Dangle
rope access specialists

Rope Access Training Manual - v1

Contents

Introduction **4**

Risk Assessment and Method Statement **7**

Equipment **9**

Techniques **13**
Ascent 13
Descent 13
Changeovers 14
Ascent in descender 14
Descent in ascender 14
Rope transfers 15
Deviations 16
Re-anchors 17
Passing knots 18
Horizontal aid climbing 19
Vertical aid climbing 20
Edge obstruction at top 21
Passing rope protection 22

Fall Arrest **23**
Fall arrest lanyards 24
Work restraint 24
Horizontal safety lines 26

Knots **27**
Figure of eight 27
Figure of nine 27
Alpine butterfly 28
Double fisherman’s 28
Barrel knot 28
Double figure of eight (bunny ears) 29
Chaining and coiling ropes 29
Cow’s tails 30

Rigging **31**
Anchors 31
Slinging 33
Mode factors 34
Basic anchor systems 35
Y hangs (small) 36

Y hangs (large) 37
Angle loading (Y hangs) 38
Edge Protection 39
Re-anchors 40
Deviations 41
Angle loading (deviations) 42
Retrievable rigging 43
Work restraint 44
Tensioned lines 45
Rigging for rescue 46

Pulley systems 47

1:1 system 47
2:1 system 48
3:1 system 48
3:1 with a back up 49
6:1 with a back up 50
Cross hauling 51

Rescues 52

Rescue from descend mode 52
Rescue from ascent mode 53
Rescue through a deviation 54
Rope to rope transfer with a casualty 55
Rescue through a small deviation 56
Large re-anchor rescue (ascender side) 57
Large re-anchor rescue (descender side) 58
Mid-rope transfer rescue (casualty's ascender side) 59
Mid-rope transfer rescue (casualty's descender side) 60
Passing mid-rope knots with a casualty 61
Climbing rescues 62
Rescue from an aid climb 62
Rescue from fall arrest equipment 63
Aid climb rescue from a short connection 64

INTRODUCTION

What is Industrial Rope Access?
'It is a technique using ropes, normally incorporating two separately secured systems, one as a means of access and the other as back up security, used with a harness in combination with other devices, for getting to and from the place of work and for work positioning'.

Many assume that modern industrial rope access techniques were developed from mountaineering and sport climbing disciplines. There is little doubt that many of the original rope access workers came from backgrounds which involved such activities, but the fundamental techniques came from single rope techniques' (SRT) developed by cavers and pot-holers.
Instead of using cumbersome ladders to descend and ascend deep shafts, rope techniques were deployed which allowed faster and safer descents and ascents of deep underground systems. Pot–holers and cavers used rope techniques to engineer access and egress to and from such areas. It is important to recognise the different philosophy which is applied. Mountaineering and sport climbing activities are ends in themselves and the participants are not one hundred percent reliant on their equipment to progress physically (unless aid climbing). When deploying single rope techniques, the manipulation of the equipment is the prime factor in the participants making physical progress.

Industrial rope access began in the late seventies/early eighties. The deployment of the single rope technique proved to be a safe system with few accidents once it was fully developed. To make it viable for the industrial environment, the system was further developed during the eighties by the addition of a back up security rope thereby providing two levels of redundancy.

Work was carried out on buildings, bridges and other structures such as radar dishes. The techniques were readily transferred to the offshore environment. Currently, it is standard procedure to utilise industrial rope access for all manner of inspection, repair and maintenance tasks.

In 1987 the Industrial Rope Access Trade Association was formed (IRATA). This association is now regarded as the lead body for matters relative to industrial rope access both in the UK and worldwide. The UK Health and Safety Executive had significant influence in ensuring that rope access would provide a safe system of working. This resulted in the production of guide-lines which covered the deployment of rope access systems and the certification of personnel involved in industrial rope access by IRATA. The acceptance of industrial rope access as a safe method of working is mirrored in the production of BS 7985: 2002: Code of Practice for the Use of Rope Access for Industrial Purposes. This standard is based upon the original IRATA Guidelines and has formed the basis of the International Code of Practice (ICOP) which came into effect on the 1st January 2010.

TRAINING

Training is a vital element in providing a safe system in any work situation, not just rope access. In the IRATA system, there are three levels of rope technician. The criteria for achieving these levels of competence are detailed in IRATA's Training and Assessment Certification Scheme, August 2014 (TACS).

To become a Level 1 requires a four-day intensive training course (minimum of 30 hours) and a one-day assessment carried out by an independent IRATA qualified assessor. The training course includes ascending and descending techniques, knots, equipment appreciation and simple rescue techniques. The training does not include the use of any tools or work skills. A Level 1 (trainee) is defined as a technician who is able to perform a limited range of rope access tasks under the supervision of a level 3.

To achieve level 2, the level 1 has to have completed at least 1000 logged hours on rope and have been working in rope access in a wide variety of situations for at least a year. It is required to undergo a further 4 days training before this assessment. A level 2 (lead technician) is defined as a technician who is capable of rigging working lines, undertaking rescues and performing other rope access tasks under the supervision of a level 3.

To achieve level 3, which is supervisor level, the level 2 has to have at least a further 12 months broad experience in rope access work, with an additional 1000 logged hours on ropes and hold a valid first aid certificate. The candidate then undergoes an independent assessment where competency in advanced rescue techniques and good knowledge of legislation will have to be demonstrated. It is required to have a further 4 days training before this assessment. A level 3 is defined as a technician who is capable of complete responsibility for work projects;

- is able to demonstrate the skills and knowledge required of levels 1 and 2
- is conversant with relevant work techniques and legislation
- has a comprehensive knowledge of advanced rescue techniques
- holds a current first aid certificate
- and has knowledge of the IRATA certification scheme

Training is carried out by specialised IRATA Member training companies. Trainers have to be level 3.

All IRATA certified personnel must be re-assessed every three years.

It is important to understand that rope access training enables successful trainees to gain access or egress to work sites and it is the safe execution of any specific works that is the priority.

SAFETY

A risk assessment must be carried out before any activities commence in order that control measures for particular hazards are put in place. Additionally, IRATA form 006 pre-training course checklist will be completed and displayed prior to course commencement.

All personnel are responsible both for themselves, their team members and any third parties who may be affected by the activities taking place.

In all circumstances safety will take the highest priority

When carrying out any rope access (work positioning) manoeuvres, all personnel must be attached to two independent lines, the working rope and backup rope.

All connectors must be fully done up

To work safely at a height requires those engaged in the work to have an appropriate attitude and aptitude for such work.

Those who work at a height need to be confident in exposed places, but not over confident or reckless. Frequently, these workers will work in remote places or will be out of sight of their supervisors. It is, therefore, especially important that the workers can be always relied upon to behave in a sensible and responsible manner.

Rope access work can only be carried out in a reliably safe manner where people are competent, suitably experienced and trained, capable of inspection of their own equipment and subject to appropriate levels of supervision. Because of the potential hazards associated with this work, it is essential that people are properly trained in the use of the methods of access that they will use.

GOLDEN RULES OF ROPE ACCESS SAFETY

STOP AND THINK
ALWAYS HAVE 2 INDEPENDENT POINTS OF ATTACHMENT
CLOSE CONNECTORS
KEEP BACKUP HIGH
LOCK OFF DESCENDER
ALWAYS ADD BEFORE TAKING AWAY POINTS OF ATTACHMENT
USE THE BUDDY SYSTEM

RISK ASSESSMENT AND METHOD STATEMENT

Many clients require a method statement before any work commences on their site. In simple terms a method statement is a safe work plan for a particular job or task and is the end product of a risk assessment. In the UK the Management of Health and Safety at Work Regulations (1999) require a risk assessment to be carried out before work can begin.

The modern good practice approach to safety requires those responsible for any work to consider in advance the risks involved and plan accordingly to eliminate them wherever possible or at least control and minimise them to an acceptable level. When working on clients premises there is inevitably a degree of shared responsibility between those supplying the service and those responsible for the site and it is important to ensure that everyone involved has a clear understanding of their respective responsibilities.

The first stage in drawing up a method statement is the risk assessment, for which two concepts need to be understood: hazard and risk.

Hazard
A hazard is something with the potential to cause harm. This can include chemical substances, methods of work and the working environment.

Risk
Risk is a combination of the likelihood of that harm occurring and the severity of the consequences.

We all do risk assessments in our everyday lives without thinking about it. We look both ways before crossing the road and assess whether the speed and proximity of vehicles make it safe to cross. However to assess some risks may require specialist knowledge such as the consequences of being exposed to a particular substance. When assessing risk, emphasis should be placed on the severity of consequences. Even if the likelihood of harm occurring is low; the consequences may be such that the risk is unacceptable.

Remember also that the consequences may affect many people other than those directly involved in the work or in the immediate vicinity. For example a swinging load could injure someone nearby but if it struck and fractured a pipe in a chemical plant it could affect the entire neighbourhood or worse.

The level of detail in a risk assessment should be proportionate to the risk. Once assessed, insignificant risks can usually be ignored, as can risks arising from routine activities associated with life in general unless the work actively compounds or significantly alters those risks.

For some tasks the method statement should be formally prepared and written down so that it can be reviewed by all parties involved. Many clients will request the method statement prior to arrival on site so that they can consider what is to be done, how it is to be done and how it will affect them and, if necessary, request changes. In any event, having a work plan is useful in preparing for any problems that might arise and ensuring that everyone concerned is aware of what is to be done, how it will be done and the risks that might arise in the process.

One way of preparing a method statement is to have a model plan and consider how the operation and conditions vary from the norm, then, adapt the plan to the particular job.

Eliminating and controlling the risk

If there is no hazard then there is no risk, so the obvious way of eliminating the risk is to remove the hazard. Taking the example of an acid cleaning fluid, it may be possible to use a detergent based cleaner instead as this has a significantly lower risk. Similarly using a purpose designed piece of lifting equipment, e.g. a lifting beam or a special clamp, may be much safer than trying to lift and manipulate a difficult load with general purpose slings. When working above other persons, consider the consequences of accidentally dropping tools or materials. An examiner with only a hand held torch can remove the hazard by attaching it with a lanyard.

For many hazards it may be possible to reduce the risk to acceptable levels or eliminate it completely by substitution or by a change of working practice. However, this will not always be the case. There may be practical or economic reasons why the hazard remains and other steps will be necessary.

Considering again the cleaning fluid, whilst a detergent based product will have significantly lower risks some remain. If the operator wears protective gloves and safety glasses, then the risk of dermatitis or eye damage are removed. When lifting equipment is used in adverse conditions, increasing the factor of safety and/or increasing the frequency of thorough examinations may control the risk. When working above other persons the risk to them arising from falling tools and material can be controlled by a safety net or cordoning off the area below.

We can see from the above that the approach to be taken is logical. Remove the hazard if possible and, if it cannot fully be removed, reduce the risk to an acceptable level by guards, PPE etc.

Step 1 – Identify the Hazards

Step 2 – Decide who may be harmed and how

Step 3 – Evaluate the risk and decide on precautions

Step 4 – Record your significant findings

Step 5 – Review your assessment and update if necessary

Preparing a method statement

For a complex job, break it down into a series of operations and prepare a method statement for each operation. Putting these together will form the method statement for the complete job. Every stage of each operation has to be considered.

First some research is required. We need to know what the site conditions are like in order to organise equipment and work procedures. For example, is it hot – cold – wet – difficult to access – restricted – noisy? Are there services in the work area that might present a hazard, e.g. gas – electricity – water? Is the lighting adequate? Is the floor, passageways and hard standing capable of sustaining any loads that might be imposed by equipment etc?

A site visit may be necessary to obtain sufficiently detailed information. From this information a method statement can be prepared showing the equipment required, the sequence of events, the hazards identified and the risks arising from those hazards and the means of controlling them. It is advisable to build in a method for varying the plan, by agreement with the customer, to allow for changing site conditions. The method statement should be agreed with all parties involved and a record kept of any safety induction meetings that are held.

Contents of the method statement
document title
company details e.g. name, address, telephone numbers, email address
document author
health and safety contact person
document traceability details, e.g. number; issue date;
revision date and revision number
site address
site contact details, including emergency telephone numbers
start date and completion date
a brief description of the works, task or process.

EQUIPMENT

Typical Equipment

Descenders

Petzl Stop

For personal or assisted rescue or descent

Under dry conditions, heavy loads or repeated descent, the temperature on parts which have to be touched may exceed 48°C, in this case the use of gloves is advisable.
Normal working load 30-150kg. Loads higher than 150kg are not recommended, due to the effect of possible high impact forces on other elements in the system.
Certified to EN341 requirements. Self braking descender for single rope Type A. Rope type kernmantel EN892, EN1891, diameter: 10-11mm. Maximum descent height 100m. In exceptional cases, e.g. accompanied descents, the maximum normal working load of 150kg specified in EN 341 may prove insufficient. Laboratory tests have shown that with caution the STOP may be safely used with loads of up to but not exceeding 200kg.

Petzl Rig

For personal or assisted rescue or descent

Self-braking descender for single rope, static, semi-static (EN1891) or dynamic (EN892) rope (of kernmantel construction). Diameters 10.5-11.5mm. Maximum descent distance 200m. Normal working load: 30-150kg. In exceptional circumstances (rescue) the maximum load can be increased to 200kg, additional friction braking will be required. Certified to EN12841 type C and EN341 class A

Petzl I'D

For rescue and independent or assisted descent

Loads of over 150kg are not recommended because of possible high impact forces on other components of the system. I'D certified to EN12841 type C and EN341 class A. Self-braking descender for single rope, static, semi-static (EN 891) or dynamic (EN892) rope (of kernmantel construction). Diameters 10-11.5 mm. Maximum descent distance 200m. Normal working load: 30-150kg.
In exceptional cases, for example accompanied descents, the maximum working load indicated by the standard EN341 may be insufficient. Laboratory tests have shown that, with precautions taken in use (no impact force may occur), the I'D can be used with a load of up to 250 kg.

Harness

Petzl Avaho Bod Croll fast

Integrated CROLL ventral rope clamp for ascending ropes.

Sternal attachment point can be used to connect a fall-arrest system and help ensure that the user is suspended in the correct position after a fall. One ventral and two lateral attachment points for multiple hands-free work positioning configurations. Can be used in conjunction with the PODIUM seat for prolonged suspension. Conforms to standards EN361 (fall arrest harness) and EN813 (Work position harness). Minimum strength of 15kN on each D-ring.

Helmet

Petzl Alveo/Vertex

Lightweight helmet for work at height and rescue

Lightweight and comfortable helmet, meets requirements for work at height. Chinstrap designed to reduce the risk of the helmet coming off as a result of an impact during a fall, it has a breaking strength greater than 50daN (EN12492 mountaineering helmet standard). Meets the requirements of the EN397 and EN12492 standards for impact protection. Meets the requirements of the EN 397 and EN 50365 standards for electrical insulation. Meets the optional requirements of the EN 397 standard for molten metal spray, lateral deformation and use in low temperatures.

Ascenders

Petzl Ascension

Handled rope clamp

Handle with ergonomic grip for comfort and thermal insulation. Trigger cam with teeth and cleaning slot: works even on dirty or icy ropes. Ergonomic spring-loaded catch is easy to use even when wearing gloves. Spring-loaded catch can be locked in the open position so the rope clamp can be put on or taken off the rope with one hand. Two holes on the bottom: one to connect a lanyard and one for installing a foot loop with a quick link. The upper holes allow a to be clipped so the rope clamp can be used for self-belaying or with hauling systems. Available in right and left-handed versions. Certification EN567 and EN12841 Type B

Petzl Croll

Chest-mounted rope clamp

To be used in conjunction with the ASCENSION for ascending a rope. Trigger cam with teeth and cleaning slot: works even on dirty or icy ropes. Ergonomic spring-loaded catch designed to facilitate installation/removal of rope when the device is in place on chest. Spring-loaded catch can be locked in the open position so the rope clamp can be put on or taken off the rope with one hand. The attachment hole is oriented so the device lies flat against the chest when clipped in. Certification EN567 and EN12841 Type B

Connectors

The essential link in any safety system

Connectors vary according to their shape, size and locking system. The size of the gate opening determines what they can be clipped to. Aluminium connectors are made of an alloy ensuring an excellent strength to weight ratio. The heavier steel connectors are most often used in anchor systems and where durability is of importance.
Certification EN362. Typical breaking strength 25kN.

Maillon Rapide

Maillon Rapide quick-links may substitute karabiners for infrequent connections in P.P.E. Use exclusively certified maillon Rapide quick links EN 362/
EN 12275.

Back Up Devices

Petzl Shunt

Although not EN certified as a back up device, the Petzl Shunt is still a common back up device for Rope Access. With proper training and adequate supervision this becomes a passive second point for security. Certified to EN567

ASAP

Mobile fall arrester for rope

For use on a safety rope. Stops a fall, slide or uncontrolled descent. Locks even if the device is grabbed during a fall. Works on vertical or angled rope. Moves along the rope without manual intervention (downwards and upwards). Easy to install and remove at any point on the rope.
Certification EN 353-2 and EN 2841 Type A
For use with 10.5 to 13 mm semi-static ropes (EN1891 type A) certified with the device. Comes with the OK TRIACT automatic locking karabiner.

