Code of practice for selection, use and maintenance of personal fall protection systems and equipment for use in the workplace

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Committees responsible for this British Standard

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British Telecommunications plc
BSIF Test and Certification Association
Confederation of British Metalforming
Construction Fixings Association
Energy Networks Association
Health and Safety Executive
Industrial Rope Access Trade Association
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National Engineering Laboratory
North West Construction Safety Group
Performance Textiles Association
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Contents

Foreword

This British Standard has been prepared by Technical Committee PH/5.

This standard has been produced in response to the need to bring together best practice regarding personal fall protection from a large number of sources including information from manufacturers, from research studies and from training organizations.

The standard applies to the use of personal fall protection systems and equipment in the workplace only, where the prime activity is the work being undertaken. It is not intended to cover, for example, leisure activities or emergency evacuation systems and their procedures. Nevertheless, those engaged in other activities would probably benefit from the advice given in this standard, as many of the principles do apply and offer good practice. This standard is not intended to apply to personal fall protection systems and equipment for use in arboriculture.

The Health and Safety Executive (HSE) commends the use of this British Standard to those who have duties under the Health and Safety at Work etc. Act 1974. This standard was drawn up with the participation of HSE representatives and it will be referred to in the relevant HSE publications.

As a code of practice, this British Standard takes the form of guidance and recommendations. It should not be quoted as if it were a specification and particular care should be taken to ensure that claims of compliance are not misleading.

It has been assumed in the preparation of this standard that the execution of its provisions will be entrusted to appropriately competent and experienced people for whose use it has been produced.

WARNING. Those who work at height should never forget that gravity is no respecter of persons. It affects everyone; too many times with disastrous consequences resulting in serious, permanent injuries or death.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

In particular, attention is drawn to the statutory regulations listed in Clause **4**.

Summary of pages
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Introduction

Falls from a height are one of the largest causes of death and injury in the workplace. It is therefore essential that measures are taken to protect workers against falls from a height. These can include measures taken at the design stage, for example in the design of a new building, collective fall protection measures such as barriers and guard rails, and the use of personal fall protection systems and equipment. It is equally essential that the fall protection measures adopted are appropriate to the particular situation, that any fall protection system or equipment is correctly maintained and that users have appropriate training.

If a person working at a height, for example on a roof-top or tower, suffers a fall such that they lose contact with the surface on which they are supported, for example by stumbling over an edge, they will almost certainly hit the ground, or any intervening obstruction, with sufficient force to cause severe or fatal injuries. The severity of the injuries will be determined by the person's impact velocity, which will depend on the height of the fall, the nature of the impact surface and the part of the body that strikes the surface. The injuries are actually caused by the forces resulting from the rapid rate of deceleration of the body at impact.

NOTE A fall of 3.05 m (10 ft) takes only 0.8 s, giving no time for the person falling to react, and results in an impact velocity of 7.74 m/s (17.3 mph).

The severity of injury does not only depend on the height of the fall. While serious or fatal injuries can result from impact from a high fall onto a solid surface, they can also result from the following:

— impact from a relatively short fall onto, or through, a fragile surface;

— a head-first impact from a relatively short fall;

— a relatively short fall into water or a hazardous substance.

The present standard deals with personal fall protection systems in the context of a hierarchy of fall protection measures. It provides details of the types of fall protection systems and equipment available and gives guidance on their selection, use and maintenance, and on the training of users.

1 Scope

This British Standard gives recommendations and guidance on the selection, use and maintenance of personal fall protection systems and equipment for use in the workplace to prevent and/or to arrest falls from a height, including systems and equipment suitable for use in rescue. It also gives guidance on rescue of persons working at a height, in the event of an accident.

It is intended for use by employers, employees and self-employed persons who use personal fall protection systems and equipment. It is also intended for use by designers, e.g. architects and structural engineers, including those who are responsible for the design of safe access routes on buildings and structures, by those who commission work at a height, e.g. building owners and contractors, and by those involved in training persons for work at a height.

The standard is not applicable to collective fall protection systems, for example work platforms and fall arrest nets. It is not intended to apply to personal fall protection systems and equipment for use in leisure activities or in professional or private sports activities. It is also not intended to apply to personal fall protection systems and equipment for use in arboriculture.

NOTE 1 A discussion of the basic principles of fall protection is given in Annex A.

NOTE 2 Recommendations and guidance on the use of rope access methods are given in BS 7985.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

BS 7985:2002, *Code of practice for the use of rope access methods for industrial purposes.*

BS EN 353-1, *Personal protective equipment against falls from a height: guided type fall arresters including a rigid anchor line.*

BS EN 353-2, *Personal protective equipment against falls from a height: guided type fall arresters including a flexible anchor line.*

BS EN 354, *Personal protective equipment against falls from a height — Lanyards.*

BS EN 355, *Personal protective equipment against falls from a height — Energy absorbers.*

BS EN 358:2000, *Personal protective equipment for work positioning and prevention of falls from a height — Belts for work positioning and restraint and work positioning lanyards.*

BS EN 360, *Personal protective equipment against falls from a height — Retractable type fall arresters.*

BS EN 361, *Personal protective equipment against falls from a height — Full body harnesses.*

BS EN 362, *Personal protective equipment against falls from a height — Connectors.*

BS EN 363, *Personal protective equipment against falls from a height — Fall arrest systems.*

BS EN 795:1997, *Protection against falls from a height — Anchor devices — Requirements and testing.*

BS EN 813, *Personal protective equipment for the prevention of falls from a height — Sit harnesses.*

BS EN 892:1996, *Mountaineering equipment — Dynamic mountaineering ropes — Safety requirements and test methods.*

BS EN 1497, *Personal fall protection equipment — Rescue harnesses.*

BS EN 1891:1998, *Personal protective equipment for the prevention of falls from a height — Low stretch kernmantel ropes.*

ISO 1140:1990, *Ropes — Polyamide — Specification.*

ISO 1141:1990, *Ropes — Polyester — Specification.*

3 Terms and definitions

For the purposes of this British Standard, the following terms and definitions apply.

3.1 body-holding devices

3.1.1
full body harness
body-holding device primarily for fall arrest purposes, i.e. a component of a fall arrest system which comprises straps, fittings, buckles or other elements, suitably arranged and assembled to support the whole body of a person and to restrain the wearer during a fall and after the arrest of a fall

NOTE 1 Adapted from BS EN 361:2002.

NOTE 2 A full body harness may be incorporated into a garment.

3.1.2
sit harness
body-holding device comprising straps, fittings and buckles or other elements in the form of a waist belt with a low attachment element and connected supports encircling each leg, suitably arranged to support the body of a conscious person in a sitting position

NOTE 1 A sit harness may be fitted with shoulder straps and/or may be incorporated into a garment.

NOTE 2 Adapted from BS EN 813:1997.

3.2 anchorages

3.2.1
anchor
fixture or place for the secure attachment of anchor lines or persons

NOTE An eyebolt is an example of a fixture and a steel beam is an example of a place.

3.2.2
anchor point
part of an anchor to which other equipment in a personal fall protection system is attached

3.2.3
anchor device
element, or series of elements or components, of a personal fall protection system, which incorporates an anchor point or anchor points

NOTE Adapted from BS EN 795:1996.

3.2.4
structural anchor
element or elements, permanently secured to a structure, to which an anchor device or equipment for personal fall protection can be attached

NOTE Adapted from BS EN 795:1996.

3.3 connectors

3.3.1
connector
openable device used to connect components, which enables the user to link himself/herself directly or indirectly to an anchor point

3.3.2
karabiner
connector, formed as a complete loop, with a spring loaded gate often safeguarded in the closed position by a screwed sleeve or automatic locking device

NOTE A karabiner in which the gate is safeguarded in the closed position by a screwed sleeve is known as a “screwgate karabiner”.

3.3.3
screwlink connector
connector that is closed by a threaded sleeve which is the load-bearing part of the connector when fully screwed up

NOTE Also known as a “maillon rapide” (pronounced my-yon rapeed) or a “quicklink”.

3.3.4
gate
part of a connector which can be moved to open it

NOTE 1 Sometimes referred to as a “keeper”.

NOTE 2 A gate can move, for example, by pivoting about a hinge (known as a hinged gate), or by a sliding motion (known as a sliding gate) or by a screw motion (known as a screw-motion gate).

NOTE 3 The term “gate” is sometimes also used to refer to the opening in the connector.

