ROPES

a guide for climbers and mountaineers

PHOTO: DANARKLE.COM

BMC

FOREWORD

The BMC: 70 years old and 76,000 members strong

The British Mountaineering Council (BMC) was formed in 1944, and exists to promote the interests and protect the freedoms of climbers, hill walkers and mountaineers in England and Wales. In our 70th anniversary year, we now have over 76,000 members who support our work across a broad range of programmes including:

ACCESS & CONSERVATION: campaigning for access whilst promoting conservation

CLIMBING WALLS: supporting the management and sustainable development of climbing walls

CLUBS: facilitating the sharing of information and advice between BMC affiliated clubs

COMPETITIONS: developing competition climbing in Britain and managing the GB Climbing Team

EQUIPMENT: providing an informed source of technical advice on safety equipment

EQUITY: working to identify and remove barriers to participation

GUIDEBOOKS: publishing climbing guidebooks to the Peak District and surrounding Pennine areas

HERITAGE: preserving mountaineering's rich heritage of artefacts, history and traditions

HUTS: offering advice and guidance on the management and use of club huts

INTERNATIONAL: supporting British mountaineers travelling overseas with information and grants

MOUNTAIN MEDICINE: providing expert medical advice on keeping fit and healthy in the mountains

SKILLS: helping climbers, hill walkers and mountaineers to develop their skills

YOUTH: providing advice and support for young people and their parents

CONTENTS

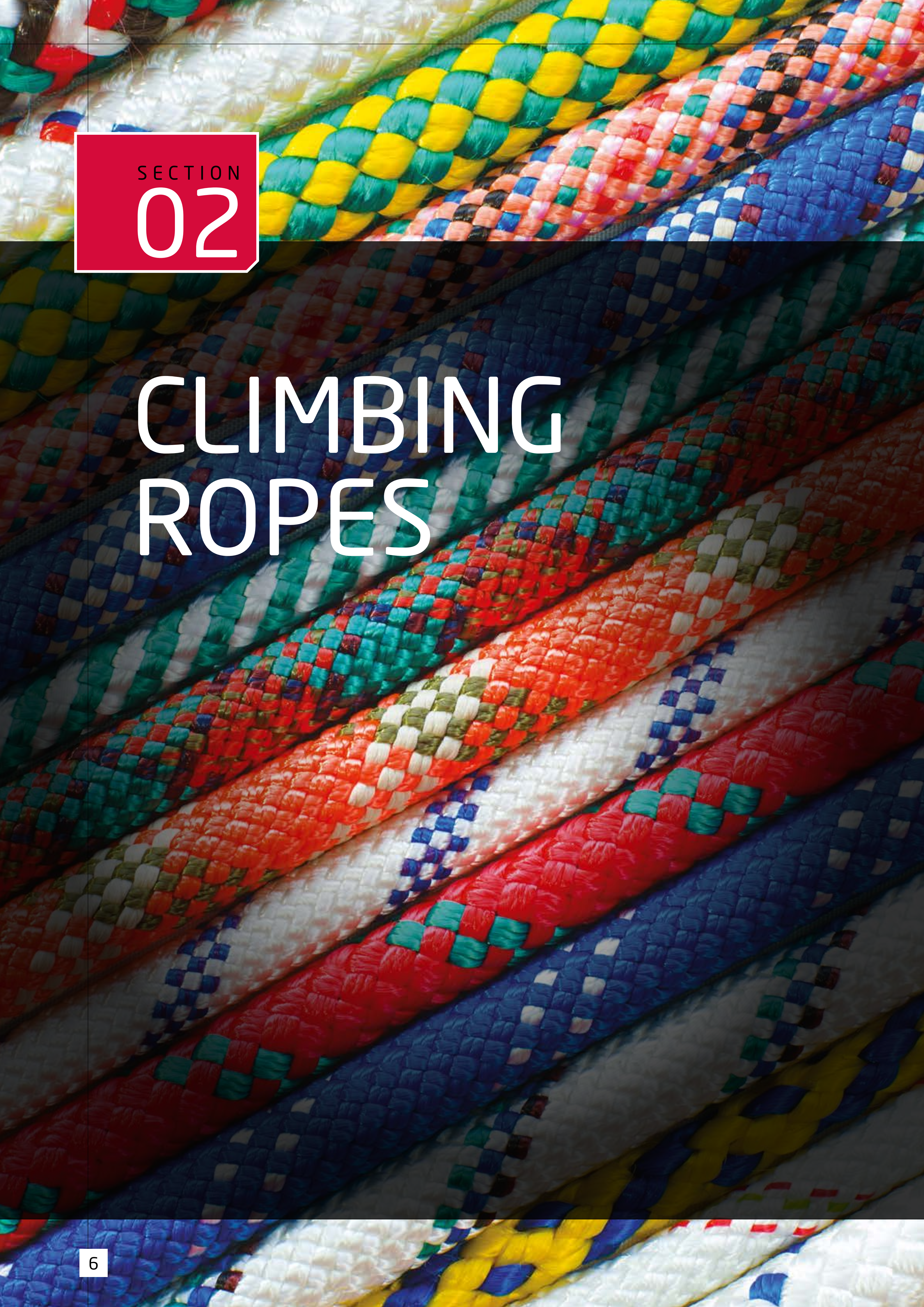
SECTION 01

INTRODUCTION

The purpose of this guide is to help climbers and mountaineers choose suitable ropes and provide advice on how to safely use and maintain them.

There has never before been such a wide range of different ropes to choose from – these vary in length, diameter, finish and construction. Some may be designed for a particular type of climbing, others make a good all-rounder. The rope is a critical piece of safety equipment, therefore choosing a suitable rope is crucial. This guide explains some of the important features to help you decide which is the best choice for you.

It is absolutely vital that a rope is used safely and maintained effectively. This guide gives advice on how to avoid damage, how to inspect for damage and how to generally maintain and care for a rope.



SECTION 02

CLIMBING ROPES

Dynamic climbing ropes stretch to reduce the peak force of a fall. You should always use dynamic rope for lead climbing as it is the only type which can effectively dissipate the energy of a falling leader. A dynamic rope is also generally the best choice for top and bottom roping.

There are three types of dynamic climbing rope; these are described below.