ASAP Lock

Mobile fall arrester for rope

As similar device to the ASAP above but has a lock function to help keep the backup high and is easier and quicker to attach to and detach from the rope.
Certification EN 353-2 and EN 2841 Type A
For use with 10.5 to 13 mm semi-static ropes (EN1891 type A) certified with the device.

Certification

All the rope access hardware equipment owned by a contractor should be individually numbered and traceable to a test certificate. The equipment is visually inspected by a competent person and certified as a minimum, on a six-monthly basis. Training equipment is inspected by a competent person every six months. This complies with Lifting Operations and Lifting Equipment Regulations 1998 (LOLER).

All equipment should be checked there after each time prior to being used on a job by the rope access team.

Care and Inspection

Hardware should be free from rust, and kept clean. The steel karabiners, maillons and wire slings should be cleaned with a wire brush and lubricated appropriately. The remainder of the hardware, (ascenders, descenders, shunts etc.) which are alloy, should be cleaned and lubricated as required.

The software; ropes, harness, and tape should be cleaned in a low temperature wash (40°C or below) with a non-bleach soap, rinsed and dried naturally. The equipment should be stored in a cool, dry environment, away from direct sunlight.

Defective Equipment

Any item of hardware showing excessive wear or damage or software showing signs of tears, cuts or abrasion should be quarantined and returned to stores with a non-conformance report for further inspection/repair. A non-conformance report is filled in and returned with the piece of equipment so that it is high-lighted to the materials controller. It is thus ensured that the piece of equipment is either repaired or withdrawn from service.

TECHNIQUES

General

When carrying out any rope access (work positioning) manoeuvres, all personnel must have two independent points of attachment, one attachment to the live or working rope and one attachment to the backup rope. When karabiners or maillons are used as an attachment, the screw gate must always be done up.

For additional notes on these manoeuvres refer to the TACS page 33 to 40.

Ascending

This particular manoeuvre uses the hand ascender and chest ascender on the same rope with the backup on the second rope.

- Attach your backup to the left hand rope and slide it up high.
- Attach your chest ascender to the other rope (this will be your working line) and place your hand ascender on the same rope above the chest ascender.
- Push the hand ascender up the rope and stand in the foot loop, your chest ascender should move up the rope at this point.
- Rest your weight on the chest ascender.
- Push your backup up the rope to keep it high, ideally your backup will not be below chest height and never below waist height.
- Push your hand ascender up the rope and repeat the process above.

Change over to descent

- Thread your descender on to the working line below your chest ascender and pull through the slack between the two, lock off the descender.
- Ensure the bottom of your hand ascender is about eye level.
- Stand in the foot loop and remove the chest ascender from the rope then lower your weight on to the descender.
- Remove the hand ascender from the rope and attach to the gear loop on your harness.
- The backup must remain on the other rope during this procedure.
- You are now ready to descend the ropes.

Descending

- To descend the ropes place your right hand on the control rope and unlock the descender with your left.
- If using an ASAP check it’s not locked with your left hand then descend, the ASAP will follow as you descend.
- If using a Duck or Enforcer you will need to move it down the rope as you descend.
- Use your left hand to pull the cord until it is level with the top of your descender then let go of the cord and descend away from the backup but stop before its loaded or out of reach.
- The backup can then be moved lower again with the cord.
- Repeat this process to descend further.
- Your right hand should always be holding the control rope during this exercise.
- If you stop for any length of time the descender should be locked of to prevent accidental slippage.
- When descending the speed of descend can be controlled by your right hand on the control rope which should be below your waist.

Change over to ascending

- Ensure your descender is locked off.
- Attach your hand ascender on to the rope above your descender, leaving enough room for your chest ascender between the two.
- Stand in the foot loop and attach your chest ascender above the descender.
- Remove your descender from the rope.
- You are now ready to ascend.

Ascent using a descending device

- Attach your backup to the left hand rope.
- Attach your descender to the working line.
- Attach you hand ascender above the descender on the working line.
- Pull any slack through your descender.
- Standing in the foot loop pull the control rope up through the descender with your right hand.
- Sit your weight on to the descender.
- Slide your right hand up the rope so it's close to the descender, do not completely let go of the rope.
- With your left hand slide the hand ascender up the rope, and repeat the process, your right hand should not completely release the control rope during this exercise unless the descender is locked.
- Your back up should always remain high during this exercise, a Duck/Enforcer will need repositioned ever move up the rope. The ASAP may travel up with you but you should always check for slack in the backup line.

Descent using an ascending device

- You should be in your ascending equipment and have a backup on before starting this exercise.
- Place a finger of your right hand on top of the cam of your chest ascender.
- Holding the hand ascender with your left hand stand up in the foot loop.
- As the weight comes off the chest ascender push down on the top of the cam and lower yourself using your leg. Do not fully open the chest ascender as you will then be on one point of attachment.
- Lower a short distance and remove your finger from the cam, you will now be suspended from your chest ascender again.
- move your hand ascender down the rope.
- If using a Duck/Enforcer you will need to move it down the rope with the cord, no lower than your chest before repeating the process.
- If using an ASAP it will follow you down as you descend.
- repeat to descend.

Rope-to-rope transfers

It is important that the technician can change from one set of ropes to another safely in order to get to a job site. There are two types of rope transfer: short and long. The long transfer involves the ropes being more than 1.5 metres away from the second set of ropes. A second backup is deployed to establish four points of attachment. If any loaded working lines were to fail, a large pendulum will be prevented.

Short rope transfers

- Before starting the transfer ensure you are in your descender and it is locked off.
- Attach one of the new ropes into your chest ascender and pull though any slack so the weight is shared between the descended rope and chest ascender rope, the hand ascender should also be attached the new rope.
- Remove your backup from the current backup line and attach it to the new backup line.
- Descend on the original working line until the weight comes off the descender.
- Remove the descender.
- Transfer complete.

Long rope transfers

- Before starting the transfer ensure you are in your descender and it is locked off.
- Attach one of the new ropes into your chest ascender and pull though any excess slack, the hand ascender should also be attached to the new rope.
- Attach your second backup to the new backup line and slide it up the rope.
- DO NOT REMOVE THE ORIGINAL BACKUP as four points of contact are required to prevent a potential large out of control swing during this exercise.
- Depending on height restrictions, ascend the new rope then descend the original rope or just descend until tension is transferred across. Both backups should be kept high during the transfer.
- Once all your weight is transferred on to your new ropes, you will be directly below the new ropes anchor point.
- Remove the descender and the original backup device.
- Transfer complete.

Deviations

Deviations are a method of rigging which allows re-direction of the ropes. Ropes may be deviated to provide more accurate positioning of the rope access technician or to avoid hazards. Unlike re-anchors, deviations allow positioning with a system rigged for rescue. On a continuously overhanging structure, or to contain movement a series of deviations may be used. Deviations can be divided into two types:

a) single-anchor deviations are used to deviate the ropes by a small angle only. Single angle deviations are only appropriate where their failure would not result in serious consequences such as a swing into a hazard.
b) double-anchor deviations may deviate the the ropes by a greater angle and distance than a single-anchor deviation, and allow the ropes and user to be protected against a serious hazard such as a sharp edge or hot pipe. Such a deviation uses a double anchor system and fully rated anchor points and connectors to prevent against a potential out of control swing should any one item of equipment fail.

Ascent

- Ensure there is a knot in the end of the ropes before starting.
- Ascend to the deviation, the deviation may be pushed higher to gain more height if needed.
- Attach the karabiner in the end of your adjustable lanyard to the anchor point on the structure and shorten it to keep you in.
- The deviation karabiner can now be unclipped from the ropes above your equipment and re-connected to both ropes below your equipment.
- Pull in and remove the adjustable lanyard from the anchor point.
- Lower yourself out by hand in a controlled manner.
- Continue to ascend.

Descent

- Descend until about eye level with the deviation anchor and lock the descender.
- Pull in towards the deviation anchor point and attach the adjustable lanyard, shorten the lanyard to keep you in position.
- The deviation Karabiner can now be unclipped from both ropes and re-connected to both rope s above your equipment.
- Pull in and remove the adjustable lanyard from the deviation anchor.
- Descend.

Double deviations

The method for passing a double deviation is the same except the adjustable lanyard should be attached to either both deviation anchor points at the same time or an independent anchor point and the deviation karabiners moved one at a time round your equipment during ascent and descent.

Re-Anchors

A re-anchor is a secondary set of anchors installed at any distance below or to the side of the primary anchors. Ropes may be re-anchored for a number of reasons, including positioning the ropes for work, avoiding hazards, or to reduce rope stretch. Basic requirements for strength and rigging methods are the same as for the primary anchors (15kN).

Re-Anchor less than 1.5m horizontal offset

Ascent

- Ascend to first anchor and attach adjustable lanyard to the anchor.
- Tension the lanyard until the weight comes off the chest ascender.
- Move both ascenders on to the upper working line and pull through the slack rope so your weight is shared between the ascenders and the lanyard.
- Move your backup to upper backup rope.
- Remove your adjustable lanyard and lower out under control by hand.
- Continue ascending.

Descent

- Descend until level with the lower anchor and lock ascender.
- Attach adjustable lanyard to the lower anchor and tension it.
- Descend until your weight is shared evenly between the descender and the adjustable lanyard.
- Remove your backup and attach it to the lower backup rope.
- Descend until the weight comes off the descender and remove the descender from the rope.
- Attach the descender to the lower working line.
- Remove the adjustable lanyard, this may require the use of your foot loop.
- Descend.

Large Re-Anchors (Loop)

- Ascend the approach ropes to the loop until you reach the anchors.
- Attach your descender on to one of the loop ropes.
- Move your backup on to the other loop rope.
- Remove your ascenders from the original working line.
- You will now still be directly below the first anchors but completely off the access ropes to the re-anchor.
- Attach your ascenders to the working line of the loop in opposition to your descender and pull all the slack rope through.
- Attach your second backup on the backup rope in the loop, in opposition to your other backup and pull all the slack through.
- Movement through the loop is now the same as a long rope transfer, four points of contact are required through this part of the manoeuvre.
- When the transfer is complete and you are in the vertical on the far side of the loop complete a short rope transfer on to the exit ropes and descent.

Passing mid rope knots

Knots may be appropriately tied in rigged ropes for several reasons. For example, a double fisherman‘s is used to join two ropes together. The longer end spare from the rope above allows a figure of eight on the bight to be tied. This can be clipped when passing the knot to facilitate two points of attachment. An alpine butterfly tied into rope will remove a damaged piece of rope from the system, with the damaged piece of rope located in the middle of the bight. There are several other scenarios.

It is essential when ascending/descending past knots that there are two attachments to two ropes at all times. If the knots are to isolate a damaged section, these knots are not to be used for attachment points. A second backup or descender should be used to make appropriate attachments.

Ascent

- Ascend ropes until you reach the knots.
- Remove your hand ascender, attach it above the knot on the working line and ascend until your chest ascender is just below the knot.
- Attach your second back up above the knot on your backup rope and remove the original backup.
- Attach your descender below your chest ascender and lock off.
- Stand in your foot loop and move your chest ascender above the knot in the working line in one movement.
- Remove your descender.
- Ascend.

Descent

- Descend until the descender is against the knot, there is no need to lock your descender at this point.
- Attach your hand ascender above your descender on the working line, stand in the foot loop and attach your chest ascender between the descender and hand ascender.
- Remove your descender and attach it below the knot, it should be as close to the knot as possible and locked off.
- Reverse on your ascenders until just above the knot.
- Stand in your foot loop and remove your chest ascender followed by your hand ascender.
- Attach your second backup below the knot on the backup rope.
- Remove the upper backup and descend.

Climbing and Traversing

Aid Climbing using only cow's tails for means of attachment is a popular method of climbing. Care should be taken to provide adequate provision for rescue and recovery from aid climbing situations. A technician too far away from a rope set or means of access and egress may result in a potentially dangerous situation.

Horizontal (fixed anchors)

- Ascend the access ropes to the start of the aid climb.
- The two etriers will be attached to the cow's tails, one etrier on each cow's tail.
- From the start location the aid climber will attach themselves to the first and second individual anchors of the aid climb using their cow's tails.
- The working position is reached by connecting your Grillon from the waist D ring on your harness to the first anchor of the aid climb and shortening the Grillion.
- The ascenders and back up on the access ropes can now be removed.
- By standing in the foot loops connected to the cow's tails, it is possible to take the weight off the Grillion that is holding the technician and move it to the second anchor point in the direction of travel. Now remove the cow's tail with the etrier attached to it from the second anchor and move it to the third anchor point in the direction of travel.
- It is possible now to move the other cow's tail with the etrier along one to the attachment point which the technician is suspended from. Repeat this process to move horizontally along and aid climb.
- When the aid climb has been completed attach your descender as high as possible on the working line and lock off
- Attach your backup on the backup rope.
- Remove your cow's tails and Grillon.
- Descend.

Horizontal (moveable anchors)

- In addition to two etriers you will need three anchors slings to slide along the steel work.
- Ascend the access ropes to the start of the aid climb.
- The two etriers will be attached to the cow's tails, one etrier on each cow's tail.
- Attach all three anchor slings separately to the steel work you are going to aid along.
- Attach one cow's tail and etrier to one of the outside anchor slings and the second cow's tail and etrier to the other outside anchor sling.
- Attach your Grillion from the waist D ring of your harness to the middle anchor sling and shorten it.
- Remove your ascenders and backup from the access ropes.
- Stand in the etriers and slide the middle sling along the beam, sit down again.
- Slide both the leading and trailing slings along the beam.
- Repeat this process until you reach the end of the aid climb.
- When the aid climb has been completed attach your descender as high as possible on the working line and lock off
- Attach your backup on the backup rope.
- Remove your cow's tails anchor slings and Grillon.
- Descend.

(**Climbing and Traversing continued)**

Passing an obstruction

- Get as close to the obstruction as you can.
- Remove the closest sling and replace it on the other side of the obstruction, it should remain attached to your cow's tail during this procedure so you can't drop it.
- Attach your chest ascender to the cow's tail you have just moved and pull through the slack.
- Lower off on the Grillion and move the middle sling and replace it on the other side of the obstruction, take in the slack on your Grillion.
- Remove your chest ascender from the leading cows tail.
- Remove the trailing sling and replace it on the other side of the obstruction, it should remain attached to your cow's tail during this procedure so you can't drop it.
- Continue along the beam as before.

Vertical

- As above attached two etriers to the cow's tails.
- Attach one cow's tail to the first anchor. If starting from ground level, one initial point of contact can only be reached.
- Standing in the etrier, connect your Grillon from the D ring on your waist to the first anchor point and shorten it.
- Reach up with the second cow's tail that has an etrier on it and clip into the second anchor point. Standing in your etriers move the Grillon up to the second attachment point.
- Move the upper cow's tail up to the third attachment point.
- Move the trailing cow's tail up to the second attachment point.
- Standing in your etriers move the Grillon up to the third attachment point.
- This process can then be repeated to progress up the aid climb.

In certain situations there may be a potential for falling on a cow's tail and achieving a fall factor of more than 1. In this situation, an energy absorbing lanyard attached from the fall arrest D ring can be used to replace the trailing cow's tail. This will have the second etrier attached to it and the sequence of movements is as above.

Edge obstructions at top

The edges of roofs, platforms, cliffs, cavities and other drops may be unprotected by guard rails or parapet walls. This can present an awkward obstruction and contact hazard to the ropes.

- There are various techniques that can be used for the exercise depending on the exact set up of the edge.
- You will approach the edge with your descender and back up attached.
- Having reached the edge enough rope should be fed through the descender to allow you to climb over the edge but not be positioned too far below the edge.
- Depending on the edge itself you may be able to step down on to a ledge below to transfer over the edge in a controlled manner.
- Other alternatives are a hand ascender and foot loop on your working line or an etrier left in position that can used instead of the ledge.
- If a hand ascender and foot loop is used it should be removed once you are over the edge before your descend.
- Care should be taken to load your descender the correct way, prevent shock loads or cross loading of equipment and to prevent the ropes contacting a hazardous edge while performing this exercise.

Passing mid-rope protection

Wrap-around canvas rope protectors may be installed mid-rope to protect the ropes against minor damage. Normally separate rope protectors will be used on each rope.

Ascend

- There are various techniques that can be used for this exercise depending on how the protector is attached. It can tied to an alpine butterfly on the rope, tied to rope with thin cord or attached to the structure.
- Ascend to the rope protectors.
- Open the protectors and continue to climb until level with the top of the rope protector.
- If the protectors are attached to the structure you can do them up on both ropes behind you.
- If the protectors are tied to the ropes you will have to use a second point to pass the protector attachment cord (as if you were passing a knot). A second backup could be used or a cows tail connection to the alpine butterfly.
- Alternatively the rope protection can be removed from the rope completely and replaced below you.
- Then do up the protection behind you.
- Continue to ascend.