3.4
anchor line
flexible or rigid line connected at least at one end to a reliable anchor to provide, as part of a personal fall protection system, a means of fall protection or support

3.5 anchor line devices

3.5.1
anchor line device
device which accompanies the user along an anchor line

3.5.2
traveller
anchor line device which travels in the broadly horizontal plane on a horizontal anchor line system and is intended to act as a mobile anchor point

3.5.3
guided type fall arrester
anchor line device with a fall arrest and self-locking function, which travels along an anchor line without requiring manual adjustment by the user, during upward or downward changes of position

3.6
lanyard
connecting element or component of a personal fall protection system consisting of flexible material with at least two ready-to-use terminations, with or without an adjustment device

NOTE 1 This includes round slings.

NOTE 2 A lanyard may be made, for example, from synthetic fibre rope, wire rope, chain or webbing.

3.7
energy absorber
component or set of components in a fall arrest system, designed to minimize the impact force generated in a fall

NOTE Also known as a "shock absorber".

3.8
retractable type fall arrester
fall arrest device with an encased flexible, extendable lanyard, that has a self-braking and locking function and an automatic return facility for the lanyard into the casing

NOTE 1 An energy dissipating function may be incorporated in the device itself or an energy absorber may be incorporated in the lanyard.

NOTE 2 Adapted from BS EN 360:2002.

3.9 loads

3.9.1
working load limit (WLL)
maximum load that can be lifted by an item of equipment under conditions specified by the manufacturer

3.9.2
safe working load (SWL)
maximum working load of an item of equipment under specified conditions, as designated by a competent person

NOTE The competent person may be the user.

3.9.3
maximum rated load
maximum mass, in kilograms, of personnel, including tools and equipment carried, that may be supported by a component of a personal fall protection system, as specified by the manufacturer

3.9.4
minimum rated load
minimum mass in kilograms of personnel, including tools and equipment carried, that may be supported by a component of a personal fall protection system, as specified by the manufacturer

3.9.5
minimum breaking load
minimum load at which an item of equipment breaks when it is tested new, under specific conditions

3.9.6
proof load
test load applied to verify that an item of equipment does not exhibit permanent deformation or other defect under that load, at that particular time

3.10
competent person
designated person suitably trained or qualified by knowledge and practical experience to enable the required task or tasks to be carried out properly

4 Legislation

4.1 General

Attention is drawn to the following acts and regulations, and HSE approved codes of practice (ACoP) and guidance.

Health and Safety at Work etc. Act 1974.

Construction (Design and Management) Regulations 1994 (CDM Regulations) SI 1994/3140 as amended and ACoP *Managing construction for health and safety* (HSE L54).

Work at Height Regulations 2005 (WAH Regulations) SI 2005/735.

Construction (Health, Safety and Welfare) Regulations 1996 (CHSW Regulations) SI 1996/1592 (as amended by the Work at Height Regulations 2005 SI 2005/735).

Construction (Head Protection) Regulations 1989 SI 1989/2209.

Electricity at Work Regulations 1989.

Health and Safety (First Aid) Regulations 1981.

Lifting Operations and Lifting Equipment Regulations 1998 (LOLER) SI 1998/2307 and ACoP and Guidance *Safe use of lifting equipment* 1998 (HSE L113).

Management of Health and Safety at Work Regulations 1999 (MHSW Regulations) SI 1999/3242 and ACoP *Management of health and safety at work* (HSE L21).

Personal Protective Equipment Regulations 2002 SI 2002/1144.

Personal Protective Equipment at Work Regulations 1992 (PPE) SI 1992/2966 and amendments, and guidance document *Personal protective equipment at work* 1992 (HSE L25).

Provision and Use of Work Equipment Regulations 1998 (PUWER) SI 1998/2306 and ACoP *Safe use of work equipment* (HSE L22).

Workplace (Health, Safety and Welfare) Regulations 1992 SI 1992/3004 as amended and ACoP *Workplace health, safety and welfare* (HSE L24).

4.2 The Health and Safety at Work etc. Act 1974

The Health and Safety at Work etc. Act 1974 places general duties on employers, clients, contractors, owners, the self-employed and employees. Many regulations have been made under this act, which expand on these duties, some dealing specifically with particular issues such as first aid and protection of eyes. Other regulations have been made under the act, which bring into force the requirements of EC directives. These regulations, for example the Management of Health and Safety at Work Regulations 1999, require a risk assessment (see HSE document *Five steps to risk assessment* [1]). They highlight the duties of clients, owners and designers of structures to ensure that, so far as is reasonably practicable, any work to be carried out in the workplace can be performed safely. It is the duty of every employer to ensure that they comply with all legal safety requirements relating to the type of work being undertaken and to work in the particular location concerned.

4.3 The Management of Health and Safety at Work Regulations 1999

The Management of Health and Safety at Work Regulations 1999 require employers, in entrusting tasks to employees, to take account of their capabilities as regards health and safety.

4.4 The Personal Protective Equipment at Work Regulations 1992

The Personal Protective Equipment at Work Regulations 1992 require employers to provide suitable personal protective equipment, which includes some protective clothing. The Personal Protective Equipment at Work Regulations 1992 also require any employee to use any personal protective equipment provided in accordance with both any training and any instructions.

4.5 The Work at Height Regulations 2005

4.5.1 *Organization and planning*

The Work at Height Regulations (Regulation 4) require that work at height be properly planned, appropriately supervised and carried out in a manner which is safe. This includes planning for emergencies and rescue. In addition, employers have a duty to ensure that work at a height is carried out only when the weather conditions do not jeopardize the health or safety of persons involved in the work.

4.5.2 *Avoidance of risks from work at a height*

The Work at Height Regulations (Regulation 6) require every employer to take account of a risk assessment under the MHSW Regulations (Regulation 3). Work is not to be carried out at height where this risk can be avoided. Where work has to be carried out at a height, it is to be undertaken from an "existing place of work", where there is no risk of a fall occurring and no additional work equipment is needed (e.g. a roof with an existing parapet). Where an existing place of work cannot be used, work equipment is to be provided to prevent any person falling a distance liable to cause personal injury. Where the risk of a fall cannot be eliminated, work equipment is to be used to minimize the distance and consequences of any fall or, where it is not reasonably practicable to minimize the distance, work equipment is to be used to minimize the consequences of any fall. Where none of the above can be achieved, other work equipment can be used, which has to be supplemented by other measures, e.g. instructions, supervision and training, to minimize the likelihood of a fall occurring in the first place.

4.5.3 *General principles for selection of work equipment for work at height*

The Work at Height Regulations (Regulation 7) require collective protection measures to be given priority over personal protection measures. When selecting work equipment for use in work at height, the following have to be taken into account:

— the working conditions and the risks to the safety of persons at the place where the work equipment is to be used;

— in the case of work equipment for access and egress, the distance to be negotiated;

— the distance and consequences of a potential fall;

— the duration and frequency of use;

— the need for easy and timely evacuation and rescue in an emergency;

— any additional risk posed by the use, installation or removal of that work equipment or by evacuation and rescue from it.

4.5.4 *Fragile surfaces*

The Work at Height Regulations (Regulation 9) require that that no person at work passes across or near (or works on, from or near) a fragile surface where it is reasonably practicable to carry out work safely, and under appropriate ergonomic conditions, without their doing so. Otherwise, platforms, coverings, guard rails or similar means of support or protection have to be provided and used, so that any foreseeable loading is supported by such supports or borne by such protection. Where the risk of a fall remains, measures have to be taken to minimize the distance and consequences of the fall.

4.5.5 *Inspection of work equipment*

The Work at Height Regulations (Regulation 12) require that work equipment exposed to conditions causing deterioration which is liable to result in dangerous situations is inspected:

a) at suitable intervals; and

b) each time that exceptional circumstances which are liable to jeopardise the safety of the work equipment have occurred.

See Clause **13**.

4.6 HSE Guidance documents

Two parts of the HSE's revised series of health and safety guidance for the construction industry, *Health and Safety in Construction* [2] and *Health and Safety in Roof Work* [3], provide valuable information in a simple but comprehensive form. The guidance covers such topics as organizing the site, the essentials of health and safety, and health and safety management and the law. Following the guidance is not a statutory requirement. However, the guidance provides sufficient information to enable the user to ensure that they comply with the law.