PHOTOS: BMC

SINGLE ROPE

Single ropes are designed to be used alone. The diameter of a Single rope currently ranges from 8.9mm to 11mm; however a general trend from manufacturers is to produce thinner and lighter ropes.

HALF ROPE

Half ropes, also referred to as Double ropes, are designed to be used in pairs as part of a double rope system where each rope is clipped in to runners separately so that rope drag can be reduced. They range in diameter from 7.8mm to 9.1mm.

Traditionally, ropes have been of only one type or another. More recently, ropes have become available which meet multiple standards, so it is possible to have a rope which can be used as a single, half or twin rope.

TWIN ROPE

Twin ropes are always used in a pair and are essentially two thinner strands of rope designed to do the job of a Single rope – when leading with twin ropes, both ropes should clipped in to every runner together. This is because an individual strand is not designed to take a lead fall. These ropes are rarely used or seen in Britain. Twin ropes are usually between 7.5mm and 8mm in diameter.

SECTION 03

CHOOSING A ROPE

An important initial choice is whether to use a single rope, half ropes or twin ropes.

SINGLE ROPE

Using a single rope is simpler and lighter than using a pair of half ropes, and works best on climbs where protection is provided in a fairly straight line; such as at an indoor climbing wall, on a sport climb or on some traditionally protected climbs. Longer extension of protection pieces may be needed to allow smooth running of the rope and to prevent traditional protection from lifting out.

When using a single rope it is usually only possible to abseil half the length of the rope and still retrieve it. The simplicity of a single rope system can make it a good choice for novices.

HALF ROPES

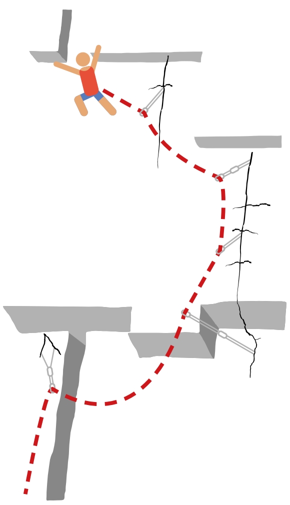
Using a pair of half ropes often makes it easier to keep rope drag at bay; by carefully choosing which rope you clip into successive pieces of protection it is usually possible to avoid serious rope drag even on the most wandering pitches. If a climb involves zigzagging or traversing then using half ropes is often better.

Using a pair of half ropes will enable you to abseil the full length of the ropes and still retrieve them. This is useful if you are climbing a multipitch route and either need to retreat, or plan an abseil descent. Usefully, if one rope becomes damaged you will still be able to use the other rope.

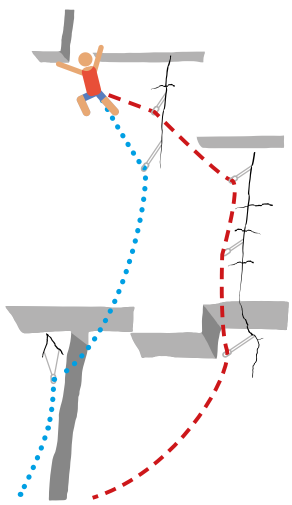
TWIN ROPES

Twin ropes offer the same abseiling advantages as half ropes, but unlike half ropes they do not allow you to reduce rope drag by clipping protection points into only one of the ropes in the pair.

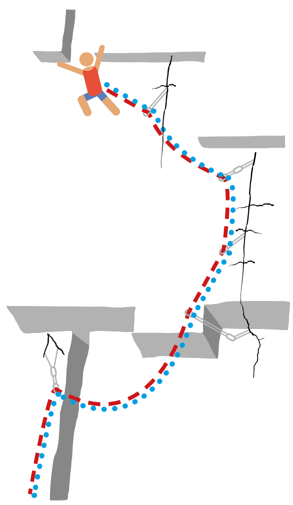
EXAMPLE 1
SINGLE ROPE SYSTEM



EXAMPLE 2
HALF ROPE SYSTEM



EXAMPLE 3
TWIN ROPE SYSTEM



ROPE PROPERTIES

Many of the properties we need to consider when choosing a rope can be found on the rope label.

ROPE LENGTH

Climbing use	Typical rope lengths
All round use	50 - 60m
Sport climbing	60 - 80m
Scrambling, Walking & via Ferrata	25 – 35m

A shorter rope is less weight to carry, but means more pitches must be climbed on longer routes. The modern trend is for longer ropes, especially for sport climbing. Many sport routes now require 70m ropes to allow safe lowering off without re-belaying. Always check that your rope is long enough, and when belaying, lowering or abseiling tie a knot in the end just in case.

DIAMETER AND MASS

Choosing a suitable diameter is a balancing act between having a lightweight rope and having a longer rope lifetime.

Diameter (mm)	Typical mass per metre (g)	Length (m)	Mass of rope (kg)
11.0	70	60	4.2
11.0	70	50	3.5
8.9	52	60	3.1
8.9	52	50	2.6
7.8	40	60	2.4

In general a larger diameter rope will last longer. They are also generally easier to hold falls with when using manual braking devices, so a thick rope is a good choice for a novice belayer.

Diameter alone is not the best measure of how hard wearing a rope will be because some ropes are denser than others. If two ropes have the same diameter but one weighs more (per metre) then this tells you that the heavier rope has more material in the body of the rope and will likely be more hard wearing. Thin and lightweight ropes tend to wear out faster so they are generally used only when low weight is the top priority, for example when Alpine climbing or for hard sport routes.

The unit mass of a rope when measured at home will be higher than expected. This isn't because the manufacturers are ripping you off; it's because of the way the mass per metre figure is measured. To obtain the figure, the rope is measured and cut when loaded by a fixed amount. This makes for a consistent test, but does underestimate the total weight of the rope in use.

IMPACT FORCE

This is the force transmitted through the rope to the climber at the moment a fall is arrested. The Impact force of a rope represents how well a rope can absorb the energy of a fall. The quoted figure is derived from the standard drop test, which is a very severe fall. A low Impact force rope will provide a softer catch, or in other words the climber will slow down more gradually. This is more comfortable for the falling climber and also reduces the load on the runners and anchors, meaning marginal protection is less likely to fail.