Descend

- There are various techniques that can be used for this exercise depending on how the protector is attached. It can tied to an alpine butterfly on the rope, tied to rope with thin cord or attached to the structure.
- Descend to the rope protection.
- If the protection is tied to the structure open the protectors and continue to descend until level with the bottom of the rope protection. Close the rope protection above you on both ropes and descend.
- If the protectors are tied to the ropes you will have to use a second point to pass the protector attachment cord (as if you were passing a knot). A second backup could be used or a cows tail connection to the alpine butterfly.
- Alternatively the rope protection can be removed from the rope completely and replaced above you.
- Then do up the protection above you.
- Continue to descend.

Care should be taken to reinstate the protection in the appropriate place.

FALL ARREST

A fall arrest system utilises PPE intended to stop a falling person from hitting the ground or obstructions, and which is designed to limit the impact force of the fall and retain the user upright in the harness.

If a fall risk onto the worker's PPE of greater than 0.5m exists then the worker is technically in a fall arrest situation. During the fall the worker and his protection system should not experience any force in excess of 6kN (600kg).
Where it is not possible to prevent a potential fall then a shock absorber must be incorporated into the lanyard system. Shock absorbency is the ability of an item of equipment to convert fall energy by dissipating it through the safety system, so that no one item of the system has to bear the full impact force, particularly the person falling. Common examples of PPE shock absorbers include tear-out lanyards and dynamic rope systems. The lanyard in its un-deployed state must not exceed 2m in length, including all connectors between the harness and the connection to the anchor point.
Ensure that lanyards are always attached to anchor points above head level, thus minimising impact forces generated by the fall.

Fall Arrests place in the Hierarchy of Risk

Within the Working at Height Regulations 2005, it states that you must use a Hierarchy of Risk to choose the most practicable method of working at height.
Firstly, avoid working at height if possible! This in most cases is impossible but there are a few measures that fall within this i.e. window cleaners using an extendable pole to wash first floor windows. This eliminates completely the need to work at height.
The next method in the hierarchy would be to prevent a fall by the means of collective protective measures. Examples of this are more common, such as permanent platforms and gantries, scaffolding and MEWP‘s. These give complete fall prevention for multiple users.
For PPE users, work restraint is the next acceptable method. A harness and lanyard would be used to prevent the worker from entering a position of danger, for example working at the edge of a flat roof. Methods such as work positioning and rope access are examples of PPE being used to suspend a worker in such a way that a fall is prevented through PPE in tension. A back-up system would be utilised in the event of a failure in the PPE and would be positioned as high as possible as to minimise any subsequent fall.
Fall arrest is therefore below all these techniques in the hierarchy as it does not prevent a fall. Falls using fall arrest techniques should be kept to a minimum to reduce the shock loading in the body. This is expressed by the use of Fall Factors.

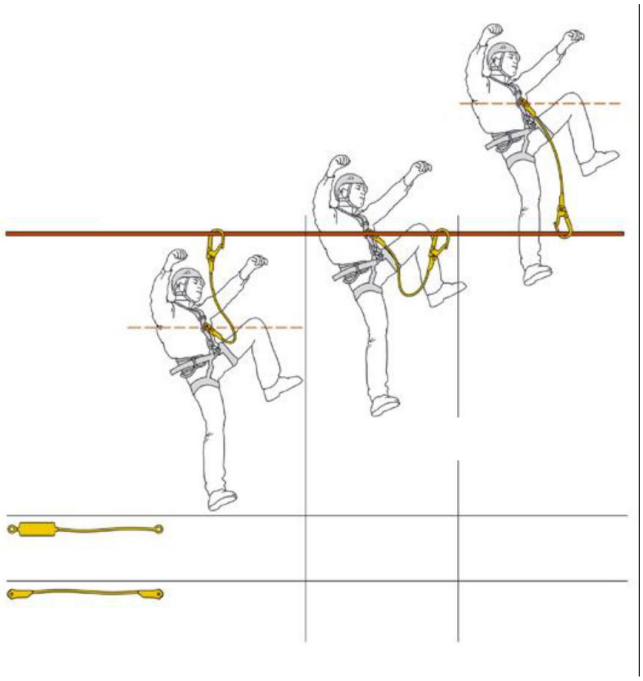
Fall Factors

A fall factor describes the severity/ seriousness of a fall. This series of diagrams shows the most common fall factors. To work out a fall factor, you must divide the total length of the fall by the length of the lanyard.

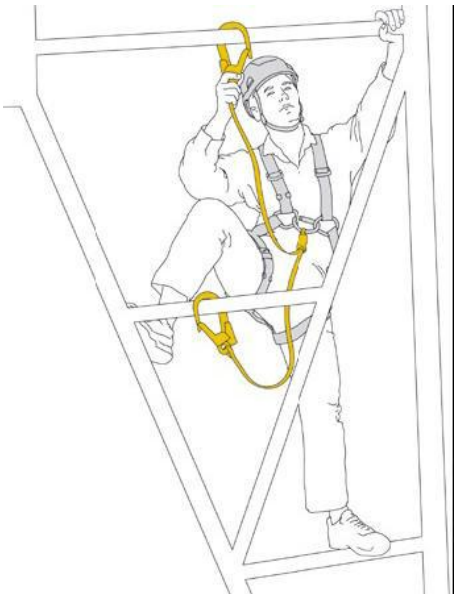
The lowest worker is a fall factor 0

The middle worker is a fall factor 1

The upper worker is a fall factor 2



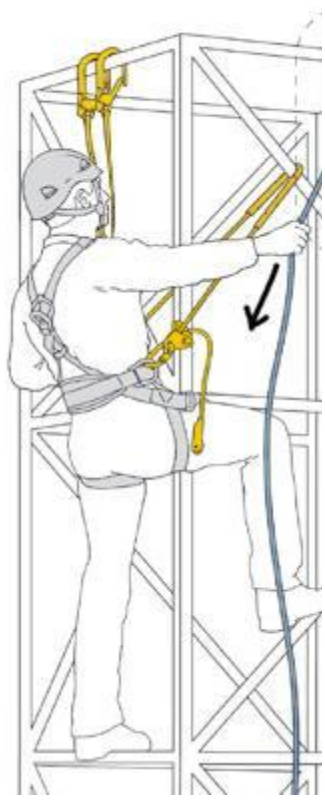
Climbing with Fall Arrest Lanyards



Whilst ascending or descending the training tower you will ensure at least one point of contact is maintained at all times. You must also ensure that you can maintain effective hand and or foot contact. Using either y-shaped energy absorbing lanyard or fixed line fall arrest device, connect your fall arrest lanyards to a suitable fall arrest point on your harness. Whilst climbing the tower with the double lanyard, maintain at least one of the legs of the lanyard on the structure keeping this as high as is practicable. If you have to use work positioning techniques, connection with the fall arrest lanyard must be maintained. During ascent one of the lanyards will be attached to the structure at an appropriate point above shoulder height. As the first attachment is passed and it is at waist level you will attach the second lanyard at, or above, shoulder height. Only when the second attachment is secured can the first attachment be removed. Repeat this sequence until you are at the required point.

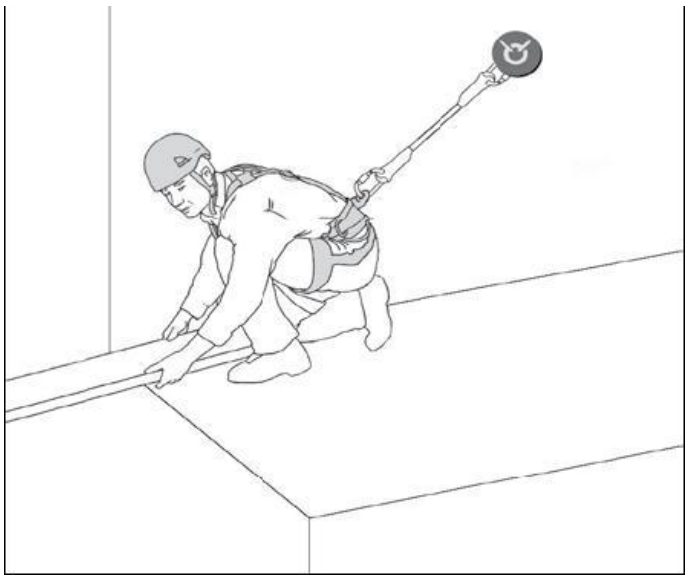
Work Positioning

Work positioning is a technique (shown below, left) for supporting a person while working by means of PPE in tension, in such a way as to prevent a fall. What this means is that the worker uses PPE to support himself while working as opposed to fall arrest where the PPE is there to catch the worker in the event of a fall. There are important distinctions that must be made depending on the nature of the work task, the level of reliance on the PPE and the level of back up required. Correct use of work positioning techniques and equipment should mean that the worker is physically unable to fall as his PPE is preventing him doing so therefore work positioning techniques can be viewed as preventative safety measures.



Work Restraint

Work restraint (shown below, right) is a technique which makes use of items of PPE to prevent a person from entering an area where a risk of a fall from a height exists. What this means is that the worker is effectively tethered via an anchor point and line in such a way that he is prevented from reaching the exposed edge from which a fall may occur. Work restraint techniques are often used to protect workers on flat roofs or open decks. By careful selection a single anchor point can cover a large working area.



Minimum Clearance Distance

Lanyards or lanyard assemblies must not exceed 2m in length. This rule is designed to prevent extreme interpretations of safe lanyard length and the resulting massive falls. However even the correct selection and deployment of lanyards and shock absorbers does not guarantee total safely. The subject of clearance, or headroom, must first be carefully considered. Clearance is the available space between the anchor point and the ground or nearest obstruction. Various factors must be taken into account when calculating this distance; these will vary depending on the system in use, for example not all lanyards have the same amount of tear out.

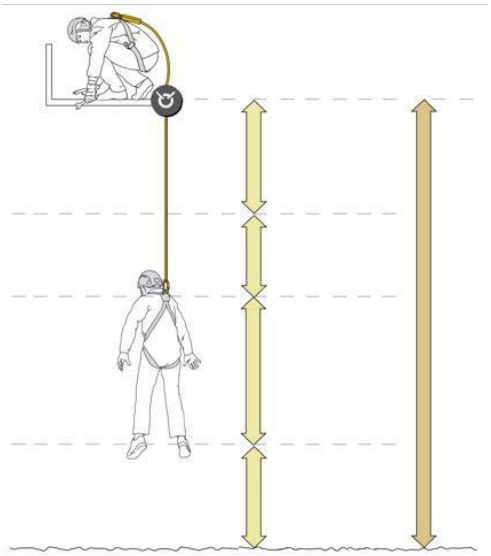
Below is an example of the minimum clearance required for a typical low attachment point with a 1.15m Fall Arrest Lanyard.

Lanyard length + connectors = 1.15 m

Energy absorber extension = 0.7 m

Distance between harness attachment & worker's feet = 1.5 m

Minimum stopping distance above ground = 1m



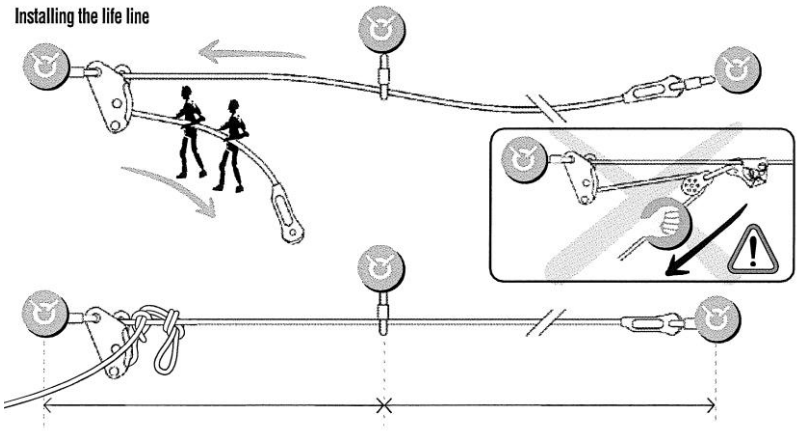
Total clearance required = 4.35 m

Horizontal Safety Lines

A horizontal lifeline for protecting the rope access workers access or egress to a work site or a temporary restraint line may be needed.
A useful tool for this is the Petzl Grillon, normally used as a work positioning lanyard but comes in longer lengths and is certified as a horizontal safety line.

Installation

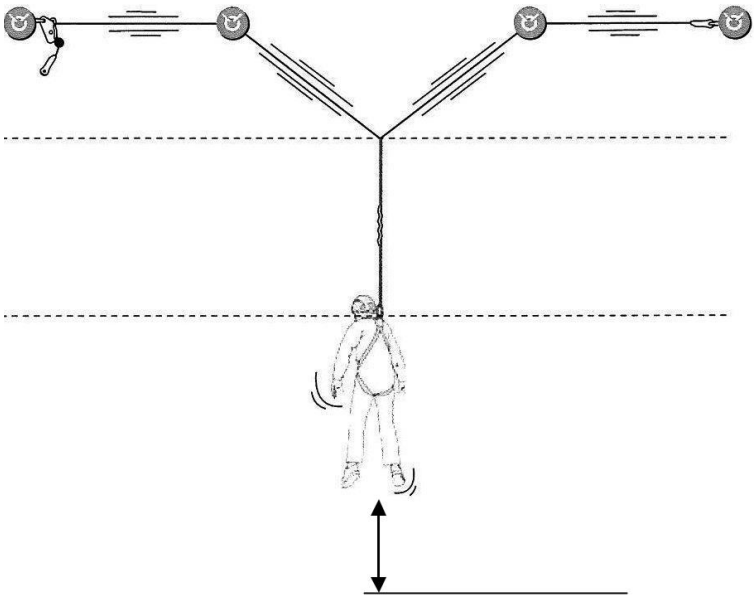
Anchorages and connectors must have a minimum breaking strength of 12Kn and where possible the line must be above the users. The life line must be hand tensioned by one or two people, without using a mechanical advantage pulley system. This is so the line is not over tightened creating an angle multiplier force on the anchors and Grillon.
Before each use, make sure the life line is well tensioned by pulling as hard as you can on the free end of the rope. As the Grillon has no positive locking mechanism, a knot must be tied on the tail rope close to the Grillon.



Do not make knots at the intermediate anchor points. Ensure that the intermediate anchor points are touching the horizontal line.
The slope of the life line must not exceed 15°.

Using the temporary horizontal lifeline

Allow only one person per span and a maximum of two persons on the lifeline.
If there is a risk of a fall of more than one meter, or one having a fall factor greater than or equal to 1, you must use an energy absorbing lanyard with a fall arrest harness.



You must calculate the clearance distance and include the amount of sag that will be generated by the falling person. The sag must be calculated from the distance between the intermediate anchor points.

The same system can also be achieved with an EN 12841 A descender and an EN 1891 A semi-static rope.

KNOTS

General

All knots act as weak points reducing the overall strength of a rope. In some cases this can have an effect of reducing the overall breaking load of the rope by up to 50% depending on the type of knot, condition of the rope, overall conditions during use etc. This effect is not cumulative.

Other criteria which must be considered in determining a good knot must include:

- Ease of determining whether the knot is correctly tied.
- Ease of tying and untying.
- Easily recognisable for it's strength and security.

All knots should be checked and tightened immediately after tying and prior to each time the knot is loaded.

Once a knot has been tied into a rope it is important to ensure that it is properly aligned; the knot should be cleanly tied and all parts must be in the correct place. This is known as dressing the knot.

Types of Knots

Figure of Eight on a Bight

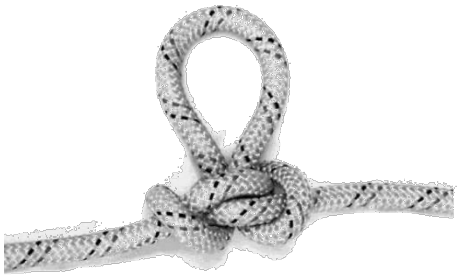
By forming a bight with the running end of the rope, a reliable loop can be formed.
Weakens rope by approx. 30%

Figure of Nine on a Bight

An extra turn on the figure of eight gives this stronger knot which is easier to undo after loading.
Weakens rope by approx. 25%

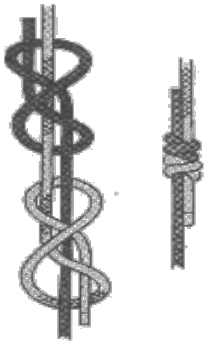
Alpine Butterfly

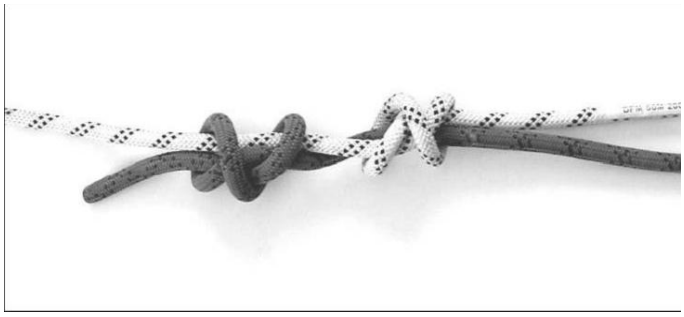
A compact mid-line rigging knot - provides for a multi-directional pull
Weakens rope by approx. 35%



Double Fisherman's

For tying two ropes of equal diameter together
Weakens rope by approx. 25%





Barrel Knot

Tightens onto Karabiner. Good on ends of cow's tails
Weakens rope by approx. 25%

Stopper Knot

Tied to the ends of rope to prevent abseiling off your ropes.