4.7 Health and safety file

Where the CDM Regulations apply, there is a requirement for a health and safety file. This is required to contain information concerning the safety aspects of the construction work, and some or all of the file should be made available to those planning work at height. When construction work has been completed, there could be a need to update the health and safety file.

5 Fundamental principles

5.1 Hazard identification and risk assessment, and hierarchy of protective measures

5.1.1 The primary objective is to so organize, plan and manage the work that there will be an adequate margin of safety to minimize risk, with a goal of no incidents.

5.1.2 The Management of Health and Safety at Work Regulations require that before fall protection systems are employed for a particular job, employers carry out a hazard identification and risk assessment (see **6.1**) and set out clear requirements for all aspects of the work. In addition, the work should be carefully assessed to ensure that the method of access is appropriate to the quality of the work required.

5.1.3 Regarding the risk of a fall from a height, the measures that can be taken need to be considered in order (see **6.2**, which gives a hierarchy of fall protection measures).

5.2 Principles of selection of personal fall protection systems and equipment

5.2.1 *Use of CE marking*

When it is planned to use CE marking as a criterion for purchasing equipment, it is essential to ensure that the marking is for goods appropriate to the intended use (see **7.1.2**).

5.2.2 *Use of standards*

Equipment should be selected that conforms to standards relevant to the intended use (see **7.1.3**).

5.2.3 *Types of fall protection systems and equipment to be considered*

If, after the hazard identification and risk assessment (see **6.1**), and with due consideration of the hierarchy of protective measures (see **6.2**), it is decided that it is necessary to choose personal fall protection equipment, it is then necessary to choose the correct type of personal fall protection system and equipment to be used (see Clause **7**).

The types of personal fall protection systems and equipment available are as follows.

a) *Restraint (travel restriction) systems and equipment*, which restrict the user's travel so that access is not possible to zones where the risk of a fall from a height exists (see **7.2.2**).

b) *Work positioning systems and equipment*, which enable the user to be held in a partly or entirely supported position (see **7.2.3**).

c) *Rope access systems*, which employ two separately secured lines, one as the means of support and the other as a safety back-up, for access or egress to and from the workplace, both lines being attached to the user's harness (see **7.2.4**).

NOTE Rope access systems can be used for work positioning.

d) *Fall arrest systems and equipment*, which act to arrest a fall and which are used in situations where, if the user loses controlled physical contact with the working surface, there will be a free fall (see **7.2.5**).

5.2.4 *Limits of equipment use*

It is essential that limits of equipment use are observed, as follows.

— Equipment designed exclusively for restraint should not be used for work positioning or as fall arrest equipment.

— Equipment designed exclusively for work positioning should not be used as fall arrest equipment.

It should be noted however, that some equipment is designed to be multi-purpose, e.g. for both work positioning and fall arrest, or to allow the attachment or connection of other components in order to meet the requirements for a category of work other than the one for which it was primarily designed.

5.2.5 *Compatibility of equipment*

When selecting equipment, it is essential for purchasers to ensure that components in any system are compatible and that the safe function of any one component is not adversely affected by, and does not interfere with, the safe function of another, or of the system. Sometimes this is not obvious, so it is important to check with the supplier or the manufacturer. Sometimes, the only way to be sure is to carry out a system performance test.

5.3 Principles of use of personal fall protection systems and equipment

5.3.1 *Competency of users*

It is essential that users are competent in the use of their personal fall protection systems and equipment and have a suitable attitude for working at a height.

Users should have sufficient professional or technical training, knowledge and actual experience to enable them to:

- — carry out their assigned duties at the level of responsibility allocated to them;
- — understand fully any potential hazards related to the work and the equipment to be used;
- — detect any technical defects or omissions in that work and equipment, recognize any implications for health and safety from those defects or omissions, and be able to take remedial action to deal with these.

Users should also be competent to check their personal fall protection system and equipment for defects before every use.

5.3.2 *Training and assessment of users*

It is essential that users are suitably trained and assessed for competency in the use of their personal fall protection systems and equipment for the particular intended application (see Clause **15**). They should also be trained and assessed in the pre-use checking of their equipment (see **5.3.6**).

5.3.3 *Users' knowledge of equipment*

Under the Personal Protective Equipment at Work Regulations 1992, the manufacturer of the equipment is required to supply product information. This information should be read and thoroughly understood by the user before using the equipment. Time should be allowed for this in the planning of the work. This also applies to replacement equipment, because changes might have been made to the original specification or advice given. Knowledge of the strengths and weaknesses of equipment can help to avoid misuse. This knowledge can be enhanced by training and by studying the information provided with the product and other technical brochures and catalogues.

5.3.4 *Compatibility of equipment in use*

When assembling equipment into a system, the user should check that the components in the system are compatible and that the safe function of any one component is not adversely affected by, and does not interfere with, the safe function of another, or of the system.

5.3.5 *Pre-use examination of equipment new to the user*

Before new or used equipment is used for the first time by a particular user, that user should ensure that it is appropriate for the intended application, that it operates correctly, and that it is in good condition. Before using a harness for the first time, it is recommended that the user is assisted in carrying out a comfort and adjustability test in a safe place, in accordance with the procedure given in Annex B, to ensure that the harness is the correct size, has sufficient adjustment and is of an acceptable comfort level for the intended use, including suspension. It should be noted however, that the test described in Annex B is suitable only for belts with sub-pelvic support, sit harnesses and full body harnesses. It should not be applied to belts without sub-pelvic support or to chest harnesses.

5.3.6 *Pre-use checks*

All equipment should be subjected to a pre-use check before each use. Damaged equipment should be taken out of service immediately. (See Clause **13** and Annex C.)

5.3.7 *Detailed inspections*

In addition to pre-use checks, equipment should be subjected to detailed inspections by a competent person in accordance with a predetermined regime. Damaged equipment should be taken out of service immediately. (See Clause **13**, Annex C and HSE Guidance document *Inspecting fall arrest equipment made from webbing or rope* [4].)

5.3.8 *Interim inspections*

Interim inspections might be needed between detailed inspections in situations where the risk assessment has identified a hazard that could cause significant deterioration in the equipment, for example paint, chemicals or an acidic or alkaline environment. The need for and frequency of interim inspections will depend on the particular circumstances in which the equipment is to be used.

5.3.9 *Anchors and anchor points*

Anchors and anchor points should be of adequate strength (see Clause **16**).

Wherever possible, anchors and anchor points should be above the user so that the anchor line or lanyard is taut or has as little slack as possible. Alternatively, it is permissible for the anchor or anchor point to be below the user, provided that the force on the anchor line connected to the user acts from above. An example of the latter would be on a ridged roof when the user is on the opposite side of the ridge to the anchor point and the anchor line passes over the ridge. This is to minimize the length and effect of any fall; the importance of this cannot be stressed enough. Positioning of anchors and anchor points should be such that hazards such as sharp or rough edges and hot surfaces are avoided, as they are very likely to cause damage to tensioned anchor lines and lanyards, particularly those made from textiles, which would cause them to fail on being put under load.

5.4 Principles of maintenance of personal fall protection systems and equipment

The life of the user depends on his or her personal fall protection systems and equipment being maintained properly. Equipment should be kept clean and dry and should be properly stored. Wet equipment should be thoroughly dried before storage. Equipment should not be altered or repaired, unless this has been authorized by the manufacturer. (See Clause **13**.)

6 Hazard identification, risk assessment and safety method statement

6.1 General

6.1.1 Hazard identification and risk assessment which have to be carried out before the work commences, as required by the Management of Health and Safety at Work Regulations, has to include consideration of whether or not the proposed method of work would be appropriate in view of the hierarchy of protective measures laid down in the Work at Height Regulations 2005 (see **6.2**). A safe system of work then needs to be planned including selection of appropriate working methods and equipment, together with competent personnel, and it is recommended that a safety method statement should be prepared (see **6.1.8**).

6.1.2 A safety method statement, although not required by law, has proved to be an effective way of producing an action plan for a safe system of work. It is particularly useful in bringing together the assessments of the various hazards which might arise in a particular job. Safety method statements may also be linked to, or form part of, a company’s safety policy and procedures, particularly where these do not cover the particular circumstances of the work concerned.

6.1.3 Hazard identification should comprise identification of anything that could cause harm, for example, electrical installations, sharp edges or working from a ladder.

6.1.4 A risk assessment should comprise a careful evaluation of all hazards identified, to determine the level of risk posed by each. Action should be taken to eliminate the hazards. If this is not possible, precautions should be taken to minimize the probability of persons being harmed.