Choosing a lower Impact force rope may be preferable if you use traditional gear or ice screws, or if you just want the longest possible use. The Impact force of all ropes will increase with use and as they accumulate falls.

However, ropes with lower impact forces tend to be stretchier, that is, they have greater elongation. In a fall you will effectively fall further due to the stretching. Falling further could increase your chances of hitting something on the way down. Also, ascending a very stretchy rope is hard work.

The impact forces quoted for single and half ropes are not readily comparable as they are each tested with a different mass.

ELONGATION

If a rope has high elongation it will be very stretchy. Low elongation is useful if you are top roping or ascending. Ropes with low elongation tend to have higher impact forces.

NUMBER OF FALLS BEFORE FAILURE

In the EN Standard for Dynamic Ropes a sample of rope is drop tested repeatedly until it fails. Based on the result of these tests the manufacturer has to state the number of drops which they will guarantee that the rope can take without failing. This will be written in the information supplied with a rope. Each drop test is roughly equivalent to an extremely severe fall. This number is not the number of falls before you have to retire a rope. The numbers quoted for single and for half ropes are not readily comparable as they are not tested with the same mass. A rope that can handle a larger number of falls will tend to last longer.

OTHER FEATURES

DRY TREATMENTS

A wet rope is unpleasant to handle, heavy and prone to freezing. Also, while a rope is wet its strength will be reduced; hence various chemical and physical treatments have been developed to reduce the absorption of moisture. These dry treatments can also increase rope life by reducing the tendency of dirt to enter the weave and by reducing running friction. Treatments become less effective with extensive use of the rope but manufacturers are gradually improving longevity. Dry treatment can make the rope harder to grip ,especially when new. Take great care when belaying with an unfamiliar rope, particularly if it is new, thin and dry treated. Both the core and the sheath of a rope can be dry treated. Ropes with both parts treated will be more resistant to water than ropes with dry treatment of the sheath only.

Choose dry treated ropes for winter or alpine use, or if you climb in the rain: they will absorb less water and therefore be lighter and easier to handle.

HANDLING AND CONSTRUCTION

Each rope feels and handles differently, even ropes which are the same diameter can behave very differently. Some are soft and supple while others maintain their round cross section more firmly. Often you can check the feel of a rope without having to remove it from its packaging in a shop. The handling properties can also affect how much friction there is between a rope and belay device; take care because some rope and belay device combinations may not give enough friction to comfortably hold a fall.

There are some ropes on the market that use an extra thick sheath to make them more hard wearing. These ropes tend to have a higher impact force and so may not be ideal for all types of climbing, but in high wear and tear situations like indoor climbing, they can be a good option.

Indoor climbing using a single rope

PHOTO: BMC

TYPE OF CLIMBING

TRADITIONAL

A pair of half ropes is usually most appropriate. Low impact force is preferable, dry treatment is optional. If you are climbing on a shorter single pitch outcrop it may be possible to use one half rope as though it was a 'pair' simply by doubling it up and having the leader tie into both ends while the second ties into the middle. On easier routes some people will use a single shorter rope instead. A single rope might also be the best choice when starting out as a climber or if on a budget. A single rope simplifies rope work and belaying, and can be used for all types of climbing if necessary.

SPORT

A single rope is most practical for single pitch sport climbing. A 60m rope is usually ideal, but consider a 70m or 80m rope if planning on sport climbing abroad, for those long modern pitches. The best solution is probably to have a relatively thick and hard wearing rope for working routes and top roping, and a lighter one for red pointing. Many climbers will have to compromise and plump for one rope in the 9.5 – 10.5mm diameter range to do both.

For long multipitch sport climbs it may be best to have the option of being able to abseil full 60m lengths – in which case you could use a pair of half ropes, or alternatively a combination; a single to lead with and a lightweight half or twin rope stored away in a rucksack in case abseiling is required.

INDOOR

A large diameter heavyweight single rope is preferable (e.g. 10-11mm) because it will stand up better to the wear and tear of wall use. It is generally easier to hold falls with a thicker rope too. Some manufacturers sell extra 'tough' ropes for indoor use – these are usually large diameter ropes with an extra thick sheath to help them stand up to the abuse of intense indoor use. You may only require a short rope for many climbing walls, but always check first. Better to have a rope that's too long than too short.

PHOTO: DANARKLE.COM

PHOTO: CLIMBWHENYOUREREADY.COM

ALPINE, WINTER OR ICE

A pair of half ropes – either 50m or 60m long. Dry treatment is important and a low impact force is preferable. For steep rock routes the pair will be used together as a normal half rope system, whilst for less difficult routes where you move together you might rope together using just use one rope from the pair. Low weight is very important for alpine climbing but be aware that skinny lightweight ropes may wear out quickly on alpine rock routes. On easier routes some people may use a shorter single rope instead. (see Scrambling and walking below).

Twin ropes are occasionally used for ice climbing – these can be slightly lighter than half ropes but are less versatile as both ropes must always be clipped into each piece of protection. Perhaps the best choice is to use the lightest, thinnest, lowest impact force half ropes for icefalls and pure ice climbing, but to choose a slightly heavier and more durable pair for routes with a lot of rock climbing.

BIG WALL

A large diameter heavyweight 60m single is preferable (e.g. 10-11mm diameter) for use as the main leading rope. There are many different rope systems for climbing big walls but as an example you might also need a 60m low stretch rope for hauling and a thin half rope for use as a 'zip-line'.

PHOTO: S.MACALEESE COLLECTION

SCRAMBLING AND WALKING

A shorter piece (25-35m) of single rope may be used when scrambling to protect the more difficult parts of a route. A short single rope is best because it is light and can easily be stowed away when not in use. Traditionally a single strand of half rope was used, but with the advent of thinner single ropes, it makes sense to choose one of these – they'll last longer and be more secure to belay with.

A walker's safety or confidence rope is intended for emergency use only. It isn't intended to hold falls or to belay a leader. It is designed to enable a leader to rig hand lines, and allow short rock steps to be descended by lowering and abseil. As this usage is below that required by the dynamic rope standard, many manufacturers repackage a single strand of their lightest twin or half rope and sell short lengths as a walker's rope. Never use a walker's rope for scrambling or climbing.