Double fig. 8 on the bight (Bunny Knot)

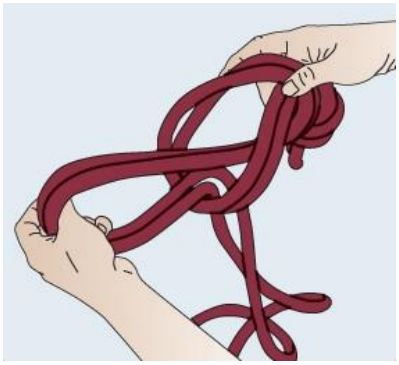
Links and equalises 2 anchors
Weakens rope by approx. 35%

Rope Coiling, Chaining and Bagging

Hanking

Coiling or Hanking (coiling is not a good method as it promotes tangles) is a method used to conveniently carry ropes. This is done by taking either the middle or the ends of the rope and laying the rope back and forth creating equal laps of rope. This can be finished off by wrapping a few metres of the end of the rope around the hank.

Chaining



When chain linking a rope you can start from either the middle of the rope or with both ends together, makes no real difference. Begin with a simple slip knot, drop your hand through this loop and pull through another bight of rope. This creates another loop for your hand to drop through. Keep repeating the process until you have reached the end of the rope. Finish by pulling the rope tail through the final loop, this will secure the chain.

Bagging

Tie one end of the rope to the outside of the bag. This will be required so as to not lose the bag when thrown, leaving the ends out will also show there are knots and tags in the end of the ropes. Then simply feed the rope into the bag compacting the rope down when required.

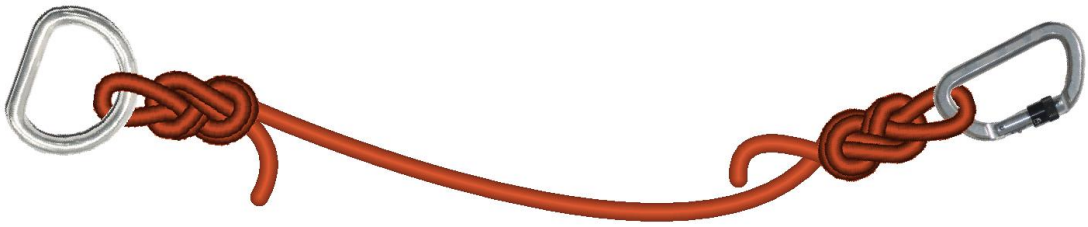
A bagged rope is useful for fast deployment or in the case of long descents when wind can blow the ropes around causing snagging and tangles.
Use the spare cow's tail on your harness to hold the bag at around your feet area. This will give you enough free rope out of the bag to descend comfortably.

Cow's tails

Some commonly used back up devices such as the Duck or Enforcer and our hand ascender are connected to the harness by a short length of Dynamic rope of 10.5-11mm in diameter. This is connected by a re-threaded Figure of 8 or overhand knot tied directly to the ventral D ring of the harness and terminated by either a Figure of 8, overhand or a Barrel knot. 3 cow's tails are usually attached, giving one for each back up (if used in a situation which requires two back ups) and one attached to the Hand Ascender. When using the cow's tail as a lanyard to the backup device, it must be positioned so that a fall of no greater than a fall factor of 1 may be achieved. In all cases a potential fall onto the back up device must be minimised at all times.

The knots must be set before use. Typically preloading them with body weight will ensure the knots do not undo themselves. If a fall is taken onto a cow's tail the cow's tail must be immediately replaced. Ensure that a minimum of 10cm of tail protrudes from the knot after setting.

The length of a cow's tail should not be so long that it will be out of reach at full extension. On the cow's tail that carries the back up, the shorter the better. Some manufacturers require a specific length of lanyard to be used with their devices. Always refer to the manufacturers instructions.



RIGGING

General

Everyone working using full rope access methods (i.e. where a rope is used as a primary support or for positioning) must use two completely independent ropes arranged so that, in the event of a failure of one, the worker cannot suffer a fall.

To meet the above recommendations, workers will need a separate working rope and safety rope, i.e. a working line and a safety line. Each line should have its own separate anchor. However, both anchors may be connected to each other for added security. Supervisors are responsible for checking that the ropes are correctly rigged so that if one should fail, a shock load would not be passed on through the system.

The effects of high winds should be minimised through good rigging. Working on the lee side of a structure, fixing guide lines that are pre-tensioned, using deviations and re-anchors to keep ropes in the correct place or to simply not work are all considerations.

Rope Protectors should only be used when it is not possible to protect the ropes from abrasion or sharp edges by other means such as double deviations and re-anchors. There are several types of rope protectors, ranging from complex edge rollers to simple canvas sheaths. It is not suitable to use plastic or other homemade varieties (pieces of carpets, rubber hoses or kit bags) of rope protectors. The heat generated through friction will cause the rope to fail after a fairly short period of time.

Anchors

The anchors themselves should be unquestionably reliable and capable of withstanding any potential loads to which they may be subjected. Examples might be lift-shaft housings on tower blocks, structural steel work, suitably tested mechanical and chemical bolt anchors or sound concrete and geological features.

The strength of the main anchor system should be as least as strong as the ropes attached to it and not less than 15kn. The minimum strength of a fabric sling for rope access is 22kn and must conform to EN 566 or EN 795B.

Consideration should be given to the possibility of rescue, which may involve the weight of two persons. Attention is drawn to BS EN 795, which deals with all kinds of anchor devices, and BS 7883, a code of practice for the application and use of anchor devices to BS EN 795. BS EN 795 is generally designed to cater for the fall arrest of a single person, i.e. it uses a mass of 100 kg in the dynamic tests.

Anchors that are used onshore can vary according to location, i.e. working up on a mast, a side of a building, or on a cliff face. Some buildings may have in-situ bolts, hangers, or trolley/cradle rails to utilise. However, a building may have a flat roof with no anchor points. In this case, counter balance weights would be required for anchors. Be aware that wet conditions can significantly affect the frictional performance of anchor-weight systems. The frictional resistance of any dead weight anchor system should be such that it does not slip when under a load that could be applied to it under working conditions e.g a fall generating 6kN with a safety factor of 2.5, i.e. 15kN. When working on a cliff face metal stakes driven in at the top of the face can be used, or expansion bolts put in to the rock.

If using chemical or mechanical anchor bolts, they must comply with the standard BS EN 795 and the installation should be in accordance with BS 7883. Selection of whether to use mechanical or chemical bolts will depend on the substrate the anchor is to be placed in, for example a chemical resin bolt would be used if the effects of an expansion type bolt might fracture the substrate. Manufacturers‘ instructions must be followed closely.

Some general points of bolt installations

- *Anchor bolts be used in rope access must always be used in pairs as stated in BS 7985.*
- *Host substance must be checked for soundness.*
- *Correct anchor choice must be made for substrate material.*
- *Holes should be drilled at 90 degrees and a depth gauge used on the drill.*
- *Minimum distance between 12mm bolts should be 150mm if maximum strength is to be maintained. Bolts may be placed closer together but check manufacturers recommendations.*
- *Holes should be cleaned before the bolt is placed.*
- *Expansion bolts should be torqued to the manufactures recommendations.*
- *A pre-use check using an outward pull of 6kN for 15 seconds should be performed.*

Fabric slings can be used for anchor points especially if work is to be done inside a building. This prevents damage to paintwork; fabric slings can be used round large anchor points where wire slings may be too short. It is important to remember that fabric slings are not as durable as wire because of susceptibility to abrasion.

Wire slings can have soft or hard eyes, and a special plastic sheath to protect the wire from abrasion and to an extent, protect the surface of the structure. It is important that the plastic sheath is transparent as inspection of the wire can only be performed by seeing through the sheath. On each sling there will be a safe working load (SWL) which complies with the lifting equipment regulations.

Further information on the installation and placing of anchor devices can be found in the ICOP (annex F).

Slinging

A variety of slings are and can be used for anchorage points around fixed and secure structures such as steelwork, ladder support steel, trees and pipe work. Process pipelines shall be considered for anchors only as a last resort, where no structural anchors can be safely utilised. Pipelines used for anchoring shall be no less than 100mm diameter and no less than 6mm wall thickness, it shall be in good condition and adequately supported to a suitable structure.

Anchor areas shall be protected from interference by third parties using barriers or a sentry.

Anchors for suspended platforms and any heavy tools, materials and equipment that use ropes, which are not the operatives shall have separate anchors. Often it will be possible to connect directly to a substantial steel, concrete or masonry section. Steel wire strops of minimum breaking load 15kN or fibre slings of minimum breaking load of 22 KN will be used.

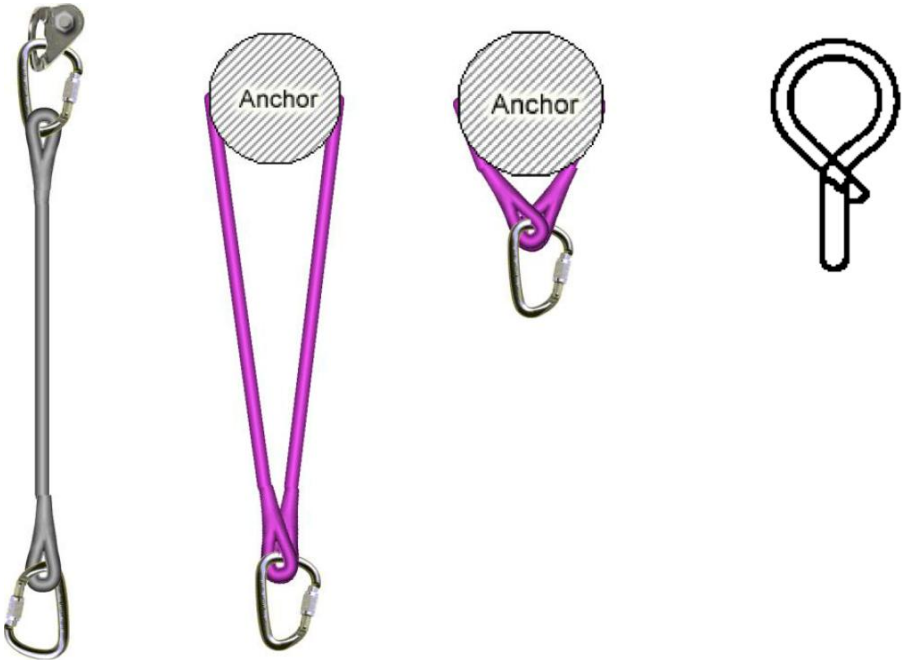
It may be preferable to use fibre slings in situations where wire strops may mark paintwork or damage masonry. Sharp edges should be avoided and all ropes and slings shall be protected from abrasion using rope protectors.

All main anchor/belay points used shall be unquestionably reliable and have a minimum breaking load of 15KN.

It is an important factor when anchor/belay points are chosen that in the event of the working rope failing, the safety rope and anchor point is not shock loaded. To prevent the system from shock loading suitable knots that are adjustable will be used and load sharing between anchors is carried out.

Mode Factors

When using slings to provide an interface with an anchorage point, the strength of the sling will vary depending on the configuration. Some examples of slinging are show below and their modes factors of a 22 Kn minimum breaking load fibre sling.



1x22kN MBL 2x22kN MBL 1.4x22kN MBL 0.8x22kN MBL

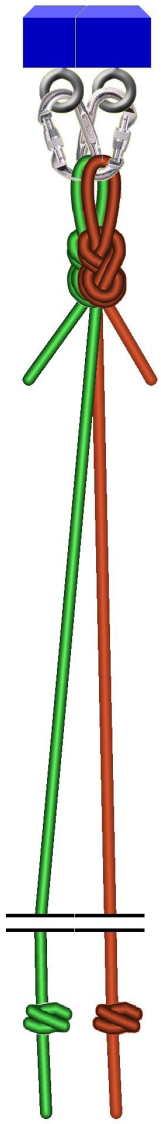
Mode factor 1	Single leg, inline
Mode factor 2	Doubled (angle as close to 0 as possible)
Mode factor 1.4	Doubled (angle 90º)
Mode factor 0.8	Larks foot (choke hitch)

With a choke/lark‘s foot configuration the strength of the sling will be reduced so this should be avoided where possible. However, in some circumstances, a Lark‘s foot configuration will give added security to the rigging by preventing slippage of the slings especially when moving from rope to rope or rigging to a diagonal member. In this case, use slings with a greater SWL or breaking load. (i.e. rigging strop 1te SWL or 30kN breaking load.)

The back choking of slings to gain height will weaken the anchor sling considerably more then the larks foot example above. The weakening affect in this case will be between 50% and 70% and should therefore be avoided.

Basic anchor system

As a minimum, a basic anchor system consists of two ropes, each with it's own anchor connection. Where a suitable structure is present, ropes can be rigged to two similar anchor slings or strops placed next to each other. Where practicable it is best practice to equalise the anchor slings.



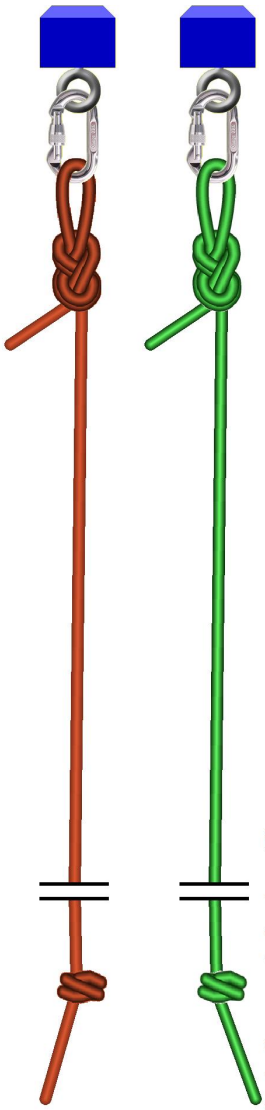


Illustration created using vRigger

Y-hangs

Where ropes are to be rigged from two separate structural elements or bolt anchors, the rigging of a Y-hang has three advantages: precise positioning of ropes, sharing of loads on the anchors and reduced impact forces in the event of anchor failure.

Small Y-hangs

A small Y-hang is the equalising of two anchors points less than 1m apart where the consequences of failure of one side is not catastrophic. Only one bolt or anchor sling is required on each side or the Y-hang.

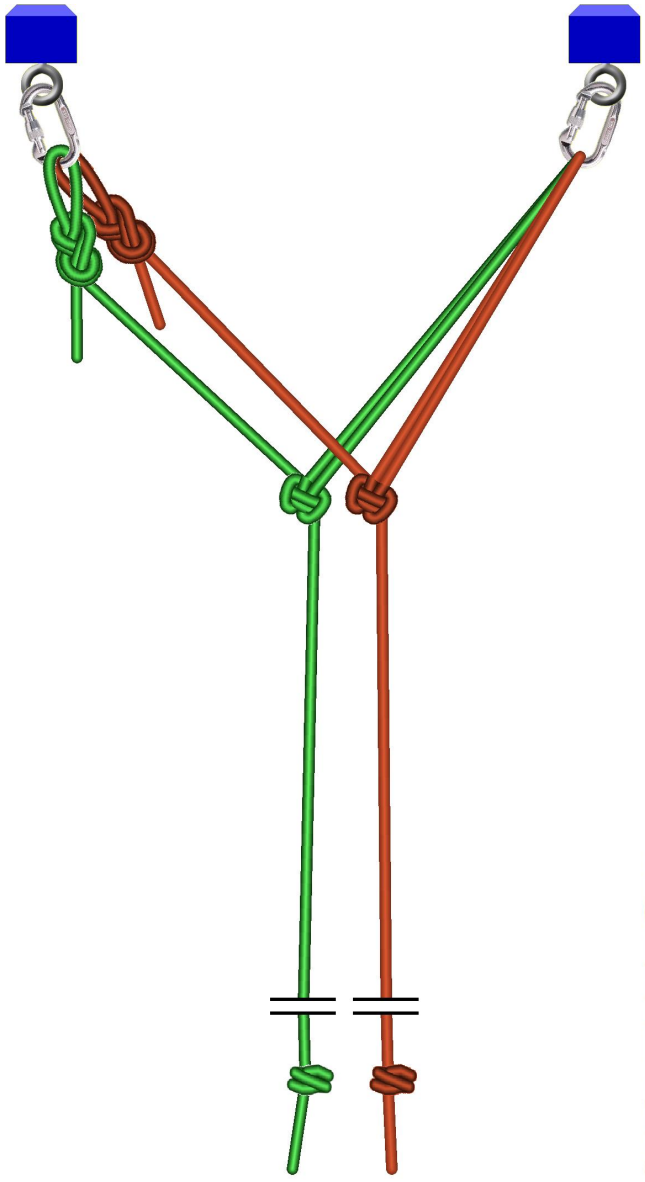
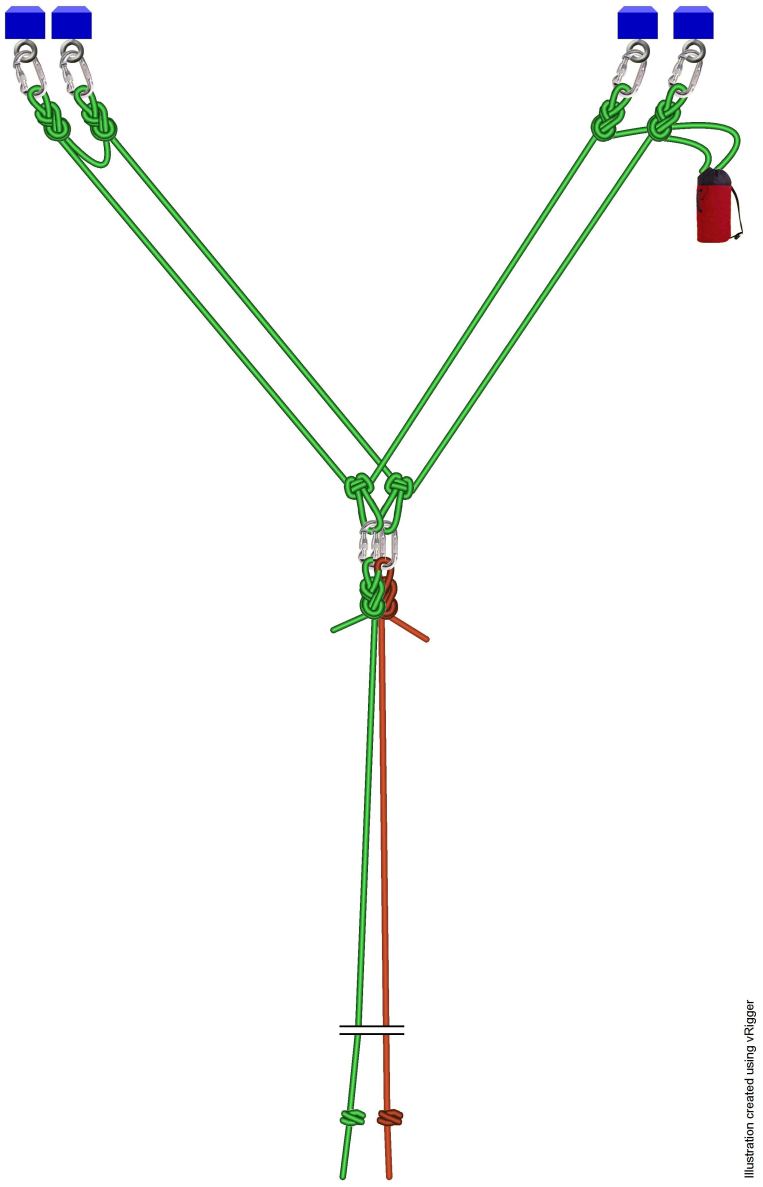