6.1.5 Taking the examples given in **6.1.3** the levels of risk and the precautions that should be taken are as follows.

— Electrical installations pose a high risk of electric shock. The probability of harm should be minimized by ensuring that all potentially “live” components are insulated and metal casings are earthed.

— Sharp edges pose a high risk of laceration injuries and also a high risk of indirectly causing injury through damage to equipment such as lanyards. The probability of harm should be minimized by ensuring that all sharp edges are protected.

— Working from a ladder poses a high risk of a fall from a height. The probability of harm should be minimized by ensuring that the ladder is correctly positioned and secured, and its use limited if necessary.

6.1.6 It is only after such hazard identification and risk assessment has been carried out that the appropriate fall protection equipment and systems can be selected. The hazard identification and risk assessment should be site specific and should be reviewed on a continuous basis, for example, each day or at each change of job.

6.1.7 In the risk assessment, detailed consideration should be given to all possible emergency scenarios and to planning how any necessary rescues would be carried out (see Clause **11**).

6.1.8 A record should be kept of each hazard identified, the assessment of the risk and the action taken to minimize it. For companies with five or more employees this is a legal requirement under the Management of Health and Safety at Work Regulations, but makes good sense for companies of all sizes, as records can provide valuable information and documentary evidence in case of any incident. Taking the examples given in **6.1.3** and **6.1.5**, the records would need to state the following:

— electrical installations: insulation and earthing checked and found to be sound;

— sharp edges: edge protection in place;

— ladders: secured at top and bottom; angle of lean adjusted; use restricted to access only.

6.1.9 It should be ensured that the following actions have been taken and reported in the records:

— a proper hazard identification and risk assessment has been made;

— a check has been made of who and how many people could be affected by each hazard;

— all the obvious and significant hazards have been taken into account;

— reasonable precautions have been taken to minimize the risks;

— the residual risks have been determined and found to be low.

6.1.10 When planning a safe system of work, an employer should consider the following, as early in the planning of the work as possible:

a) The workplace, in particular:

1) the nature of the workplace including its form, structure, geometry and materials;

2) the nature of the environment in the workplace including any adverse climatic or atmospheric conditions.

b) The work, in particular:

1) details of the tasks to be carried out including any special risks associated with them;

2) how much space is needed;

3) how long the work is expected to take.

c) The workers, in particular:

1) their body size;

2) the range of movements they will need to make and the postures they will need to adopt.

d) The personal fall protection equipment, in particular:

1) who it is for [see item c)];

2) features and limitations of the equipment, including the materials from which it is made and its means of operation.

6.1.11 The Personal Protective Equipment at Work Regulations 1992 require every employer to ensure that:

a) suitable personal protective equipment is provided;

b) the items of personal protective equipment are compatible;

c) an assessment is made to determine whether the personal protective equipment he intends to provide is suitable;

d) the personal protective equipment is maintained in an efficient state.

6.1.12 As part of the selection of personal fall protection equipment it is recommended that:

a) field trials be undertaken, with input from those individuals who will use the equipment;

b) technical information be carefully evaluated; in particular a careful comparison should be made of the methods used for testing the equipment and the planned mode of use.

6.2 Hierarchy of protective measures for people working at a height

The working environment should be as hazard-free as possible, thereby minimizing the risks to workers (see **6.1**). This applies particularly to work at height. Each hazard needs to be dealt with in a manner that ideally eliminates the risk, or, if that is not practicable, reduces that risk as far as possible and at least to the highest acceptable level. The Work at Height Regulations 2005 (Regulation 6) require a hierarchical approach to the planning of work at height, with collective protective measures to be given priority over personal protective measures, and measures that prevent a fall to be given priority over those that minimize the height and consequences of a fall. This is illustrated in Table 1.

Table 1 — Illustration of hierarchy of protective measures given in the Work at Height Regulations 2005

Priority		***Highest***	***Lowest***
	Category of work equipment	**Examples of protective measures**	
		Collective	**Personal**
Highest	Work equipment which prevents a fall	Working platforms with barriers Advanced guardrail systems Barriers Multi-user mobile elevating work platforms (MEWPs)	Personal fall prevention systems (e.g. valley frames) Personal fall protection equipment (work restraint systems) Single-user MEWPs
	Work equipment which minimizes the height and consequences of a fall	Safety nets at high level (rigged close to the work) Soft landing systems installed close to the work	Other personal fall protection equipment (rope access, work positioning and fall arrest systems) (See Note 2.)
	Work equipment which minimizes the consequences of a fall	Soft landing systems Safety nets rigged at low level ($\leq$ 7 m below the work)	Inflatable injury prevention systems, e.g. air jackets Other personal protective equipment not normally associated with fall protection, e.g. lifejackets for work over water
Lowest	Work equipment which does neither (ladders, step ladders, hop-ups, trestles, etc.)	Instruction, supervision and training of users to minimize the risk of them suffering a fall	

NOTE 1 Within each category:

a) collective protective measures take priority over personal protective measures;

b) appropriate work equipment (and its order of priority) needs to be determined by taking into account the work to be undertaken and by considering the risk to those installing, using and removing the equipment and the implications for rescue associated with the work equipment being used.

NOTE 2 The fall factor (see **9.1.3.1**) has to be kept as low as possible, with systems with a fall factor of zero being given priority.

7 Selection of personal fall protection systems and equipment

7.1 General

7.1.1 *Risk assessment*

Regulation 3 of the Management of Health and Safety at Work Regulations 1999 requires that before equipment is selected or used a risk assessment is carried out for each job for which that equipment is to be used.

7.1.2 *CE marking*

7.1.2.1 Under the Personal Protective Equipment (EC Directive) Regulations 1992, which are based on the Personal Protective Equipment Directive (89/686/EEC) [5], equipment used for fall protection that is classified under the directive as personal protective equipment (PPE) is required to carry CE marking. This applies to most equipment used for personal fall protection.

7.1.2.2 It is essential not to use CE marking as the sole criterion for purchasing equipment. It is often thought that the CE mark means that the equipment will be suitable for the particular task for which it is being purchased. This is not necessarily the case, as the testing specified in the relevant European standard is often limited to checking the most important parameters under laboratory conditions and therefore might not cover the specific circumstances of use. Therefore, ensuring that the equipment has a CE mark is only one of the factors involved in the selection process. When it is planned to use CE marking as a criterion for purchasing equipment, it is essential to ensure that the marking is for goods appropriate to the intended use. CE marking is mandatory on many different types of product, not just personal protective equipment (PPE). For PPE, there are three different categories, ranging from simple items like protective work gloves (category I) to category III equipment for protection against mortal danger (e.g. harnesses). Most equipment for fall protection is category III.

7.1.2.3 For PPE category III, CE marking indicates that the product has been independently type tested and meets the basic health and safety requirements of the Personal Protective Equipment Directive (89/686/EEC) [5] and the Personal Protective Equipment Regulations 2002. This is certified by an organization, approved by the government, known as a notified body. A notified body also monitors the quality of production, either by random but regular inspections of the manufacturer's quality system (e.g. to BS EN ISO 9001) or by carrying out batch tests. The usual way for manufacturers to ensure that their products meet the requirements of the Personal Protective Equipment Regulations is to have their products tested to a recognized standard, although this is not the only way. The alternative is for equipment to be CE marked to the Personal Protective Equipment Directive (89/686/EEC) [5] via the technical file route as defined in the directive. Category III PPE (see **7.1.2.2**) will always have a four-digit numerical code attached to the CE mark to identify the relevant notified body. A booklet entitled *Personal Protective Equipment: Guidance notes on UK Regulations* [6], published by the Department of Trade and Industry (DTI), provides further details.

7.1.2.4 The prime function of CE marking is to protect against barriers to trade within the European Union. It is not meant to be taken as a mark of quality, although PPE category III is subject to such rigorous controls that this point could be argued otherwise.

7.1.3 *Standards*

Equipment should be selected that conforms to standards relevant to the intended use. Whenever possible these should be appropriate BS EN standards. In the absence of these, equipment conforming to other standards, e.g. international (ISO), national or trade association standards, may be chosen. If there is doubt about whether or not a particular standard is relevant to the intended use, it is advisable to discuss it with the manufacturer of the equipment. The alternative is to select equipment that has been CE marked to the Personal Protective Equipment Directive (89/686/EEC) [5] via the technical file route (see **7.1.2.3**).