PHOTO: CLIMBWHENYOUREREADY.COM

Table: choosing a dynamic climbing rope for each type of climbing.

	Traditional	Sport	Indoor	Winter/ Alpine/Ice	Big wall	Scrambling/ Walking
Length of rope	50 or 60m	60-80m	30m or more	50 or 60m	50 or 60m	25-35m
Diameter	Small for low weight, or large for lasting longer, 8.5-9mm	Small for low weight, large for longer lasting, 8.7-10.5mm	Large for long life, 10.5-11mm	Small to medium, 8mm icefalls 8.5mm rock	Large for hard wearing, 11mm	Small to medium for moderate weight, 8mm walking, 9-9.5mm scrambling
Dry treatment	Preferable	Optional	Optional	Yes	Yes	Preferable
Single or half ropes	Either	Single	Single	Half ropes	Either	Single
Desirable properties	Low impact force	High number of UIAA falls	Hard wearing (heavy weight), thick sheath	Low weight, low impact force	Hard wearing (heavy weight), abrasion resistant	Low weight

OTHER ROPES FOR CLIMBING

LOW STRETCH ROPE

Low stretch ropes, often referred to as semi-static, are used primarily in caving and rope access work. Low stretch ropes should never be used for leading as they do not have enough stretch to effectively dissipate the energy of a lead fall.

The main uses for low stretch rope in climbing are abseiling and ascending, and for rigging anchors. Dynamic climbing rope can also be used in these situations; but low stretch rope is preferred. Abseiling and ascending on a low stretch rope is less effort as the rope does not bounce and stretch as much. This reduced stretching also helps to reduce abrasion damage due to the reduced rope movement over rock. Low stretch ropes are also much stiffer and harder wearing than dynamic ropes. If you climb regularly at sea cliff venues where you need to abseil to the start of the routes, a low stretch rope might be a worthwhile investment. If you leave the abseil rope in place you will be able to escape from the bottom of the cliff by ascending it to safety.

ACCESSORY CORD

Accessory cord is commonly available in diameters from 4 to 8 mm, and can be used to make cord slings or Cordelettes, Prusik loops, or for threading runners. Accessory cord does not have the energy absorbing capacity of dynamic rope and therefore should never be used as a lead rope.

Choosing accessory cord is mainly down to selecting the right diameter. If you are using the cord to make Prusik loops then 5 or 6mm will usually work well; try to choose a soft, pliable cord as these grip or "bite" better than a stiff construction. If you are using the cord to thread nuts or other runners then choose a cord diameter so that the cord is at least as strong as the runner itself. Nylon cord is most commonly available but it is also possible to get Dyneema® cord; this is stronger than nylon but is not suitable for making Prusik loops, as it has a low melting point and poor frictional qualities.

PHOTOS: BMC

SECTION
04

CARE AND MAINTENANCE

It is important to take good care of all climbing equipment and the rope is no exception. Depending on how it is used a rope can last many years. Heavy use can reduce the lifetime to months or even weeks, whilst poor treatment or misuse can require immediate retirement of a rope.

The overriding priority whilst using a rope is to prevent it from dragging over sharp edges and rough rock. This requires constant attention to where the rope might run during a climb, and also to how and where it will be loaded over the rock in a fall. This requires some skill on the part of the climber whilst placing runners; try to avoid sharp edges and protrusions near your runners. The use of a rope protector or padding material can greatly reduce the risk of rope damage when top-roping or abseiling.

When alpine or winter climbing you must take extra care not to accidentally damage your rope with your axes or crampons. Even when not wearing crampons it is best to avoid standing on your rope as this can embed dirt into it.

CAUSES OF DAMAGE

SHARP EDGES AND ROUGH SURFACES

Abrasion or cutting occurs if a rope moves over a rough surface or sharp edge. This can happen in many situations; for example during a fall, whilst abseiling or whilst top-roping. Where possible try to make sure that your rope does not run over rough or sharp surfaces, especially while it is weighted. The sheath will wear out very quickly if the rope is loaded while running over a rough surface or sharp edge. Rope protectors can be used to reduce abrasion; these are usually sheaths or covers which stop the rope from touching the sharp edge directly.

FALLS

Even moderate falls will very gradually reduce the dynamic properties of a rope. A rope which has held a fall with a fall factor of greater than 1 should no longer be used for leading. It may still be fine to use the rope for top-roping or abseiling but it should be inspected thoroughly for damage before being used again. See Annex IV for explanation of fall factors.

ROCK FALL

Rock fall can cause catastrophic damage to a rope. Large rocks need not fall very far to cause severe damage, whilst smaller rocks can cause very severe damage if they have had time to gain speed.

GRIT, SAND OR DIRT

These can work their way deep into a rope and cause internal damage to the rope which may not be visible. Try to avoid laying your rope down directly on the ground if it is likely to pick up debris; the use of a rope bag as a ground sheet can help in stopping dirt from becoming ingrained. Regularly clean your rope to extend its lifetime, particularly after use in sandy or muddy environments.

HEAT

Ropes should not be exposed to high temperatures. As a rough guide it is best not to expose your rope to temperatures above 50°C. However, recommendations from manufacturers vary and you should always consult the documentation which comes with a rope. Above the recommended maximum temperature the properties of the rope may begin to be permanently adversely affected. High temperatures can be achieved by friction heating if a loaded rope is allowed to slide over another rope or sling; it is surprisingly easy to melt ropes or slings in this way. Abseiling or lowering too quickly can cause your belay device to become very hot and melt the surface of a rope. Although they may become stiffer or frozen when cold; ropes can be safely used down to -40°C.

CHEMICALS

Corrosive chemicals such as acids cause catastrophic damage to ropes. Many household cleaners contain strong acids which would quickly cause severe damage to a rope. This damage is not always visible so if you suspect your rope has been subjected to any corrosive chemicals it is best to discard it immediately. Batteries are another household source of strong acid – car batteries are particularly hazardous and should be kept away from ropes.

UV

Sunlight can cause discolouration and accelerate aging; a rope subjected to intense sunlight for prolonged periods of time might become more rigid and lose elasticity in its sheath, therefore when not in use ropes should be stored out of direct sunlight.