Illustration created using vRigger

Wide Y-hangs

Wide Y-hangs of over 1.5m where the consequences of one side of the Y-hang failing are unacceptable require the use of four anchors, two on one side and two on the other. This rigging technique is also required where the Y-hang is less then 1.5m but a failure of one item of equipment will result in a swing into a hazard such as a sharp edge or hot pipe.



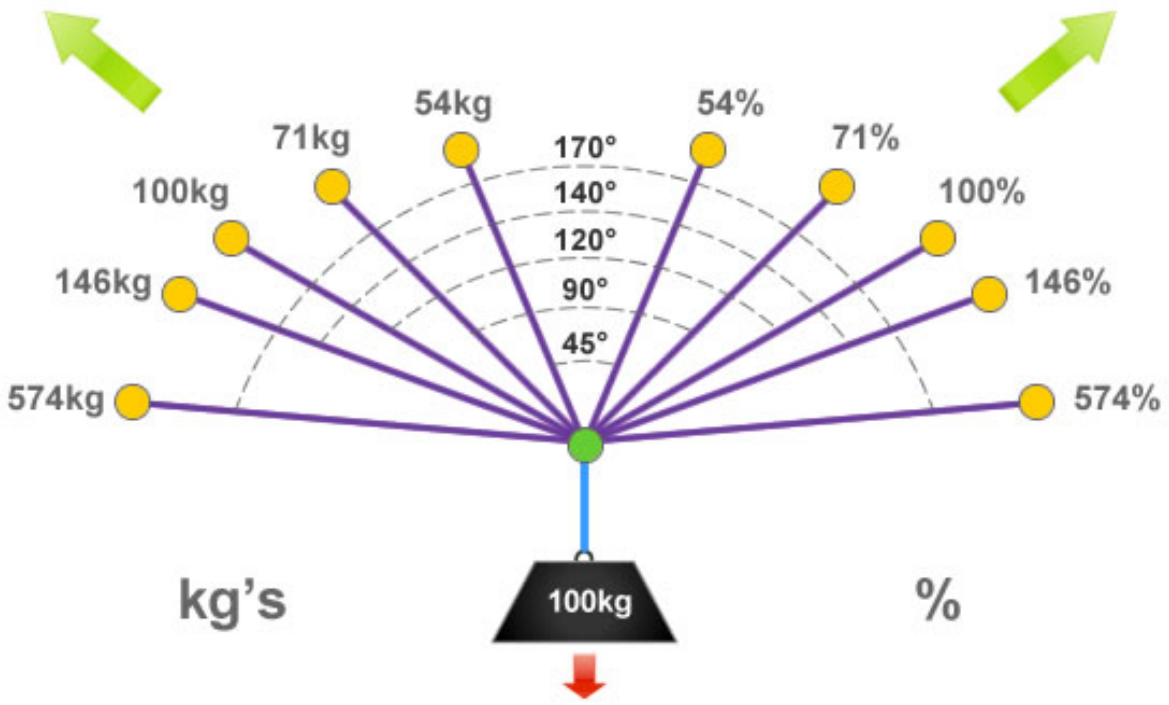
Angle loading

When rigging Y-hangs it is important to understand the effects of angle loading. As the angle of the Y increases the forces transferred to the anchor points also increases.

The preferred angle for rigging is less than 90 degrees.

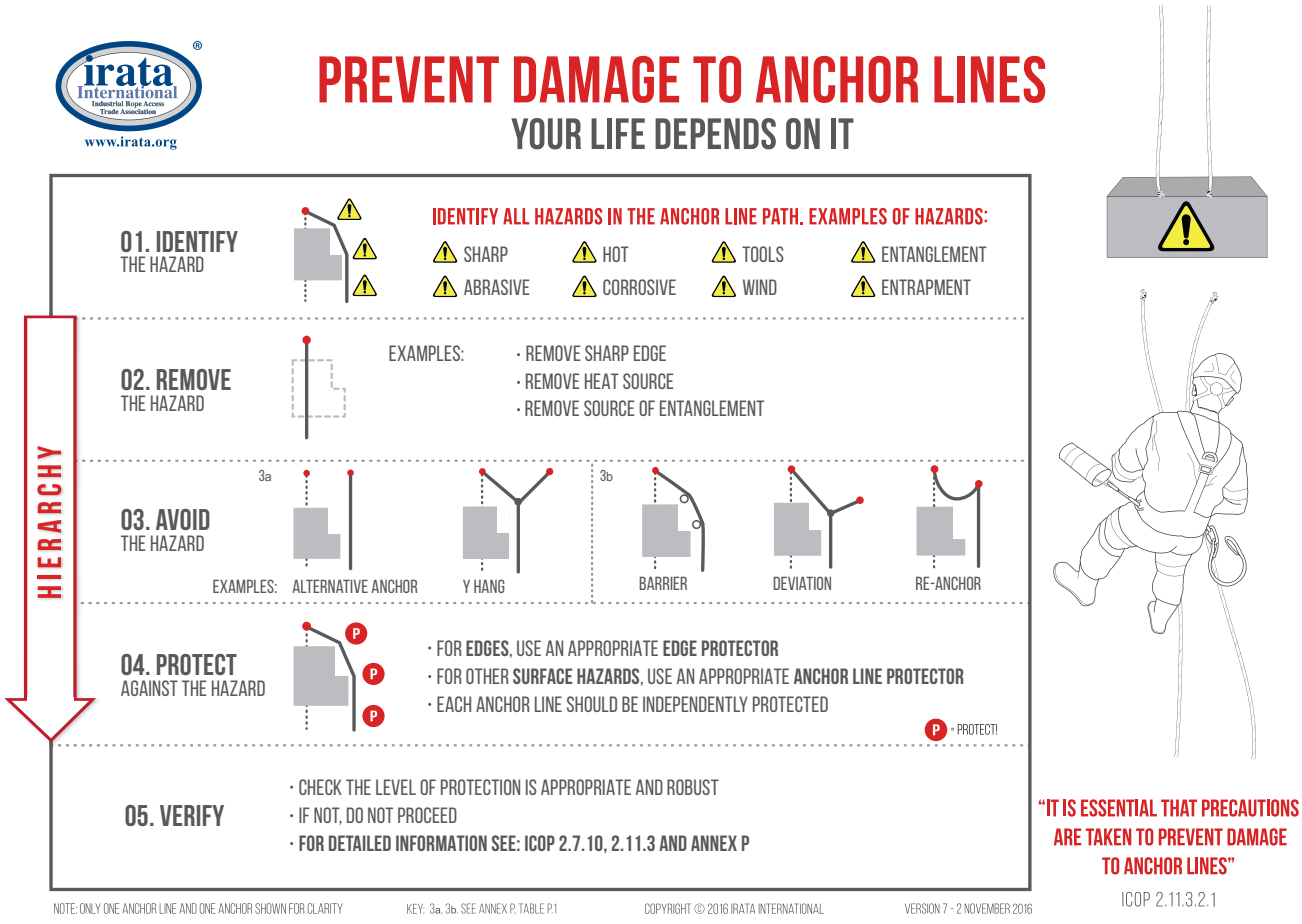
The maximum angle for normal rigging, also know as the critical angle is 120 degrees as at this angle the force on the anchors is equal to the load.

Above 120 degrees there will be more force on each anchor and this will increase drastically the wider the angle gets.



Hazard avoidance and rope protection

Hazards such as sharp edges, abrasive surfaces, corrosive substances and heat sources are common in the workplace and may cause damage to ropes which come into contact with them. Wherever feasible, such hazards should be removed or contained (e.g isolating hot pipes). Ropes should be rigged to avoid any remaining hazards using techniques such as Y-hangs (using four anchors), re-anchors and double deviations. Other methods, such as canvas rope protection, offer a limited degree of protection and may be appropriate for less serious hazards such as light abrasion.

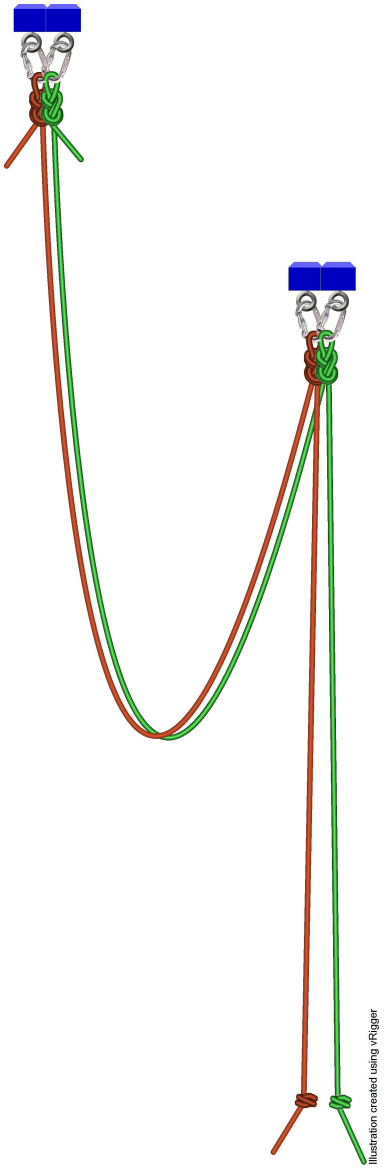


Re-anchors

A re-anchor is a secondary set of anchors installed at any distance below the primary anchors. Ropes may be re-anchored for a number of reasons, including positioning the ropes for work, avoiding hazards or to reduce rope stretch. The secondary anchor requires a double anchor with the same strength requirements as the primary anchors (15kN).

Rigging should take into account ease of use and methods of rescue. For this reason the re-anchor loops should not be too shallow as this can make both access and rescue more difficult.

Level 2 and 3 candidates shall demonstrate the rigging of a re-anchor at height. For Level 2's the off-set shall be less than 1.5m, for Level 3 candidates the off-set may be any distance apart.



Deviations

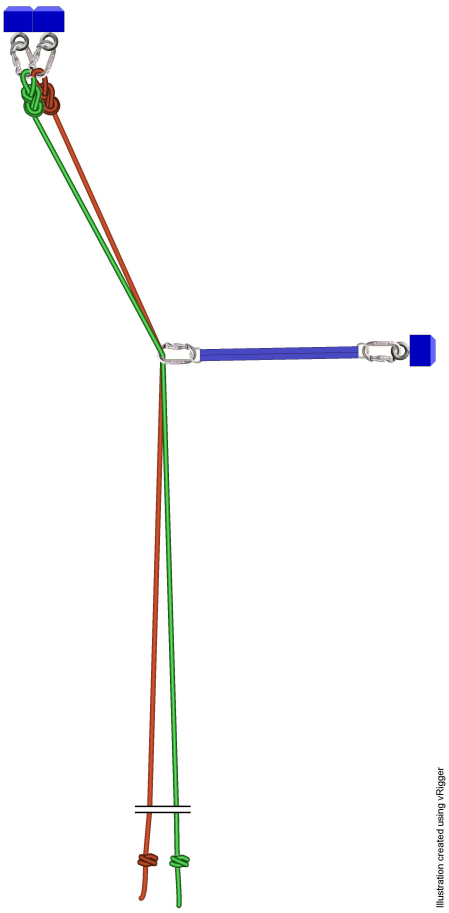
Deviations are a method of rigging which allows re-direction of the path of ropes. Ropes may be deviated to provide more accurate positioning or to avoid hazards. Unlike re-anchors, deviations allow positioning with a system that has been rigged for rescue. On a continuously overhanging structure a series of deviations may be used.

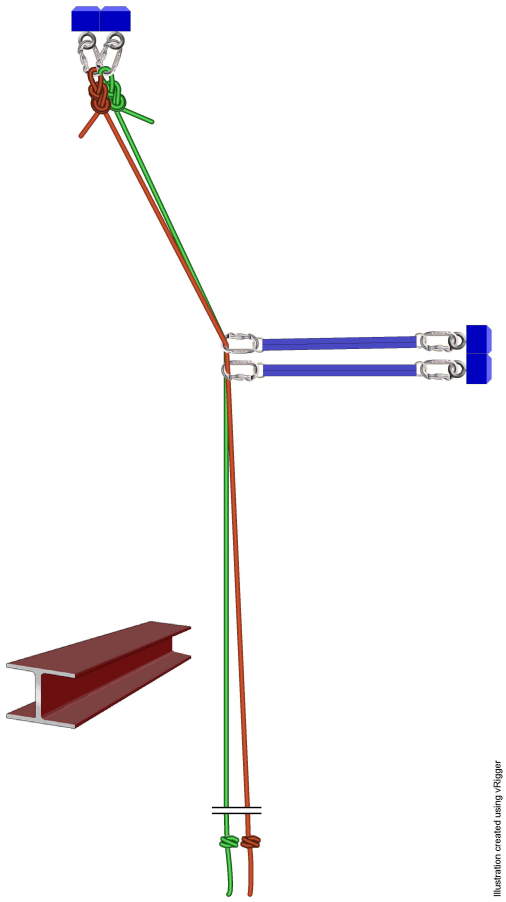
Single anchor deviations

Single anchor deviations are used to deviate the ropes by a small angle only and where the consequences of a failure of the deviation will not result in serious consequences such as a large swing or contact with a sharpe edge. A single deviation should be no more than 20 degrees off the vertical with an off-set of no more than 1.5m.

Double anchor deviations

Double anchor deviations shall be used where the consequences of a failure of the deviation are unacceptable such as a large out of control swing or contact with a hazard. Such a deviation uses a double anchor system with suitably rated anchor points (15kN) and connections. If the technician has to climb through the deviation it should be no more than 20 deg off the vertical with an off-set of no more than 1.5m. However if the technician remains below the double deviation it can be deviated at any angle and off-set any distance.

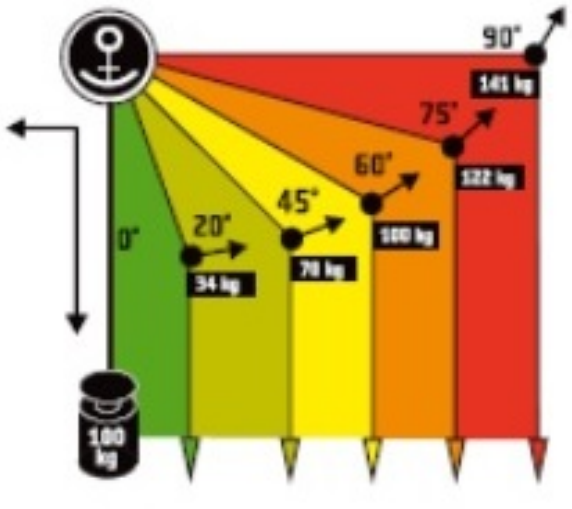




Angle loading

It is important to be aware that the loading on a deviation will increase as the angle of the deviation increases.