Many standards specify marking of the standard number on the equipment, and this can be valuable to purchasers and users for checking that the equipment is appropriate for the intended use. However, it should be noted that not all standards require marking of the standard number on the equipment; also there might not be a standard for a particular item of equipment. It is also important to note that marking of a standard number on an item of equipment represents a manufacturer's claim of conformity to the standard, it should not be confused with third party certification of conformity.

7.2 Types of personal fall protection systems and equipment

7.2.1 *General*

If, after the hazard identification and risk assessment, and after consideration of the hierarchy of protective measures (see **6.1** and **6.2**), it is decided that personal fall protection equipment is needed, it is then necessary to choose the type of personal fall protection system and equipment to be used. This may be either a system that prevents a fall or one that arrests a fall. Wherever possible, a personal fall protection system that prevents a fall should be used in preference to a fall arrest system.

If a personal fall protection system that prevents a fall is to be used it should be one designed to prevent the user reaching zones where the risk of a fall exists, or one that prevents the onset of a fall. Where it is not practicable to use a system that prevents a fall, then, as a last resort, a fall arrest system should be used.

7.2.2 *Restraint (travel restriction) systems*

If the objective is to restrict the user's travel so that access is not possible to zones where the risk of a fall from a height exists, a restraint system should be used. This may be appropriate fall arrest equipment, work positioning equipment or a simple belt coupled with a lanyard of limited length. The restraint system should be chosen and arranged so that it is not possible for the user to access zones where the risk of a fall exists. Details of restraint systems are given in Clause **8**.

Sometimes users choose to use their restraint system for support, e.g. on a sloping roof where it is possible to move around without support, but where the use of a support would aid carrying out the work. Users should be aware of the consequences of a slip or equipment failure when using this technique. They should consider in their risk assessment the appropriateness of their equipment and whether a safety back-up system should be employed.

7.2.3 *Work positioning systems*

If the planned method of work is for the user to be in a partly or entirely supported position, then a work positioning system should be used. The work positioning system should include a safety back-up system, in addition to the primary support, so that should there be an operator error or failure of the primary support, a fall will be prevented or arrested. A rope access system can be used for work positioning. Details of work positioning systems are given in Clause **10** and details of rope access systems are given in BS 7985:2002.

In addition to its primary function of providing support and preventing a fall, work positioning equipment is likely to be strong enough to arrest a free fall of limited distance and force, but might not conform to the other essential requirements for a fall arrest system, unless combined with appropriate additional components, e.g. an energy absorber.

7.2.4 *Rope access systems*

If the planned method of work is to use two separately secured lines, one as the means of support and the other as a safety back-up, for access or egress to and from the workplace, and if both lines are to be attached to the user's harness, a rope access system should be used in accordance with the recommendations given in BS 7985:2002.

NOTE If the system is based on a line which moves with the user e.g. a bosun's chair, this is not a rope access system but a work positioning system.

7.2.5 *Fall arrest systems*

If the planned method of work is such that if the user loses controlled physical contact with the working surface there will be a free fall, a fall arrest system conforming to BS EN 363 should be used. This comprises a full body harness conforming to BS EN 361, a suitable anchor, and a system or device that has energy absorbing capacity and that provides a means of attachment to that anchor. Details of fall arrest systems are given in Clause **9**.

8 Restraint systems

8.1 General

8.1.1 Restraint systems are used to prevent users from reaching zones where the risk of a fall exists. They involve the connection of the user to the structure by means of a lanyard or an anchor line, the position and length of which is such that, irrespective of the user's movements in a broadly horizontal plane, they can never get into a situation from which a fall can occur. Fundamentally, restraint systems prevent the initiation of a fall (see Figure 1).

8.1.2 Restraint systems have a number of constraints. These are as follows:

— they are limited to movement in the broadly horizontal plane;

— they restrict the user's mobility, i.e. they might allow movement to certain parts of a structure, but not to others;

— they are site-specific, i.e. the length of the restraining lanyard or anchor line might only be appropriate to one situation.

8.1.3 There are some notable differences between restraint systems and other personal fall protection systems. These include the following.

— The only fall that can occur using a restraint system is a "fall on the level" i.e. a trip or slip resulting in the user falling onto the surface on which they were standing.

— The force experienced by a user connected to a restraint system and the force at the anchor are likely never to exceed the equivalent of twice the mass of the user.

— No rescue provisions are normally needed with a restraint system.

NOTE Rescue provisions might be necessary, depending on the location of the work, to deal with a situation in which the user of a restraint system becomes incapacitated, for example if they are working at a difficult to reach location on a rooftop.

8.2 Selection of the components of a restraint system

8.2.1 *General*

A restraint system should comprise the following components:

— a body-holding device, comprising a waist belt (preferably incorporating a sub-pelvic support), a sit harness or a full body harness (see **12.6**);

— a fixed anchor point e.g. an eyebolt, or a mobile anchor point, running along a horizontal rigid or flexible anchor line (see Clause **16**);

— a lanyard or anchor line, connected between the body holding device and the anchor point (see **8.2.2**, **12.7** and **12.9**);

— connectors, for joining the lanyard or anchor line to the anchor point and to the body-holding device (see **12.5**).

8.2.2 *Lanyards and anchor lines for restraint systems*

The range of the user's broadly horizontal movement should be restricted by the length of the lanyard or anchor line and by the position of the anchor point (see Figure 1) to ensure that the user is physically prevented from entering an area where there is a risk of a fall from a height. The length of the lanyard or anchor line should be such that when connected to the intended anchor point it is long enough to allow the user to reach the intended work area but short enough to prevent fall arrest conditions being created (see Figure 2b). If it is too short the work area might not be within reach (see Figure 2a). If it is too long it might create free fall and fall arrest conditions, which, if realised, could severely injure the user or cause system failure (see Figure 2c and 2d). The limit of movement should be determined by tracing the locus of the point at which the lanyard or anchor line connects to the body-holding device, as shown in Figure 1.

To extend the range of horizontal movement, so increasing the areas accessible to the user, and permit two or more users to be connected simultaneously, a restraint system employing a horizontal anchor line may be used (see Figure 3). The anchor line may be rigid, e.g. a rail, or flexible, e.g. a wire rope. Horizontal anchor lines for fall arrest applications are suitable for this purpose (see **9.5**). Each user should be connected to the anchor line by a separate connector.

A lanyard or anchor line for restraint should not be used for fall arrest purposes.

An energy absorbing lanyard of the correct length may be used for restraint provided that the situation in which it is to be used is such that it will not be subjected to a force that could cause the energy absorber to begin to deploy (i.e. a force in excess of 2 kN).

8.3 Use of restraint systems

A restraint system should not be used in a situation in which it might unexpectedly be relied upon to perform a fall arrest function, for example where there is a risk of a fall over an edge (see Figure 4b) or where there is a risk of a fall through a surface made of fragile material (see Figure 5), as this could lead to serious injury to the user. The Work at Height Regulations 2005 specifically require steps to be taken to prevent any person from falling through any fragile material. In such situations other methods of fall protection should be utilized, e.g. platforms and crawling boards.

NOTE 1 Figure 5 shows a restraint system preventing a fall over an edge (see Figure 5a) but putting the user at risk of a fall through a roof light (see Figure 5b).

NOTE 2 A test to determine the fragility of roofing assemblies is given in ACR(M)001:2000 *Test for fragility of roofing assemblies* published by the Advisory Committee for Roof work [7].

If during the work it becomes apparent that the restraint system would not prevent a fall over an edge, for example because the connecting lanyard is too long, then work should be stopped immediately and action taken to remedy the situation, for example by adjusting or replacing the connecting lanyard or by utilizing a different method of fall protection.

Account should be taken of any elongation of a lanyard or anchor line that could allow, for example, a fall over an edge.

On a flat or shallow pitch roof a lanyard or anchor line should not be used in a position, for example near a gable, in which it might be relied upon to perform a fall arrest function, (see Figure 6a), or might allow the user to fall to the ground (see Figure 6b). In such a situation an alternative method of fall protection should be used.