Abrasion damage to sheath


Coreshot


Contaminated


Glazed

PHOTOS: BMC

PHOTO: EMILY JONES

Checking rope

› HOW TO CHECK AND WHEN

The key to preventing failure is to check your rope for damage before it is used and to minimise abrasion while you are using it. Checking your rope regularly is crucial and is probably most conveniently done whilst uncoiling and coiling the rope before and after each climbing session. As you uncoil and flake out your rope you should pay close attention to the look and feel of the rope. Pull the rope over your hand and squeeze or bend it to see how it behaves. You should inspect the entire length of the rope in this way; looking for any irregularities in its behaviour or appearance.

Damage might be in the form of burnt or melted sections, unexpectedly soft or stiff sections, and visible abrasion or cuts. You should check your rope as soon as possible if you suspect a rock has fallen on it or if it has held a major leader fall. Evidence of severe chemical damage may include patchy fading or discolouration. If your rope has any of the damage described above, or any other significant damage, you should stop using it.

CLEANING A ROPE

Regular washing maintains good handling properties and prolongs rope life. Some manufacturers recommend machine washing on a gentle setting (for example the wool program) at low temperature. Some manufacturers offer proprietary detergents specifically for cleaning ropes; a mild (pH neutral) detergent such as soap flakes is an alternative. Before machine washing make sure that the detergent drawer in your machine is rinsed out and clear of any previous residues which may be too harsh for cleaning a rope. Hand washing with warm water is also possible; a good place to clean and soak a rope by hand is in a bathtub. But before washing, make sure that there are no chemical residues in your bath, such as drain unblocker. Using a rope brush will help to remove dirt from the outside of the sheath. Never use a pressure washer as this may push grit particles deeper into the body of the rope. However you wash your rope, make sure that it is rinsed thoroughly afterwards with clean water. Let the rope dry naturally; do not place a rope on or near a radiator or other heat source as this may damage the rope.


Washing rope

PHOTO: EMILY JONES.

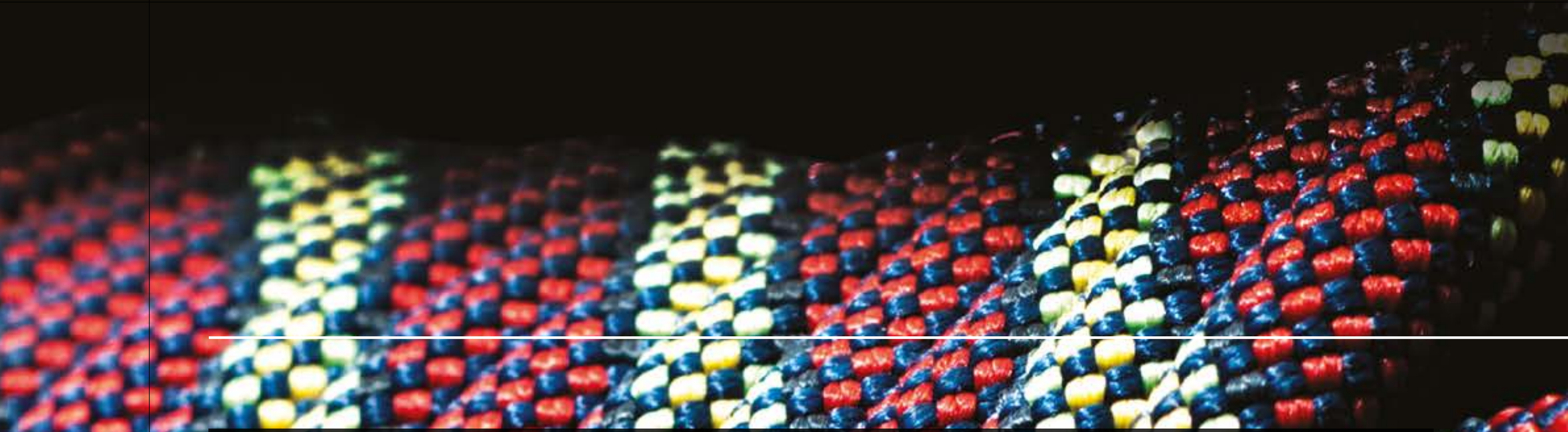
STORAGE & TRANSPORT

Ropes should be stored out of direct sunlight and away from any heat sources such as radiators, boilers or fireplaces. Avoid storing anywhere near cleaning products such as bleach or toilet cleaner, also avoid batteries as they may leak acid, and avoid any other chemicals such as acids or solvents. Also be aware that residues of any of these substances can be present without being visible, for example, if you have in the past stored a car battery in the boot of your car there may still be an acid residue.

For transport ropes can be coiled or carried in a rope bag.


Rope bag

PHOTO: BMC



MAINTENANCE

The sheath of a rope can sometimes slide and 'bunch up' relative to the core. This can make the rope difficult to handle and prone to jamming or uncontrolled movement through a belay device. To remove this sheath slippage the excess sheath should be removed. First, cut the ends off the rope so that the sheath can slide freely off the end of the core. Then push the excess sheath towards the nearest end of the rope so that the excess sheath hangs off the end of the core. Once all of the slack in the sheath has been slid off the ends, cut the ends of the rope with a hot knife to remove the excess sheath and bind the core and sheath together again. Use an old knife, heat the knife on a kitchen stove or naked flame and then cut cleanly through the rope; melting through the rope like this ensures that the core and sheath remain bonded together.

In use a rope can become twisted; this can make it very difficult to feed through a belay device and can make the rope tangle together in a big knot. Mild twists can be removed by simply by gripping the rope lightly with one hand, then gripping more firmly with the other hand and pulling the entire length of rope through your loosely gripped hand. It is important to pull through the whole length so that the twists do not merely bunch up at the end of the rope. More severe twisting can be removed by pulling your rope through a belay device – make sure you do this before you are actually belaying someone. This may need to be done more than once to fully remove the twists.

In a leader fall most damage to the rope tends to occur towards the end of the rope where the leader ties in. If you alternate which end of a rope you climb on it will wear out more evenly and last longer. If an end section gets worn out you may wish to cut it off with a hot knife so that you can keep using the rest of the rope.