The diagram below shows the increase in load on the deviation as the angle increases with a 100kg load.



Retrievable rigging

Retrievable rigging methods (often called pull-throughs) allow ropes to be installed or retrieved remotely. They should be considered temporary rigging for access or egress and are therefore not normally used in a rescue situation.

Depending on the anchorage used there may be a need to protect the ropes against abrasion from edges and care should be taken to ensure there are two independent system and that karabiners are not cross loaded.

The left hand diagram below shows a retrievable system using steel strops to take the load where edge protection is required. The right hand diagram shows a retrievable system over tubular steel where no protection is required.

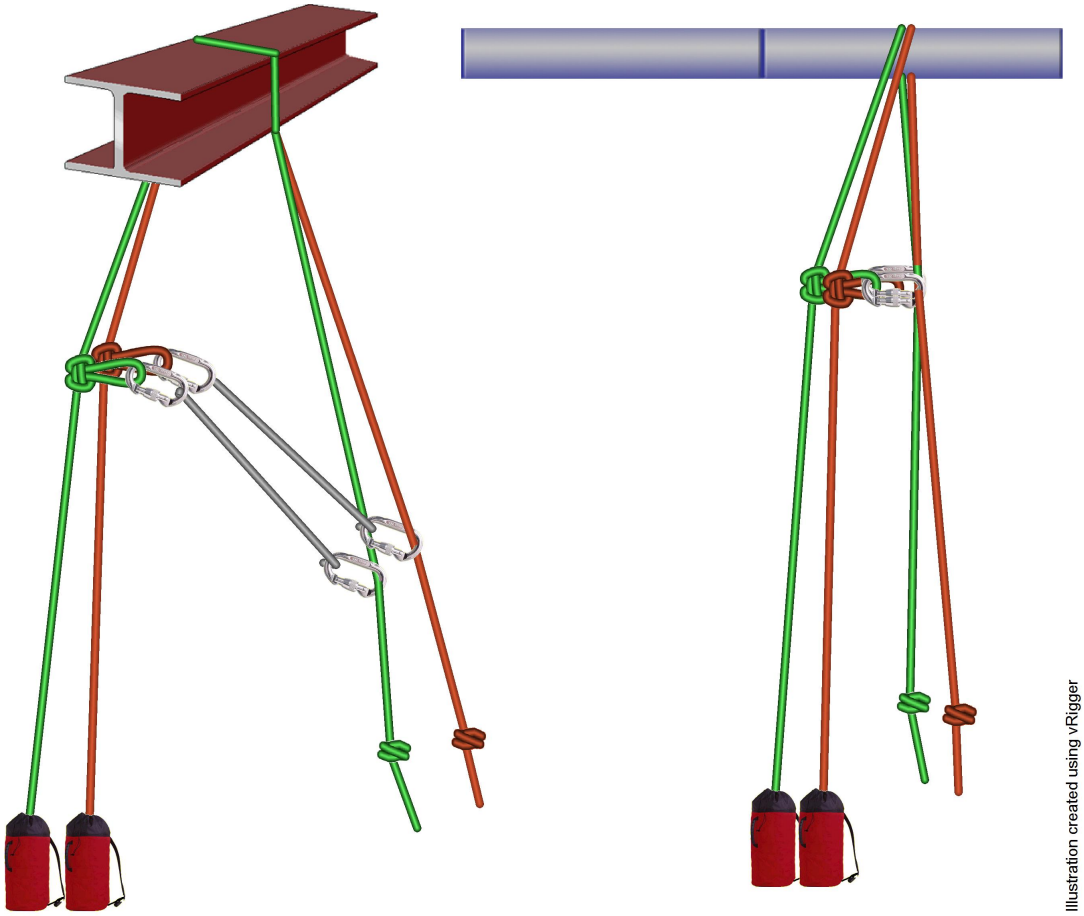
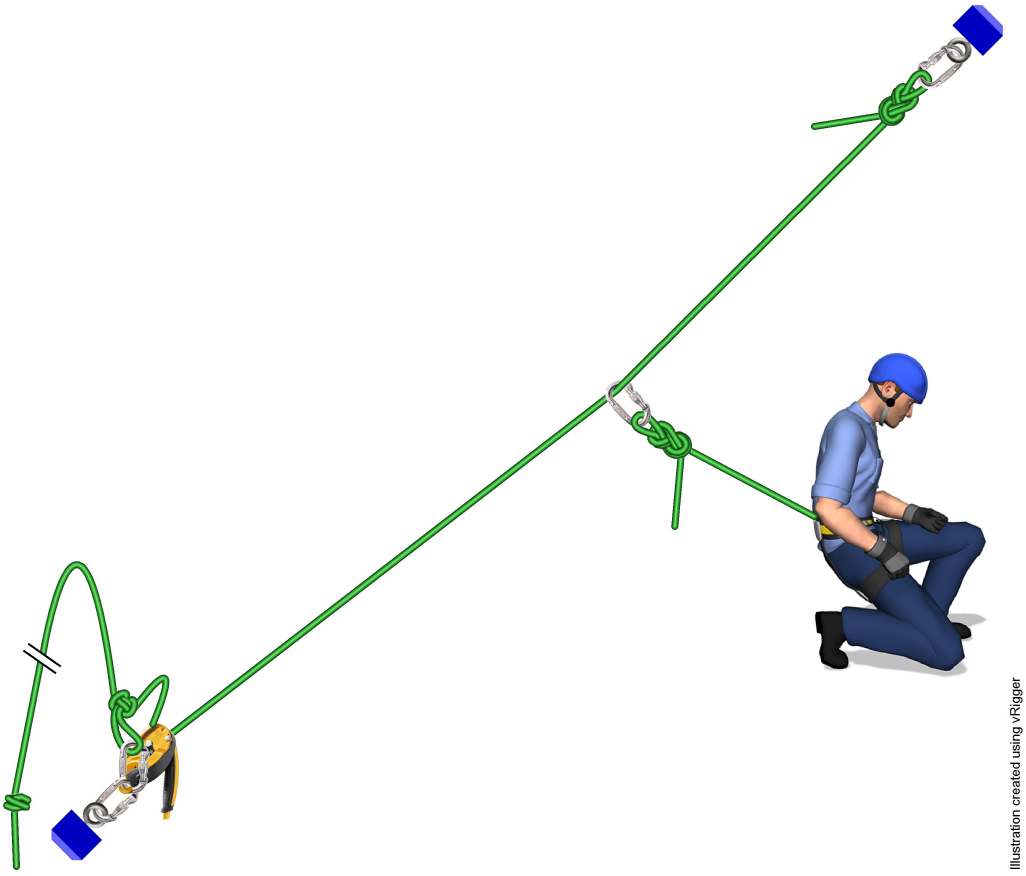


Illustration created using vRigger

Work restraint lines

Work restraint is a system where a person is prevented from entering an area where a fall from height exists by use of fall protection PPE.

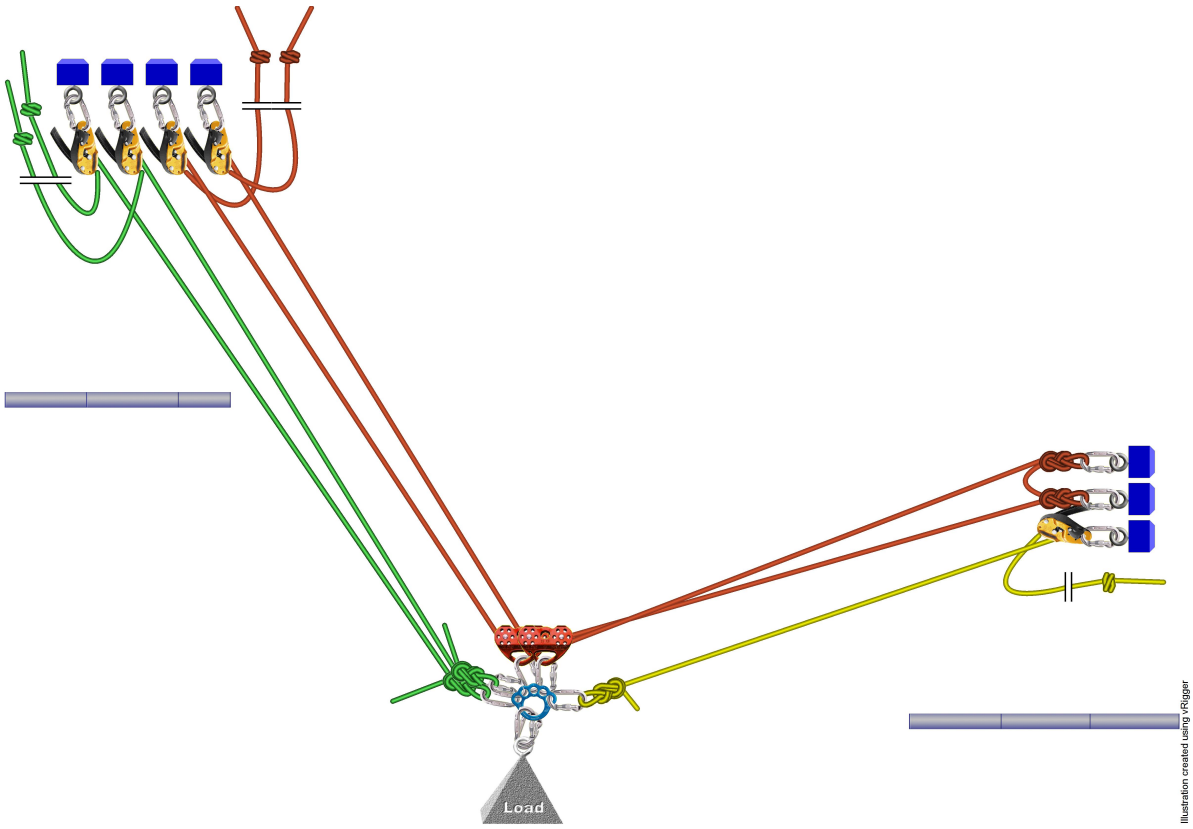
The example below shows a tensioned line that could be rigged parallel to an exposed edge allowing the user to access a larger area than a single fixed lanyard anchor at one end but still preventing the user being exposed to a risk of falling. A system like this would be tightened using at 3:1 haul system.



Tensioned lines

Ropes can be tensioned between two sets of anchors to facilitate horizontal or diagonal movement. Additional safety lines are required to control movement when using diagonal tensioned lines.

The diagram below shows diagonal tensioned lines where two control ropes (green) are required where the consequences of failure are unacceptable, a single control line (yellow) is adequate where the result of a line failure is not hazardous.

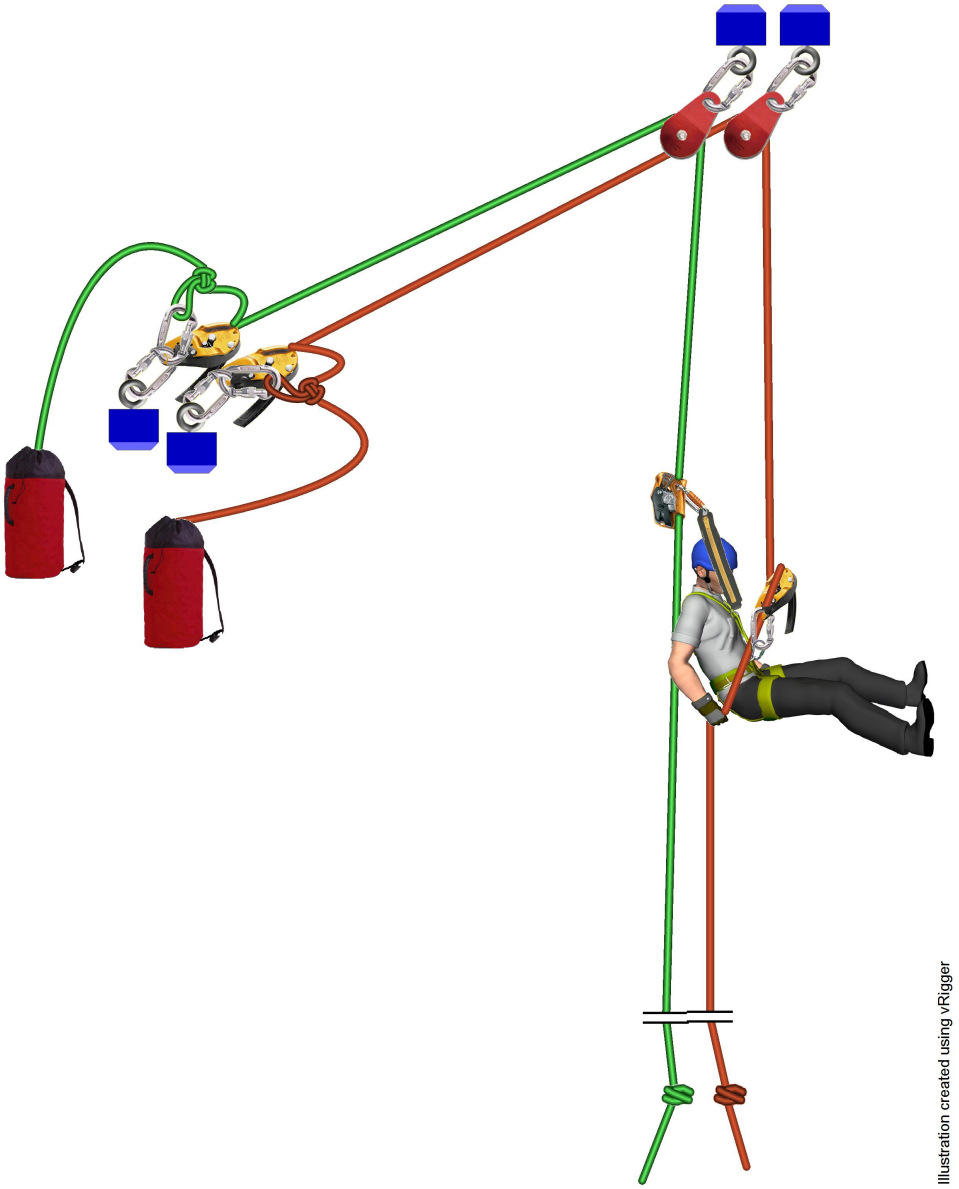


Rigging for rescue

Options and methods for rescue should be considered at the planning stage and a site specific rescue plan should be included in the safety method statement. Rope access technicians should be provided with the training and equipment necessary to implement the rescue plan.

All levels shall show awareness of rigging for rescue and the benefits of doing so. A system like the one shown below will speed up and simplify any rescue.

Level 1 candidates are required to lower a casualty using a pre-rigged system. Level 2 and 3's are required to rig a system and haul a casualty using this system as well as lowering a casualty to safety.



PULLEY SYSTEMS

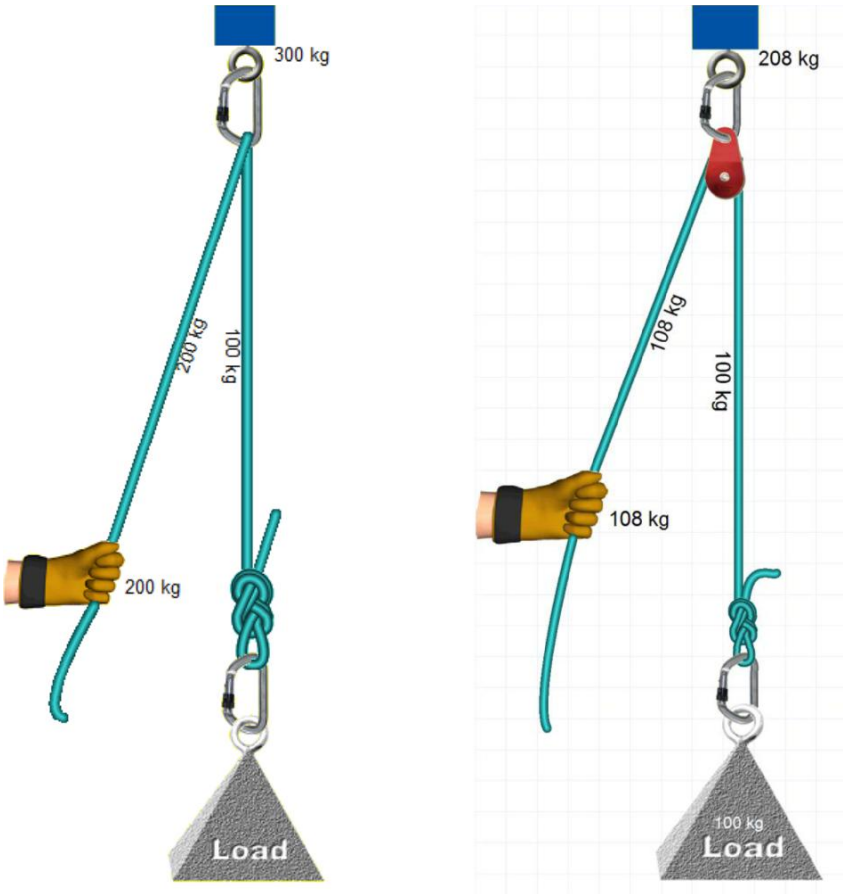
To lift casualties in rescue situations, either a substantial number of people will be needed to haul or equipment can be used to gain an advantage.