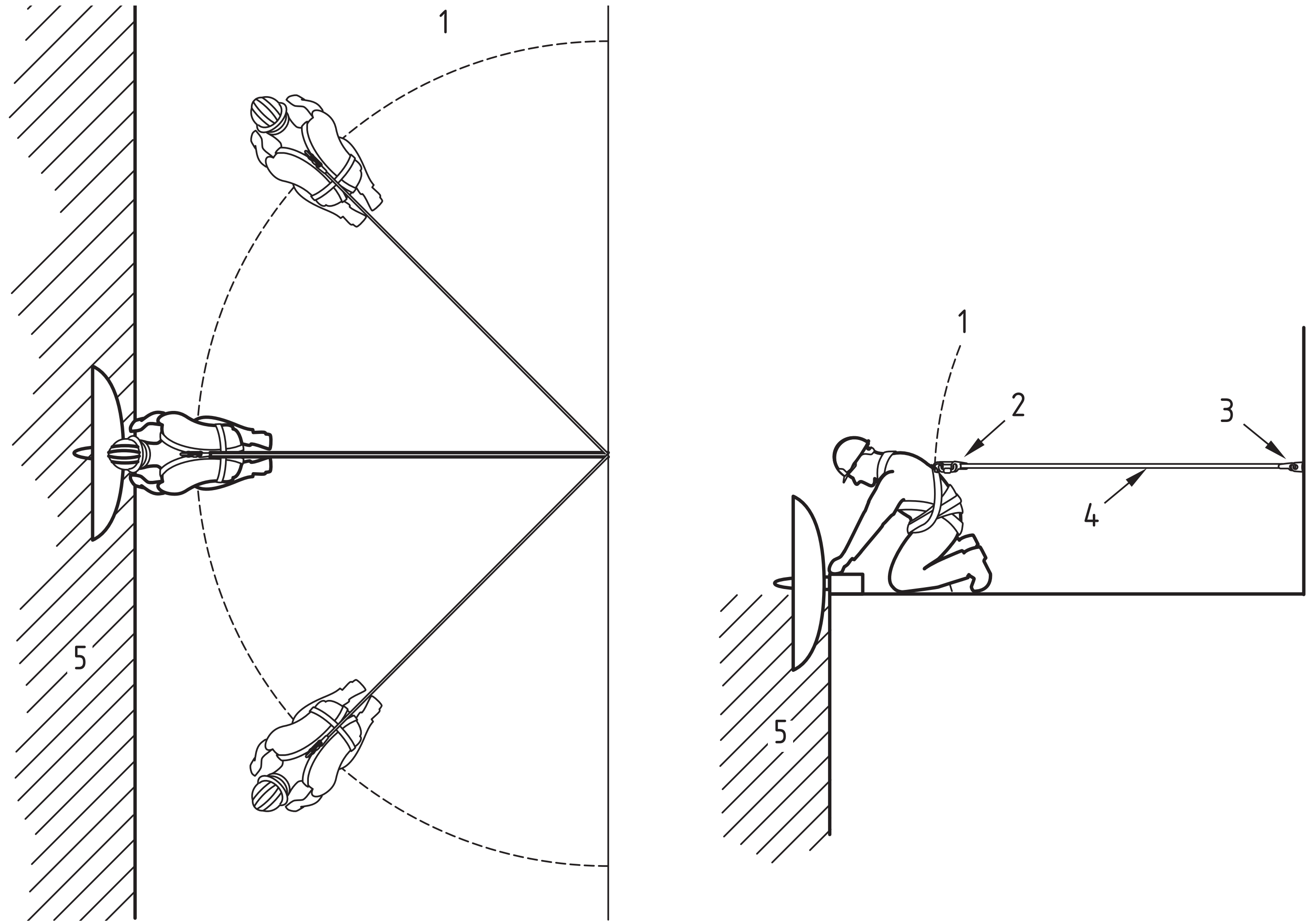
NOTE 3 In Figure 6a, Positions A, B and C are appropriate applications of restraint systems, as the user is prevented from reaching the gutter. Position D, unless a “stop” is fitted to the horizontal anchor line, would allow a fall at the gable.

NOTE 4 In Figure 6b, the length of the lanyard would allow a fall to the ground.

On a roof with a horizontal anchor line along its ridge, safe access to the gable can be arranged by using additional fixed single-point anchors. This requires the user to carry and use an additional fixed length lanyard, which should be connected to the additional anchor before the user disconnects the first lanyard from the horizontal anchor line. Thorough user training (see Clause **15**) and a detailed safety method statement (see Clause **6**) are essential if such a system is to be used. Advice on other ways of extending the accessible area is given in the new edition of BS 7883[1)].

Some restraint systems incorporate a manually adjustable lanyard or anchor line fitted with a lever by which the user can vary the limit of travel. Extreme care should be taken when using such a system to ensure that the user does not adjust the lanyard or anchor line such that he or she could reach a position from which a fall from a height could occur.

[1)] In preparation.