WHEN TO RETIRE A ROPE

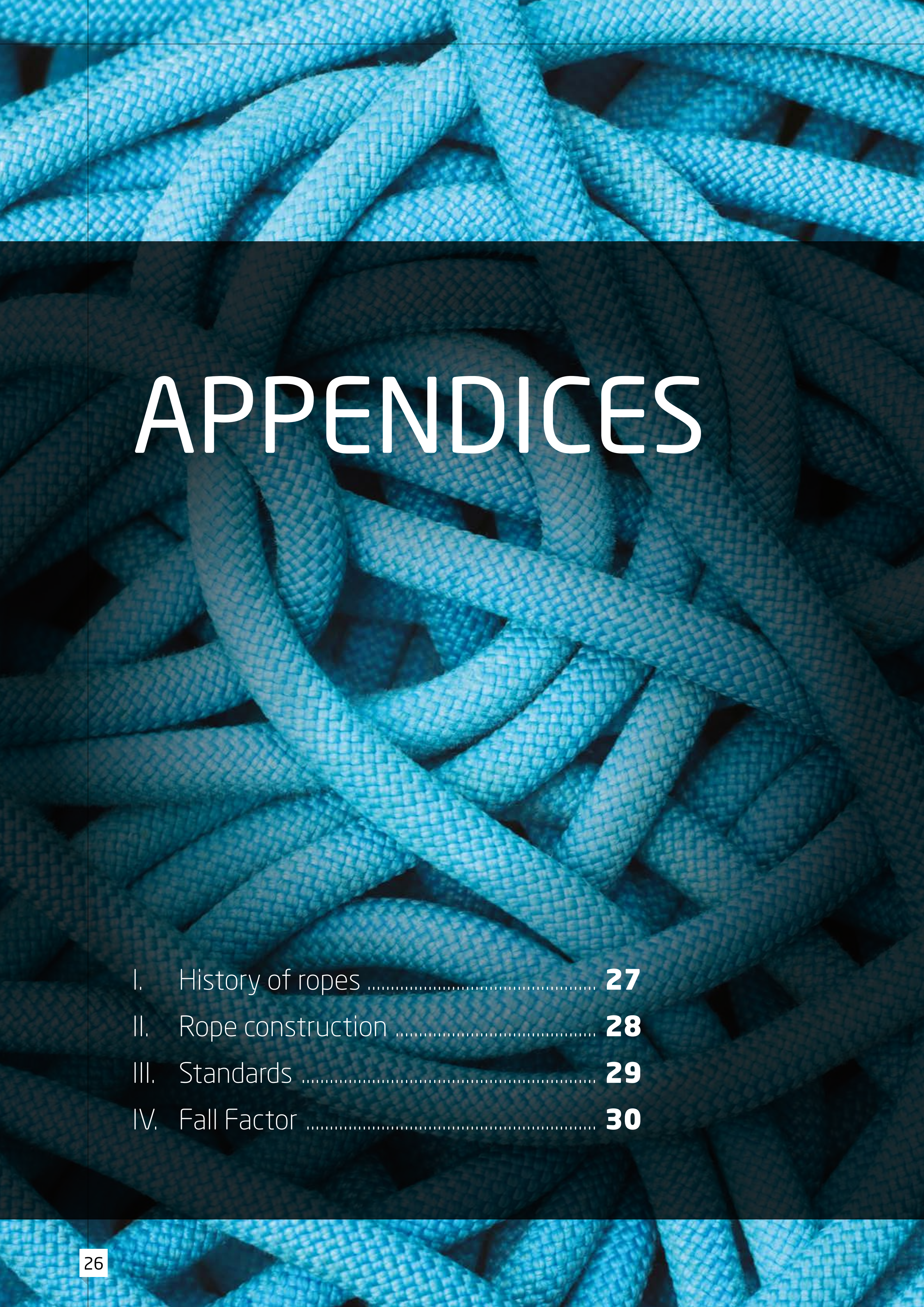
You should stop using and discard a rope when the lifetime given by the manufacturer is exceeded, or if a rope fails a damage inspection. The documents which come with a new rope will tell you the manufacturer's estimated lifetime. If you notice damage when carrying out an inspection you should retire the rope straight away. A good way of ensuring that retired ropes are not used accidentally is to cut them into short sections and dispose of them appropriately; some manufacturers recycle them, so your retired ropes need not go to landfill. Alternatively, retired ropes may be donated to Green Peak Gear (www.greenpeakgear.org) so they can be used to make new products which are sold to raise money for the BMC Access and Conservation Trust.

Knowledge of a rope's history is vital when making decisions about when to retire or downgrade it, since every traumatic event suffered by the rope will cause some damage. Downgrading a rope means no longer using it for leading, but still using it for top-roping or abseiling. As a general rule, you should consider downgrading any rope that has sustained a serious fall (with a Fall Factor of around 1 or more). Apart from knowing the number and severity of falls that a rope has sustained, a more general knowledge of its type and conditions of use is also important so that you can tell how worn out it is compared to its brand new condition. Where a rope is used by many people, for example in climbing clubs or centres, it is very important to keep a log of how and when the rope is used, and if it suffers from any harsh falls or other potentially damaging incidents.

As a very general guideline, with regular usage of around twice a week and no major incidents or falls, a rope may last around 3 years. Heavy use (i.e. most days) will greatly reduce this lifetime, and it is quite possible to wear out a rope in less than six months, whilst on a long holiday for example. Obviously, if used less and well cared for, a rope will have a much longer lifetime.

Sheath slippage

PHOTO: BMC



APPENDICES

I. HISTORY OF ROPES

The design of ropes has changed surprisingly little from Ancient Egyptian times, around 4,000 years ago, all the way up to the 19th century. Advances made over this period mainly related to improvements in rope making machines. Ropes generally consisted of 'laid' or twisted natural fibres. First, fibres were spun to form yarns, several yarns would then be twisted together to make strands, and finally a number of strands were then twisted together to create a rope. This type of rope is referred to as hawser laid and was the best design available for climbing purposes until 1951. For climbers the hawser laid twisted construction was not ideal. While dangling in mid air the climber would spin as the twists in the rope unravelled. In addition the laid construction did not allow ascenders to grip well. Although a hawser laid rope 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 these ropes were stiff, handled poorly, created excessive rope drag, absorbed water quickly and tended to freeze easily.

