richard K Irvin Collection