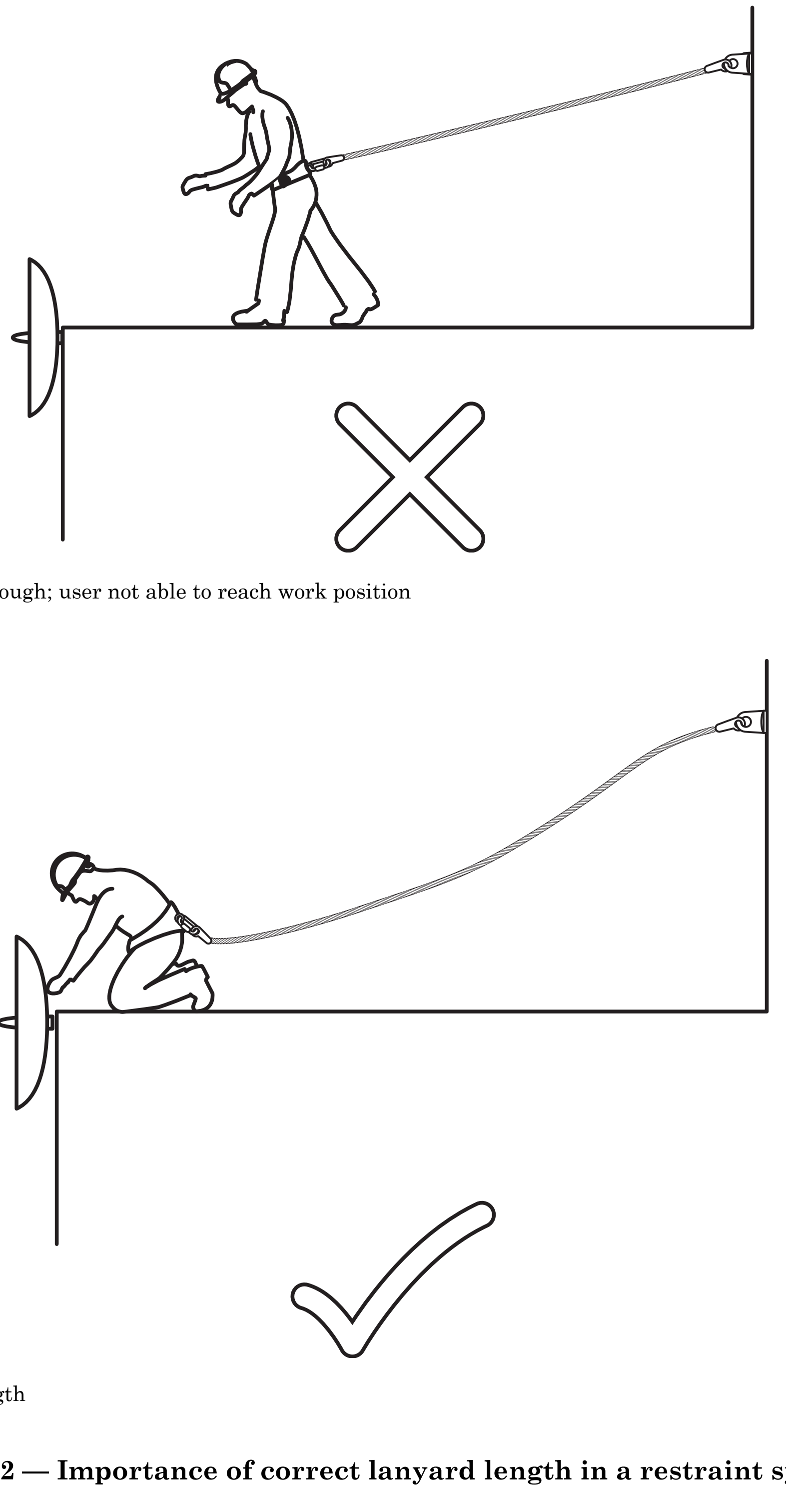
a) Top view

b) Side view

Key

1 Limit of user's movement
2 Harness attachment point
3 Anchor
4 Lanyard
5 Fall risk area

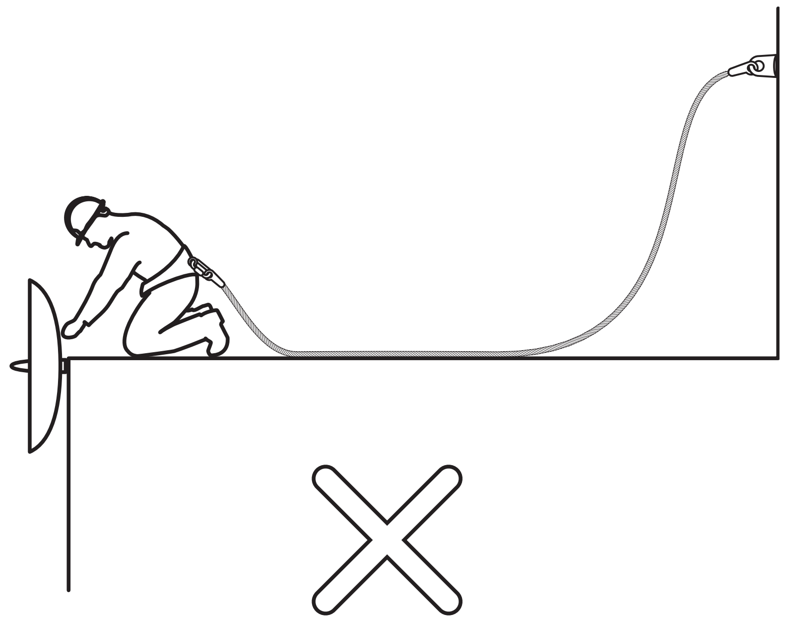
Figure 1 — Example of a restraint system limiting access to zones where the risk of a fall exists



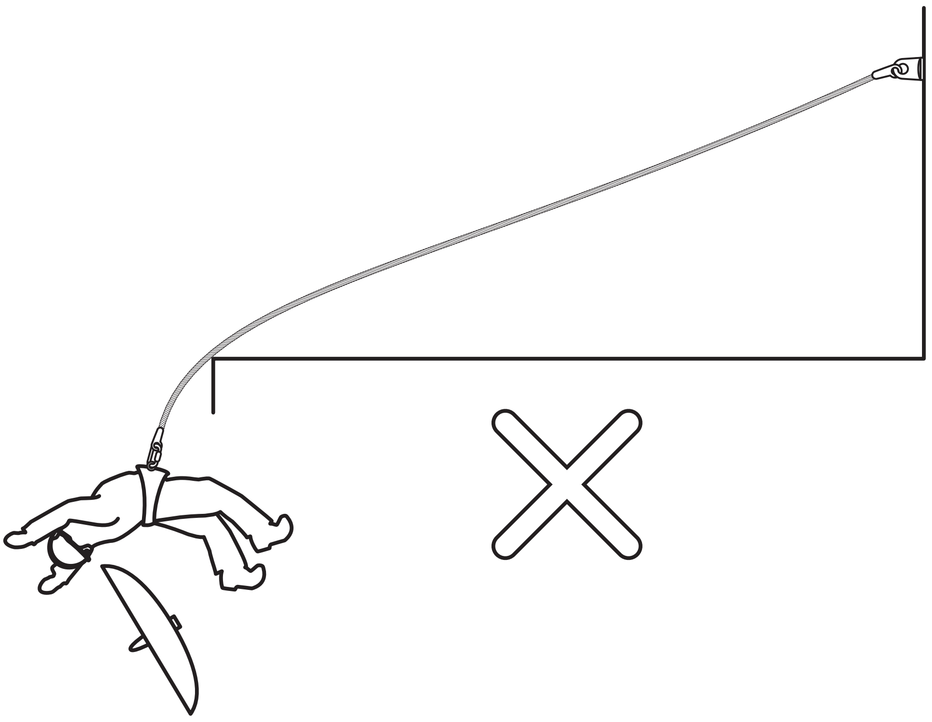
a) Lanyard not long enough; user not able to reach work position

b) Lanyard correct length

Figure 2 — Importance of correct lanyard length in a restraint system

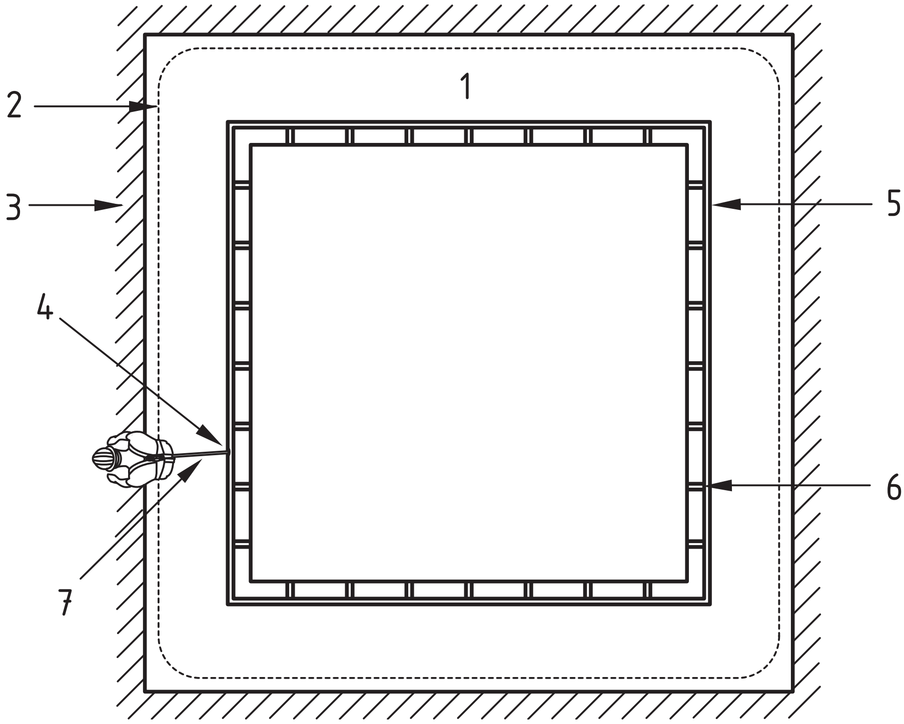


c) Lanyard too long; user at risk of a fall

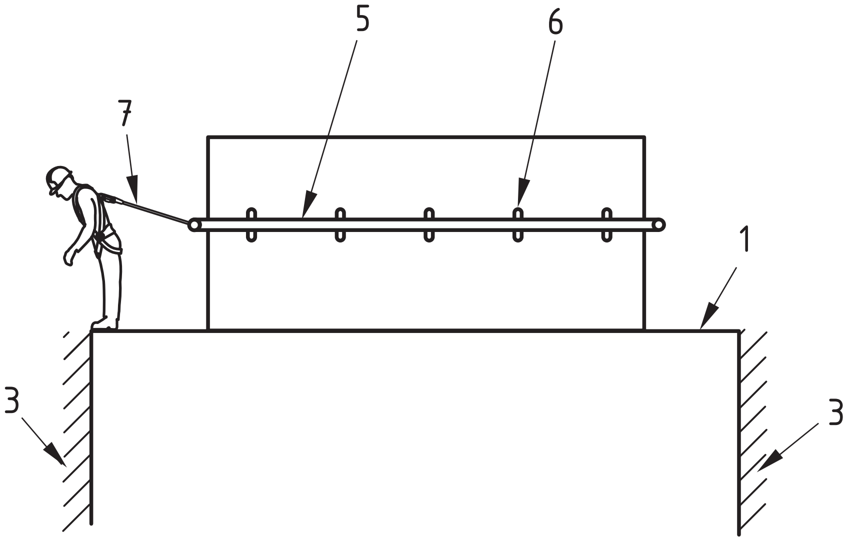


d) Lanyard too long; user falls over the edge

Figure 2 — Importance of correct lanyard length in a restraint system (*continued*)