In 1951 Edelrid™ introduced the first kernmantel climbing rope, which featured an inner load bearing core (kern) protected by an outer sheath (mantel). These ropes solved most of the problems associated with laid ropes and eventually became the industry standard. Kernmantel ropes are the only ones covered by the UIAA and European standards for Dynamic Mountaineering Ropes.

Since the kernmantel rope was first introduced they have undergone many enhancements in performance and handling characteristics, whilst the basic structure has remained the same. In 1966 the first ropes with a water repellent treatment were introduced, again by Edelrid™. Other innovative concepts have come onto the market since, such as ropes that change colour or pattern halfway, ropes with varying sheath tension, and ropes with radio cables for identification purposes. More recently attention has been focused on producing thinner and lighter ropes.

II. ROPE CONSTRUCTION

All modern climbing ropes are kernmantel ropes, consisting of an inner core covered by an outer sheath. In most climbing ropes the core contributes more to the fall holding and dynamic properties of the rope whilst the sheath acts to protect the core from abrasion or cutting. The basic building blocks of both the sheath and the core are Nylon filaments – these are very fine strands of Nylon material. A large number of filaments are twisted together to form a yarn, the number of filaments per yarn and the amount of twist put into the yarn affects the final properties of a rope. Yarns are heat treated in a carefully controlled temperature and pressure cycle. The heat treatment causes the yarns to shrink and affects the ability of the yarns to absorb the energy of a fall. Yarns are then combined in various ways to form the core and sheath.

CORE

Typically several yarns are twisted together to form a ply, then several plies are twisted together to form a bundle, then several bundles are twisted together to form the core. At each stage the number of smaller strands combined to make the next larger strand, and the severity of the twisting used to combine them, are controlled to affect the final dynamic (elongation and energy absorption) properties of the core. The ability of a rope to absorb energy comes roughly half from the elasticity of the yarn and half from the design of the core and sheath. The proportion of energy absorbed in each depends on what proportion of the rope's mass is from the core and how much is from the sheath. In most climbing ropes the majority of mass is in the core – therefore the core is responsible for most of the energy absorption. However in some ropes designed for specific purposes, for example climbing wall ropes, there is more sheath than core. Nylon has considerable natural elasticity and energy absorbing capability, but in itself this is not enough to keep the impact force in a fall at an acceptable level. To achieve the required dynamic properties, core fibres are twisted or otherwise combined to act like a spring and absorb energy, this energy is ultimately converted into heat within the rope.

SHEATH

The sheath covers and protects the core and its design largely defines the handling properties of a rope. The characteristics of the sheath depend on the amount of twist in the sheath yarns, the number of yarns used, the angle of the yarns as they are laid, the braiding pattern, and the tightness of the weave. A loose weave can give supple handling characteristics but will flatten in use and may abrade more easily. A tight weave will be stiffer and tend to be more abrasion resistant.

A very important factor for sheath performance is the number of strands it is woven from – more strands mean a finer sheath. Larger diameter ropes require more strands to maintain an equally fine sheath compared to narrower diameter ropes. The number of strands usually varies between 32 and 48.

Commonly used weave patterns include 2 over 2 (the most common pattern for dynamic ropes) and 2 over 1 (more often used for accessory cord). The former is used more often for dynamic ropes because it tends to give better abrasion resistance and a smoother feel.

DRY TREATMENT

Nylon readily takes up and retains moisture, and when wet its mechanical properties are impaired. A wet rope could hold as little as 50% of the number of falls of a dry rope. Both strength and dynamic properties are negatively affected.

Dry treatments aim to make the rope water repellent. There are a number of different ways to achieve this but most involve submerging the rope in a treatment solution after manufacture – examples include a fluoropolymer based solution, or silicone based solutions. These treatments can also improve abrasion resistance as they may make a rope slide more easily.

III. STANDARDS

EUROPEAN STANDARD EN 892:2012 DYNAMIC MOUNTAINEERING ROPES

Any rope which has been tested according to a European Standard will have the number of that Standard on display on either the rope, or in the information booklet supplied with the rope.

EUROPEAN STANDARD EN 1891:1998 LOW STRETCH KERNMANTEL ROPES

There are two types of low stretch rope: Type A ropes are designed for general use by persons in rope access including all kinds of work positioning and restraint work; Type B ropes are not required to pass such severe tests as Type A but are still suitable for use in rope access.

EUROPEAN STANDARD EN 564:2012 ACCESSORY CORD

Accessory cord comprises a core and sheath, and has a diameter between 4 and 8mm. Accessory cord is intended to hold static loads; it does not possess the energy absorbing properties of a dynamic climbing rope.

UIAA SAFETY LABEL

For many years the UIAA Ropes Standard was the main standard against which mountaineering ropes were tested. The UIAA Standard for Ropes is UIAA 101 and ropes which meet this standard are allowed to use the UIAA Safety Label. The UIAA Standard incorporates all of the requirements in the European Standard EN892 with some additional requirements shown below.

ADDITIONAL REQUIREMENTS

If there is a middle marking on the rope, the marking should be within 1m of the actual middle of the rope.
A single or half rope which withstands 10 or more drop tests may be referred to by the manufacturer as a "multi drop rope".
The diameter of a rope, as given in the information supplied with the rope, should be no more than 0.3mm above or below the measured diameter of the rope.
There should be a warning given in the information supplied with a rope, stating that ropes may shrink during use.

Pictorial versions of the standards can be found at www.theuiaa.org

IV. FALL FACTOR

The Fall Factor gives a good estimate of the 'severity' of a fall. A high fall factor means a severe fall with high forces on the climber and his equipment. There are two main considerations when determining the force exerted upon a climber in a fall, these are; the length of the fall and the length of rope available to absorb the energy of the fall – the Fall Factor is the ratio of fall length to this rope length.

As you fall you accelerate, and as you gain speed you gain kinetic energy. In a long fall you have more time to gain speed and therefore build up more kinetic energy. To arrest the fall this energy must be dissipated by the rope. The rope dissipates this energy through internal friction and by stretching. The length of rope between the belay device and the climber is the only part of the rope which can dissipate the energy of a fall. More rope between the belay device and the climber means more rope is available to dissipate fall energy. Therefore, a long fall where there is very little rope between the belay device and climber will result in a high Fall Factor and a 'severe' fall. On the other hand, a short fall when there is a large amount of rope out between the belayer and climber will result in a low Fall Factor, where the fall will be arrested more 'softly'.