Mechanical advantage is usually expressed as a simple ratio. We need to understand how we get these ratios and what they mean. Simply adding a pulley into your system does not automatically give mechanical advantage.

In the example below right all the pulley gives us is a change of direction creating a downward pull. This has a ratio of 1:1. Notice the loading on the anchor has doubled, this is called the head load.

Other factors such as friction and the angle of the pull will have an effect on the efficiency of the system. The example on the left shows what happen when a karabiner is used instead of a pulley and frictional forces are taken into account.

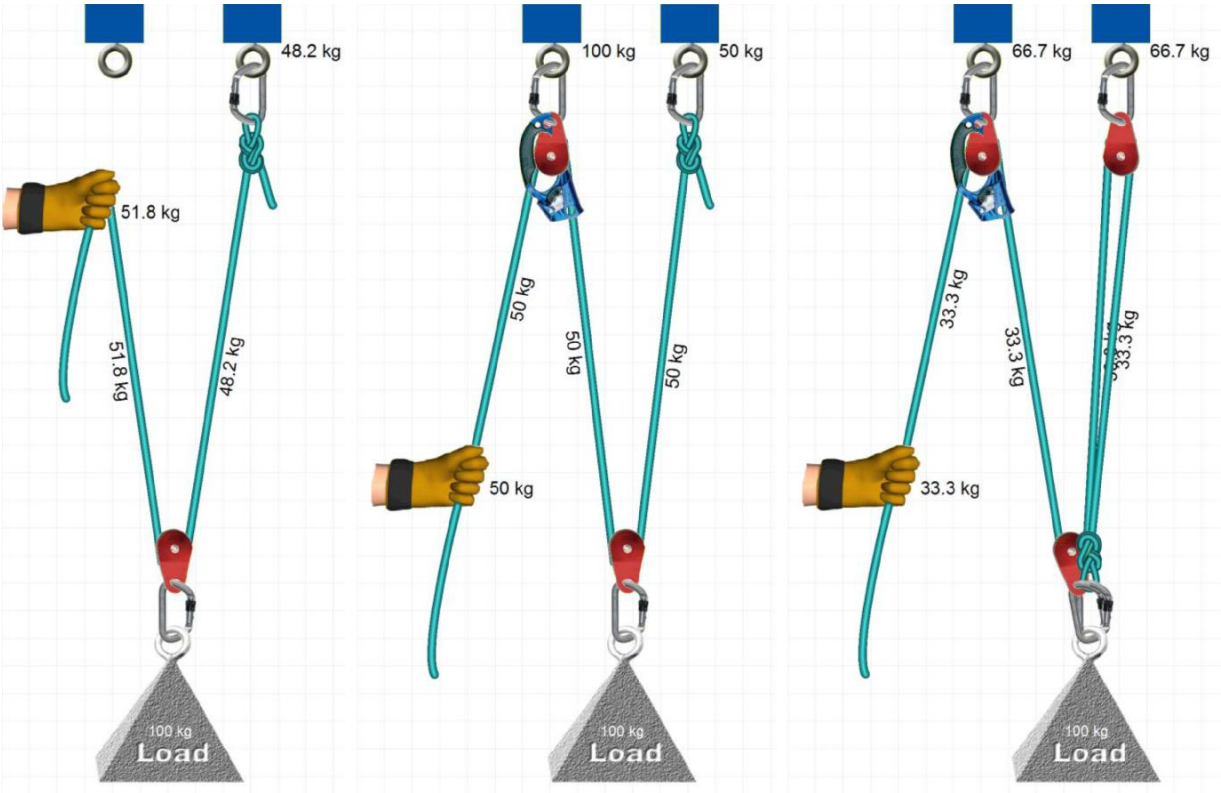
A petzl rescue pulley will add about 8% more to the tension in the rope each time it is added to a haul system. A karabiner as you can see will at 100%. Make sure you have pulleys and you use them, it will make your life a lot easier.



If we anchor the rope above the load and add a pulley to the load, a mechanical advantage of 2:1 can be gained. In the first example we have added in 8% for the friction on the pulley. An upward pull has to be used for this so adding in a pulley to the other anchor bolt would give a change of direction only, keeping the ration 2:1 but making the haul easier. The consequence of the efficiency is that twice the amount of rope will need to be used in the system.

Another problem we have is that if the control hand lets go, the load will be lost! By adding in a hand ascender, we can create a clutch to hold the load. In the middle example we have shown the theoretical loads and have not accounted for angles or friction. A 2:1 mechanical advantage for hauling a single person, fully equipped and over a distance of more than a few metres maybe extremely difficult so more advantage may be needed.

By attaching the rope directly to the load, running it up over a pulley then around the pulley on the load the back up to be re-directed, a 3:1 ration is made. This will give a good balance against effort to lift and amount of rope that needs to be hauled. 3:1 is the most suitable ratio for hauling a single casualty over moderate distances.

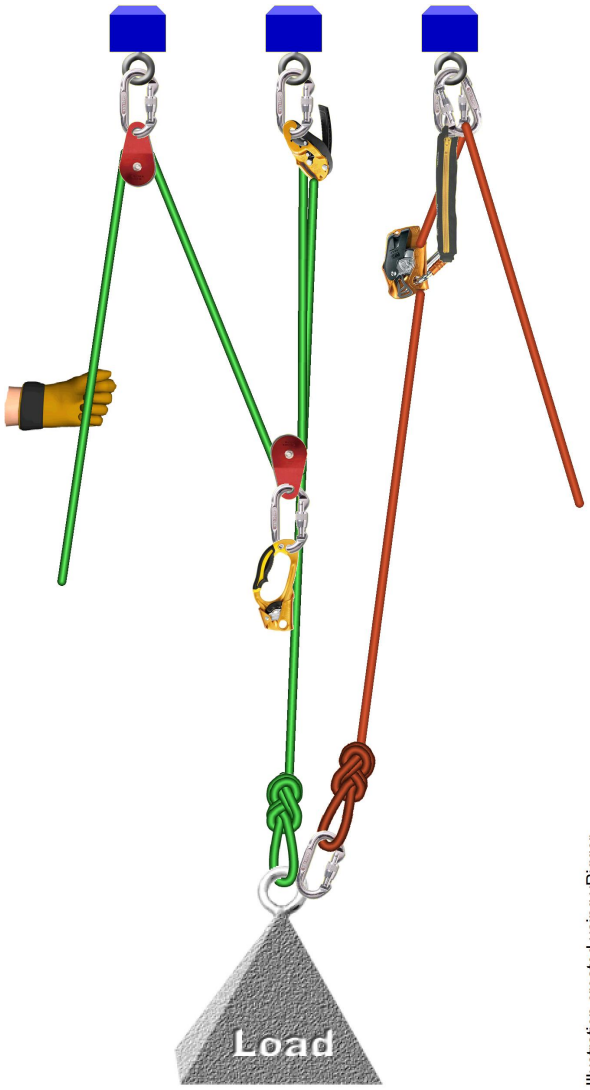


3:1 with back up

By adding a descender in to the system as a clutch, this gives the ability to lower the load without having to change equipment. The drawback with this method is increased friction when hauling. Although the system opposite is a theoretical 3:1, in reality it will feel more like 2:1 due to the increase friction. Any descender clutch will have this effect whether it‘s an ID, Stop or Rig.

A back up rope has been included to maintain 2 points of contact. When hauling, ensure that the slack rope is taken in, minimising any slack in the backup system.

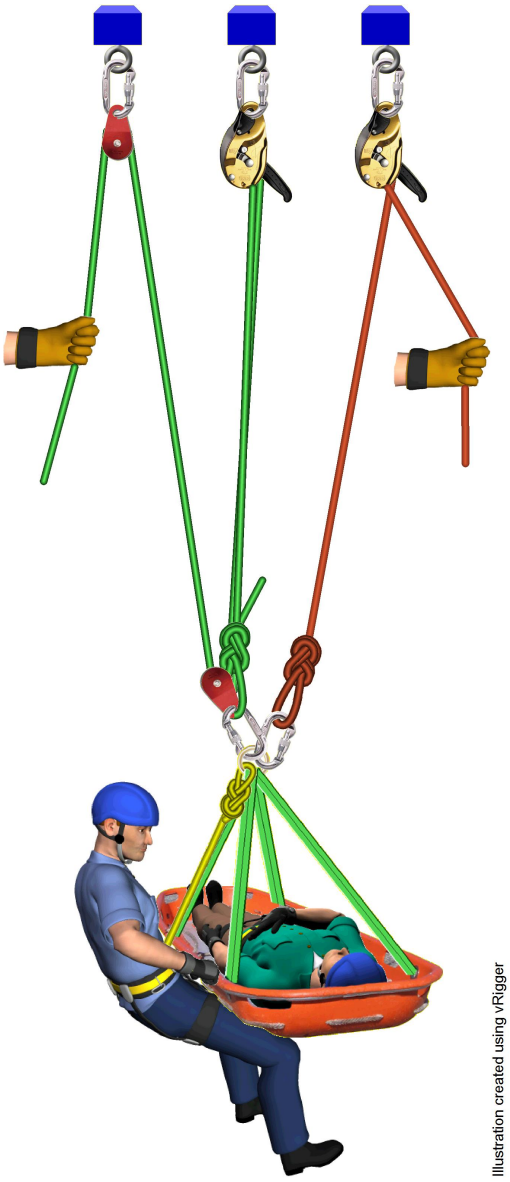
Instead of connecting the pulley directly to the load, it‘s connected to a hand ascender on the main rope attached to the load. This allows us to use less rope in the hauling system. For example, if the load was 40m away, we would not need 3 times the rope (as in a conventional 3:1 set-up) but only a few extra metres would be needed to build the 3:1 in the way shown below.



6:1 with back up

If we have a rescue load such as a casualty, a stretcher and a barrow boy, a load of two people can be hauled or lowered. In this situation a 3:1 may not be suitable. By beginning our hauling system with a 2:1 then adding a 3:1 to this, a 6:1 ration can be achieved.

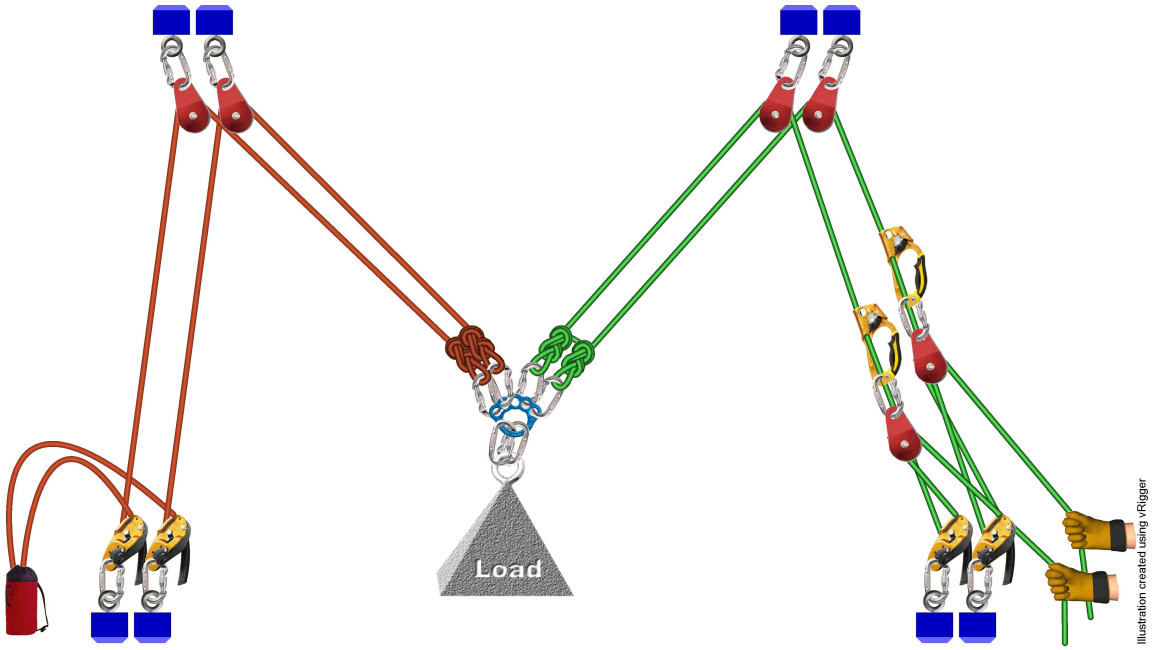
Any back up rated for a two person dynamic fall could be used as a back up, however if a fall is prevented by such a device it will need to be reconfigured to continue hauling or lowering. A Petzl ID has a maximum SWL of 250kg in a rescue scenario, therefore with care to avoid any slack in the system this would be an acceptable back up. This system would need 2 persons to lower in this configuration.



Cross haul

Moving a casualty around or through three-dimensional obstacles can be achieved with a cross haul system.

Where there is potential for a large out of control swing, four (or more) independent rope systems must be used. The potential for anchor points to slide, angle loading and obstacles in the path of both the load and ropes should all be taken into account when rigging a cross haul.



Rope rescues

If rigging a system for rescue is not considered feasible, intervention rescues may be considered the rescue plan. Such rescues can often be simplified if an additional set of ropes and equipment is available. Required equipment should be specified in the rescue plan and prepared to enable rapid deployment. To fully test candidates' skills, assessment tends to concentrate on intervention using existing ropes and rigging; however, technicians should be aware that pre-planned systems would normally be the first choice at work. Care should be taken in all rescues to maintain the backup device in a high position, and to minimise tangled ropes and rope on rope abrasion.

Equipment loading during rescues often exceeds the loading normally allowed for one person. This reduces safety factors on equipment strength, and may require more careful management of backup devices to reduce the potential for high dynamic loads.

Rescue of a casualty who is in descent mode

Rescue from descent using another set of rescue ropes beside the casualty.

- This rescue can be carried out either from above or below.
- If approaching from above descend until level with the casualty.
- If approaching from below ascend until slightly higher than the casualty and changeover in to your descender, the hand ascender should also be removed.
- Attach a cow's tail from your harness to the casualty, this could be attached to the ventral D ring or sternal D ring.
- Attach a karabiner between the casualty's sternal D ring and the karabiner on your descender.
- If the casualty has a duck/enforcer back up remove it at this point.
- If the casualty has an ASAP back up check it is not locked but leave it attached to the rope.
- Lower off the casualty's descender until there is no tension on it and remove it from the rope.
- Taking care not to trap the ropes between you straddle the casualty so you are both in a more comfortable position.
- Connect an extra friction karabiner to your descender karabiner and clip the descender control rope to it.
- Check your backup is not locked and descend holding the control rope high to add extra friction.
- Descend

Rescue from descent using the same ropes as the casualty

- Ascend until level with the casualty
- Attach your second backup above the casualty and remove the original.
- Changeover in to your descender making sure you are at the casualty's chest level.
- Attach your adjustable lanyard to the casualty's ventral D ring and shorten it. This can also be done with a Grillon or cow's tail. If an adjustable lanyard or Grillon is used it will reduce the chance of a shock load if the short connection to the casualty was to fail.
- Connect the casualty's sternal D ring to your descender karabiner with a spare karabiner.
- Remove the casualty's backup
- Lower off the casualty's descender and remove it from the rope
- Taking care not to trap the ropes between you straddle the casualty so you are both in a more comfortable position.
- Connect an extra friction karabiner to your descender karabiner and clip the descender control rope to it.
- Check your backup is not locked and descend holding the control rope high to add extra friction.
- Descend

Rescue of a casualty who is in ascent mode

Rescue from ascender using a length of cord

- Ascend until level with the casualty
- Attach your second backup above the casualty and remove the original.
- Changeover in to your descender making sure you are at the casualty's chest level.
- Attach your adjustable lanyard to the casualty's ventral D ring and shorten it. This can also be done with a Grillon or cow's tail. If an adjustable lanyard or Grillon is used it will reduce the chance of a shock load if the short connection to the casualty was to fail.
- Connect the casualty's sternal D ring to your descender karabiner with a spare karabiner.
- Remove the casualty's backup.
- Remove the cow's tail from the casualty's hand ascender.
- Attach one end of the cord to the casualty's sternal D ring and thread it through the karabiner on the casualty's hand ascender, thread it through the D ring and again through the top karabiner to create a 3:1.
- Half the length of your foot loop and attach your hand ascender to the cord, slide it high and stand in the foot loop to lift the casualty.
- Remove the chest ascender and lower the casualty using the cord until the weight is transferred to your descender karabiner.
- Remove the cord and hand ascender
- Taking care not to trap the ropes between you straddle the casualty so you are both in a more comfortable position.
- Connect an extra friction karabiner to your descender karabiner and clip the descender control rope to it.
- Check your backup is not locked and descend holding the control rope high to add extra friction.
- Descend

Rescue from ascender using a Grillion.