However, the Fall Factor is not a completely accurate measurement of the severity of a fall. For example the Fall Factor does not take into account friction between runners and the rope. If there are runners between a climber and his belayer, then in the event of a fall only the length of rope between the final runner and the climber is free to take the full force of the fall. Rope between successive runners, as you move down towards the belayer, is not fully loaded due to friction between the rope and the runners. This effect is often experienced by a belayer when there is significant rope drag due to the rope rubbing against runners or rock; even a long fall from a heavy climber can seem unexpectedly soft and easy to hold.

Although this might make the life of the belayer easier in that the fall is easier to hold, the flip side is that the climber gets more of a jolt and his top runner is loaded more severely. Friction between the rope and runners reduces the amount of rope that is freely available to dissipate the energy of a fall and therefore effectively increases the Fall Factor.

When determining Fall Factors you normally assume that only the rope available between the belay device and the climber can dissipate the energy of the fall. In most falls there will be some slippage, where the rope slides through the belay device as the belayer attempts to arrest the fall. This means that additional rope will be available to absorb the energy of the fall. If a lot of rope slips through the belay device then the Fall Factor may be effectively reduced. However, it is not advised to allow rope to slip through your belay device intentionally as you may injure your hand as the rope slides through your grip and it may not be possible to regain control of the rope.

Finally, the Fall Factor is not always the most important issue when considering a potential fall – for example it is less relevant where the main danger is hitting obstructions or the ground; in this case the length of the fall alone is more important!

EXAMPLE 1
NO RUNNERS PLACED

FALL FACTOR = $\frac{20m}{10m} = 2$

EXAMPLE 2
ONE RUNNER AT 1m

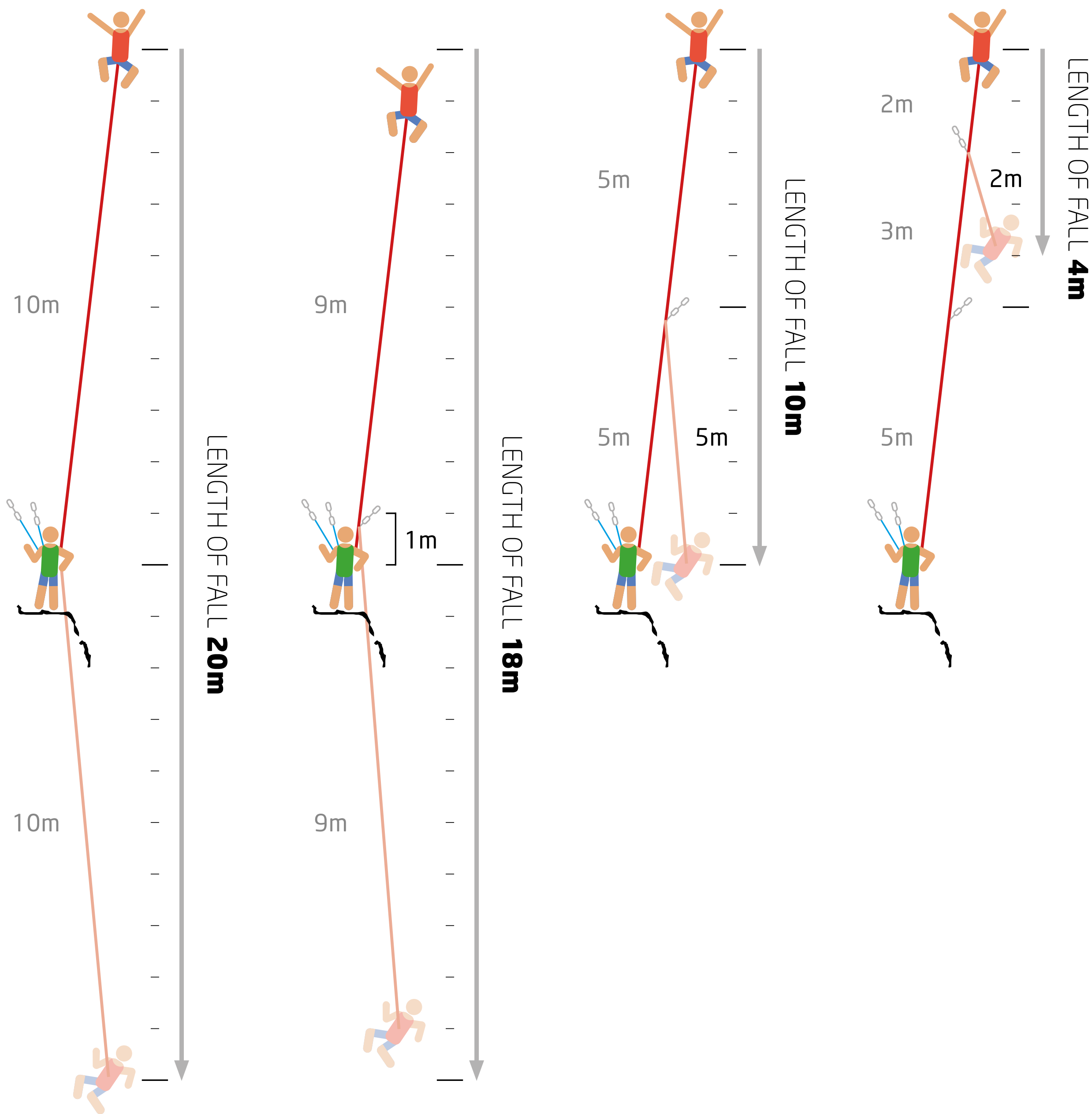
FALL FACTOR = $\frac{18m}{10m} = 1.8$

EXAMPLE 3
ONE RUNNER AT 5m

FALL FACTOR = $\frac{10m}{10m} = 1$

EXAMPLE 4
ONE RUNNER AT 5m AND ONE AT 8m

FALL FACTOR = $\frac{4m}{10m} = 0.4$

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