- Ascend until level with the casualty
- Attach your second backup above the casualty and remove the original.
- Changeover in to your descender making sure you are at the casualty's chest level.
- Attach your adjustable lanyard to the casualty's ventral D ring and shorten it. This can also be done with a Grillon or cow's tail. If an adjustable lanyard or Grillon is used it will reduce the chance of a shock load if the short connection to the casualty was to fail.
- Remove the casualty's backup.
- Remove the cow's tail from the casualty's hand ascender.
- Connect the karabiner end of the Grillon to the top of the casualty's hand ascender and the other end of the Grillon to the casualty's ventral D ring.
- Attach a pulley to the tail rope of the Grillon and connect it to the hand ascender.
- Attach your hand ascender and foot loop to the tail rope of the Grillon.
- Stand in the foot loop to lift the casualty and remove the chest ascender.
- Remove the pulley and hand ascender from the Grillon.
- Lower the casualty until level your descender.
- Connect the casualty's sternal D ring to your descender karabiner with a spare karabiner.
- Continue to lower off the grillon until slack and remove it and the hand ascender above.
- Taking care not to trap the ropes between you straddle the casualty so you are both in a more comfortable position.
- Connect an extra friction karabiner to your descender karabiner and clip the descender control rope to it.
- Check your backup is not locked and descend holding the control rope high to add extra friction.
- Descend

Passing a deviation with a casualty

Deviations may be rigged to position ropes or avoid obstructions. These may not be compatible with lowering systems, so the rescue plan needs to ensure sufficient competence within the team to deal with them.

Where possible the deviation should be unclipped below you and descend directly to the ground with the casualty. This will not be an option on your assessment.

- Rescue the casualty.
- Descend with the casualty until level with the deviation anchor.
- Attach the descender end of the Grillon to your ventral D ring, pull in to the anchor using the tails of your ropes and attach the other end of the Grillon to the anchor point.
- Shorten the Grillon to keep you in to the anchor.
- Move the deviation from the ropes below you to the ropes above all your equipment.
- Lower off on the Grillon and remove it.
- Descend.

Passing a double deviation with a casualty

- Rescue the casualty.
- Descend with the casualty until level with the deviation anchor.
- Attach the descender end of the Grillon to your ventral D ring, pull in to the anchor using the tails of your ropes and attach the other end of the Grillon to the anchor point.
- If you can attach the Grillon to both anchors the one lanyard is sufficient. However, if the Grillon can only be attached to one of the anchors a cow's tail should be connected to the second anchor point.
- Shorten the Grillon to keep you in to the anchor.
- Move one deviation from the ropes below you to the ropes above all your equipment.
- Move the second deviation from the ropes below you to the ropes above all your equipment.
- Remove the cow's tail if you added it.
- Lower off on the Grillon and remove it.
- Descend.

Rope-to-rope transfer with a casualty

Horizontal movement can normally be achieved by performing a rope-to-rope transfer. Such a manoeuvre could be used during a rescue to avoid obstructions or to return to an access point from underneath a structure such as a platform or bridge.

- Rescue the casualty
- Attach a second descender to your ventral D ring, taking care to connect it the same way as the original, this may include the D ring and also the short link karabiner.
- Attach the new working line to the new descender and take in any slack.
- Attach your spare backup to the new backup rope and take in any slack. Leave the original backup on to prevent a large out of control swing.
- Descend the original ropes until fully suspended on the new ropes directly below the anchor points.
- If you don't have enough hight to transfer all the way over in one move, the original descender should be locked and a hauling system added to the new working line.
- Attach a hand ascender to the new working line, add a pulley to the new control rope and attach it to the hand ascender.
- Pull down on the new control rope to climb the rope, another hand ascender and foot loop may be used to help climb.
- Lower on the original descender until directly below the new anchor points.
- Remove the original descender and backup.
- Descend the new ropes.

Passing a small re-anchor with a casualty

Small re-anchors (re-belays) may be rigged to avoid obstructions or reduce rope stretch on long drops. These may not be compatible with lowering systems, so the rescue plan needs to ensure sufficient competence within the team to deal with them.

- Rescue the casualty
- Care should be taken not to connect either the short connection or the lanyard/cow's tail connection to the casualty over the re-anchor loops.
- Double check the step above.
- Descend with the casualty until level with the lower anchor points.
- Care should be taken not to reach through the re-anchor loops when getting hold of the lower set of ropes as this will result in a tangle of ropes.
- Attach a second descender to your ventral D ring, taking care to connect it the same way as the original, this may include the D ring and also the short link karabiner.
- Attach the working line on the lower part of the re-anchor to the new descender and take as much rope through the descender as possible.
- Lower on the original descender until the weight is shared between both descenders.
- Remove the backup and re-attach it to the backup rope one the lower part of the re-anchor.
- Lower off all the way on the original descender and remove it from the rope.
- Descend.

Large re-anchor rescue (loop)

Loop rescue (casualty's ascender side)

- When approaching a casualty in the loop it is important to assess which direction is the easiest to rescue them from.
- Ascend to the top of the ropes on the casualty's ascending gear side and change into your descending device.
- Place a karabiner into the ventral D ring of your harness and attach it to both ropes of the loop.
- Connect a cow's tail into both ropes of the loop.
- This will allow you to descend to your casualty without putting your equipment into the loop.
- Descend to the casualty and remove his hand ascender in order to be as close as possible to them.
- Remove the cow's tail from the casualty's hand ascender and place it above your descending device.
- Attach your adjustable lanyard to his ventral D ring and attach a hard link between your ventral D ring and the casualty's sternal D ring taking care not to connect over the top of the loops.
- Place a pulley on a karabiner and run the rope from your descending device through this pulley, connect this to the hand ascender above your descender.
- Slide the hand ascender and pulley as far up the rope as possible.
- Now attach your hand ascender onto the rope from the pulley, shorten the foot loop in half, place your foot into it and drive your leg down.
- This will cause you to move back up the rope bringing your casualty with you.
- As the casualty moves, the rope in his chest ascender will become slack.
- You will then be able to remove the ascending device from the rope.
- Also you can remove the karabiner that was used to travel down to the casualty.
- You can now continue to ascend using the pulley system and descend on your casualty's
- descending device alternately.
- Ensure that you take your casualty's back-up device as you progress and maintain yours as high as possible.
- Now you are at the end of the loop, and your weight has been transferred onto your descending equipment, take your casualty's descending and backup devices out of the loop.
- Descend with the casualty.

Loop rescue (casualty's descender side)

- When approaching a casualty in the loop it is important to assess which direction is the easiest to rescue them from.
- Ascend to the top of the ropes on the casualty's descending gear side and change into your descending device.
- Place a karabiner into the ventral D ring of your harness and attach it to both ropes of the loop.
- Connect a cow's tail to both ropes of the loop.
- This will allow you to descend to your casualty without putting your equipment into the loop.
- Descend to the casualty.
- Attach your adjustable lanyard to his ventral D ring and attach a short link between your ventral D ring and the casualty's ventral D ring taking care not to connect over the top of the loops.
- Lower off on the casualty's descender and remove it from the rope.
- Replace the descender below the casualty's chest ascender making sure it is loaded to prevent a swing in the direction of the rescuer.
- Remove the cow's tail from the casualty's hand ascender and place a spare karabiner through the top of the hand ascender.
- Connect the 5mm cord to the casualty's sternal D ring and tread it through the on the hand ascender twice to create a 3:1.
- Place your hand ascender and foot loop on the cord and stand in the loop the lift the casualty.
- Alternatively the above step can be done using a Grillon as you would do for an ascent rescue when a Grillion is used instead of cord.
- Remove the casualty's chest ascender.
- Lower on the cord/Grillion and then remove it.
- Remove the casualty's hand ascender and place it on your working line above your descender.
- Connect a pulley to the hand ascender and run the rope from your descending device through this pulley.
- Slide the ascending device and pulley as far up the rope as possible.
- Now place your hand ascender onto the rope from the pulley, shorten the foot loop in half, place
- your foot into it and drive your leg down.
- This will cause you to move back up the rope bringing your casualty with you.
- You can now remove the karabiner that was used to travel down to the casualty.
- You can now continue to ascend and descend using the pulley system and your casualty's
- descending device.
- You can now continue to ascend using the pulley system and descend on your casualty's
- descending device alternately.
- Ensure that you take your casualty's back-up device as you progress and maintain yours as high as possible.
- Now you are at the end of the loop, and your weight has been transferred onto your descending equipment, take your casualty's descending and back-up devices out of the loop.
- You will then have to place the casualty in an upright position by clipping a karabiner through the sternal D ring of the casualty's harness and clipping this to a suitable point on you.This will ensure that the casualty is in a more comfortable position.
- Descend with the casualty.

Mid-transfer rescue

Difficult rescue situation may arise where a casualty is suspended midway across a transfer manoeuvre.

Mid-transfer rescue from above

Where you can easily access the top of the casualty's ropes this rescue is basically the same as the loop rescues above.

Casualty's ascending ropes side

- Rig a new set of ropes at the same anchor point as the casualty's ascending side ropes.
- Get on to the ropes as if to descend.
- Follow loop rescue (casualty's ascender side) steps above.

Casualty's descending ropes side

- If you can only access the anchors at the top of the casualty's descender side ropes rig a new set of ropes from these anchors.
- Get on to the ropes as if to descend.
- Follow loop rescue (casualty's descender side) steps above.

Mid-transfer rescue from below

Casualty's ascender side

- Ascend the casualty's ascender side backup rope using the casualty's descender rope or other backup rope for your backup. If you load the casualty's ascender rope from below the rope could come out of their chest ascender so this is best avoided.
- When you are as close to the casualty's backup as possible attach your new backup above the casualty's chest ascender and remove the original backup.
- Changeover into your descender.
- Attach your adjustable lanyard to the casualty's ventral D ring and shorten it.
- Remove the casualty's backup on your side.
- If you are on the low side ascend on your descender until level with the casualty.
- Connect your Grillon between your ventral D ring and the casualty's ventral D ring and shorten it as much as possible.
- Attach your hand ascender and foot loop above your descender and climb on your descender to take the weight of the casualty's chest ascender.
- Remove the casualty's chest ascender.
- Depending on which direction you want to travel you can either descend using the casualty's descender until in the vertical or descend using your own descender until in the vertical on the other side.
- When you are directly below the anchor points remove the descender and back up that are not under tension and descend.

Mid-transfer rescue

Casualty's descender side from below

- Ascend the casualty's backup rope on the descender side using the casualty's descender rope for your backup.
- When you are as close to the casualty's backup as possible attach your new backup above the casualty's descender and remove the original backup.
- Changeover into your descender.
- Attach your adjustable lanyard to the casualty's ventral D ring and shorten it.
- Remove the casualty's backup on your side.
- If you are on the low side ascend on your descender until level with the casualty.
- Connect your Grillon between your ventral D ring and the casualty's ventral D ring and shorten it as much as possible.
- Lower off on the casualty's descender and remove it from the rope.
- Attach the casualty's descender below their chest ascender making sure it is loaded to prevent a swing in the direction of the rescuer.
- Using the casualty's hand ascender as a lifting point remove the casualty's chest ascender either using a Grillon or a length of cord as you would in an ascender rescue.
- Lower off using the Grillon/cord and remove the casualty's ascender.
- Depending on which direction you want to travel you can either descend using the casualty's descender until in the vertical or descend using your own descender until in the vertical on the other side.
- When you are directly below the anchor points remove the descender and back up that are not under tension and descend.

Passing mid-rope knots with a casualty

Mid-rope knots are occasionally created either to extend ropes or to isolate small areas of damage. Such knots can complicate rescue. With proper planning, the complications can often be minimised or avoided.

- Rescue the casualty
- Descend with the casualty until 1.5m above the knots, if you have enough spare rope below you stopping higher than this is recommended.
- Place a hand ascender above your descender on your working rope.
- Tie a suitable anchor knot below the original knot in the working rope and clip the new knot to the hand ascender above.
- Make sure the re-anchor loop is not too shallow to avoid being trapped in the loop.
- Attach a second descender to your ventral D ring, taking care to connect it the same way as the original, this may include the D ring and also the short link karabiner.
- Attach the re-anchored rope that goes to the ground to the new descender and take in any slack.
- Lower off on the original descender and remove it from the rope.
- Descend until your backup is close to the knot in the backup rope.
- Attach your second backup below the knot and remove the original backup.
- Descend.

Climbing rescues

Rescue from an aid climb

Where rope access technicians are climbing directly on the structure, either by aid climbing techniques or with fall arrest equipment, planning needs to consider rescue methods. Team selection should take account of the time taken to reach and rescue a casualty. In some situations, techniques such as assisted aid climbing where the rope access technician is suspended on remotely controlled work-positioning ropes can allow straightforward lowering of a casualty.

The rescuer may either remain on the structure and lower the casualty to safety or descend with the casualty.

Descent with the casualty

- Aid out to the casualty.
- Rig twin ropes as close to the casualty as possible. This could be a basic anchor system or Y hang depending on the aid climb.
- Attach your descender to the working line and your back up on the other line.
- Remove your aid climbing attachments.
- Attach your adjustable lanyard to the casualty's ventral D ring and shorten it.
- Attach your karabiner connection between the karabiner on your descender and the casualty's sternal D ring.
- Remove all the casualty's unweighted lanyards.
- If the casualty is suspended by a Grillon lower off on the Grillon and remove it.
- If the casualty is suspended from a lanyard, lift the casualty using either your length of cord, Grillon or hauling system. The anchor point above the casualty can be used as a lifting point.
- Disconnect the casualty's lanyard and lower until the casualty is suspended from the karabiner connection.
- Remove the cord/Grillion and descend to the ground.

Rescuer remaining on the structure

- Aid out to the casualty.
- Connect two ropes to the casualty's sternal D ring.
- The descender should now be placed on the working rope and anchored directly above the casualty, a new anchor sling may be used here to give you a higher lifting point.
- The back up should now be placed on the back up line and anchored to a separate anchor point.
- Remove all the casualty's unweighted lanyards.
- If the casualty is suspended by a Grillon lower off on the Grillon and remove it.
- If the casualty is suspended from a lanyard lift the casualty using either your length of cord or Grillon, the anchor point above the casualty can be used as a lifting point.
- Disconnect the casualty's lanyard and lower until the casualty is suspended from the descender rope.
- Add a change of direction karabiner and lower the casualty to the ground.

Rescue from fall arrest equipment

Wherever the use of fall arrest equipment has been selected as a suitable access method, planning needs to consider rescue methods. Fall arrest systems typically allow longer potential falls than rope access systems and, therefore, typically carry a greater risk of injury.

- Climb the structure so you are above the casualty.
- Rig twin ropes from the structure so they are directly above the casualty.
- Descend the ropes until level with the casualty's sternal D ring.
- Attach your adjustable lanyard to the casualty's ventral D ring and shorten it.
- Attach your karabiner connection between the karabiner on your descender and the casualty's sternal D ring.
- Lift the casualty using either your length of cord or Grillon, the hand ascender used as a lifting point should be placed on your working rope.
- Disconnect the casualty from the fall arrest lanyard.
- Lower the casualty so they are suspended from the karabiner connection.
- Remove the cord/Grillion and descend to the ground.

Rescue from an aid climb with a casualty on a short connection.

Aid climb rescues can be particularly complicated if the casualty is attached to the structure by a very short connection. This is especially so if the short connection consists of all-metal connections and only one connector is used. For this reason safety supervisors should ensure rope access technicians avoid the use of such attachments in the workplace. The short connection used in assessment should be a two connector attachment.

- Aid out to the casualty.
- Connect two ropes to the casualty's sternal D ring.
- The descender should now be placed on the working rope and anchored directly above the casualty using the anchor the casualty is suspended from.
- The back up should now be placed on the back up line and anchored to a separate anchor point on the aid climb.
- Remove all the casualty's unweighted lanyards.
- Tie your cord directly to the D ring the casualty is suspended from and pass the other end through the bolt or highest karabiner the casualty is suspended from, wrap the cord round a second time to create a 3:1.
- Attach your hand ascender to the cord and step down in the foot loop to lift the casualty.
- Remove the short connection and lower the casualty using the cord until they are suspended from the descender rope.
- Add a change of direction karabiner and lower the casualty to the ground.

OVER THE HEAD ANGLES AND DEVIATIONS				
ANGLE IN	MULTIPLIER		ANGLE IN	MULTIPLIER
0	2		100	1.29
10	1.99		110	1.15
20	1.97		120	1.00
30	1.93		130	0.84
40	1.87		135	0.76
45	1.84		140	0.68
50	1.81		150	0.52
60	1.73		160	0.35
70	1.64		170	0.17
80	1.53		180	0
90	1.41			
Y HANG ANGLES				
ANGLE IN	MULTIPLIER		ANGLE IN	MULTIPLIER
0	0.5		90	0.71
10	0.501		100	0.78
20	0.508		110	0.87
30	0.518		120	1
40	0.53		130	1.18
45	0.54		135	1.31
50	0.55		140	1.46
60	0.58		150	1.93
70	0.61		160	2.88
80	0.65		170	5.74

HORIZONTAL DEFLECTION BETWEEN ANCHORS IN SAFETY LINE					
Distance between anchors	2m	5m	10m	15m	20m
Deflection	1m	2m	2.5m	3.75m	4.5m