a) Top view

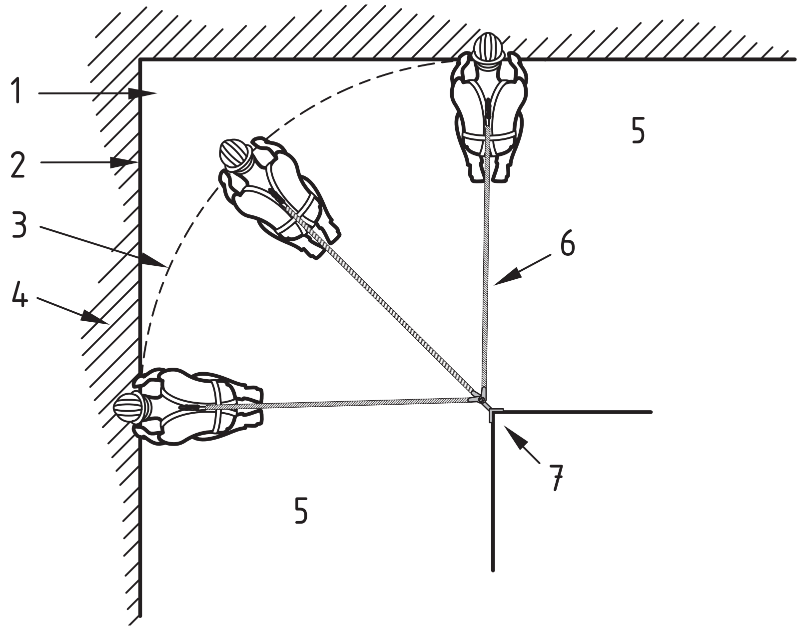


b) Side view

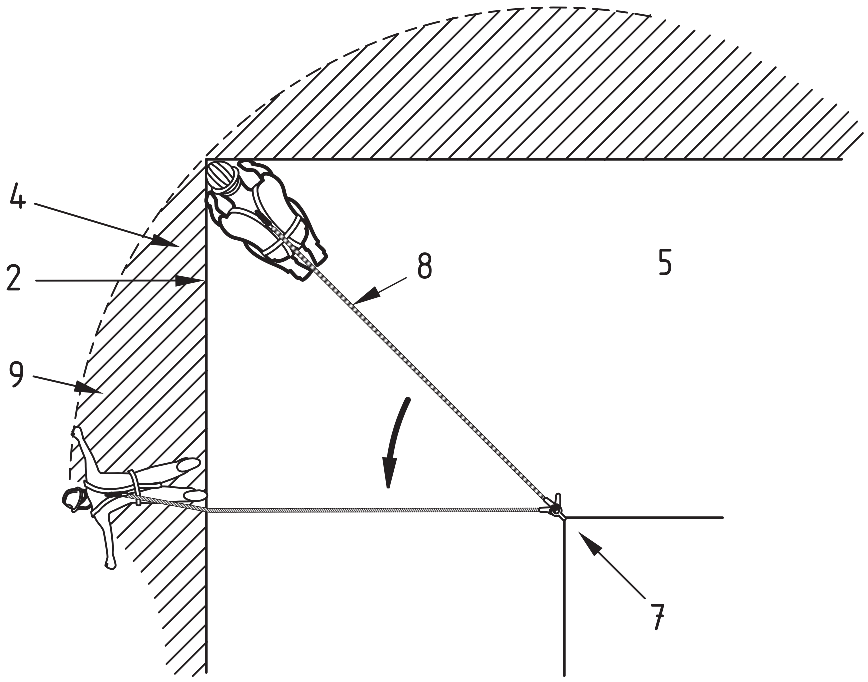
Key

1 Walkway
2 Limit of user's movement
3 Fall risk area
4 Traveller
5 Anchor line
6 Anchor line support
7 Lanyard

Figure 3 — Example of a restraint system using a rigid horizontal anchor line



a) Restraint system prevents user from reaching the corner of the roof

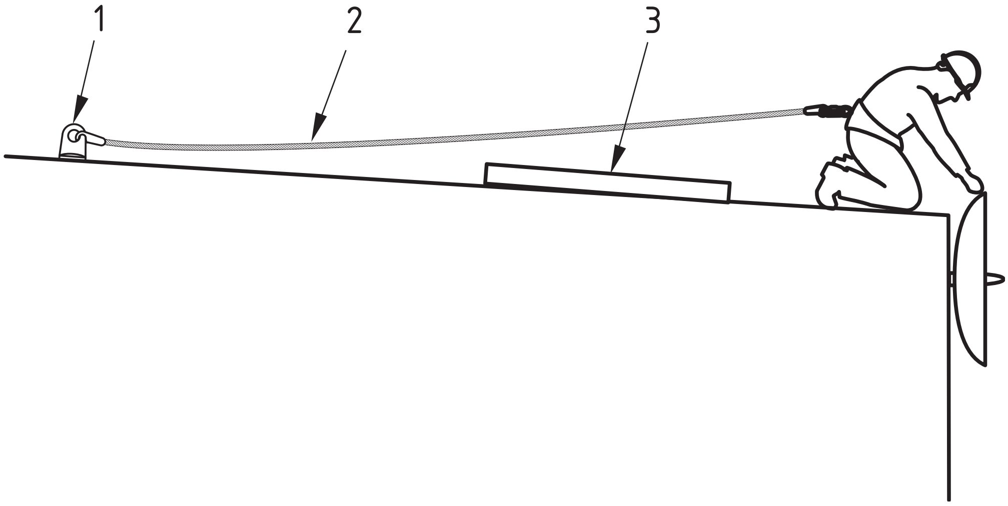


b) Increasing lanyard length permits user to access the corner but puts them at risk of a fall over an edge

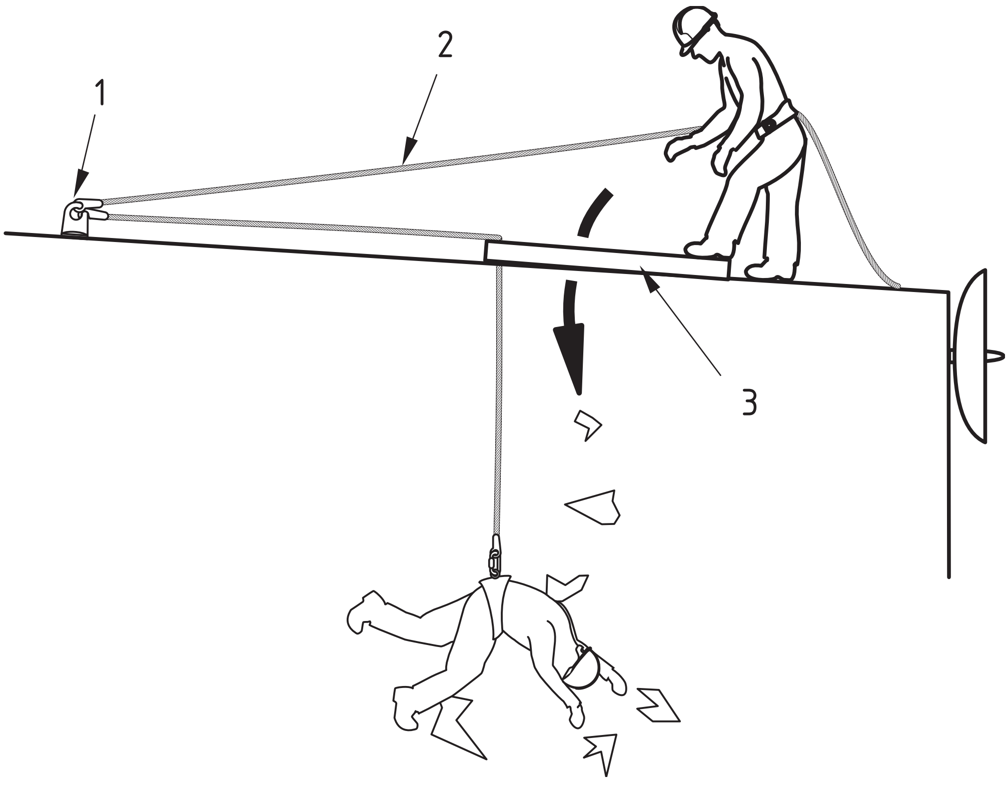
Key

1 Area that user cannot access
2 Edge of walkway
3 Limit of user's movement
4 Fall risk area
5 Walkway
6 Lanyard
7 Anchor
8 Lanyard extended to enable user to reach corner
9 Swing fall over edge possible

Figure 4 — Dangers of using a restraint system to access the corner of a flat roof



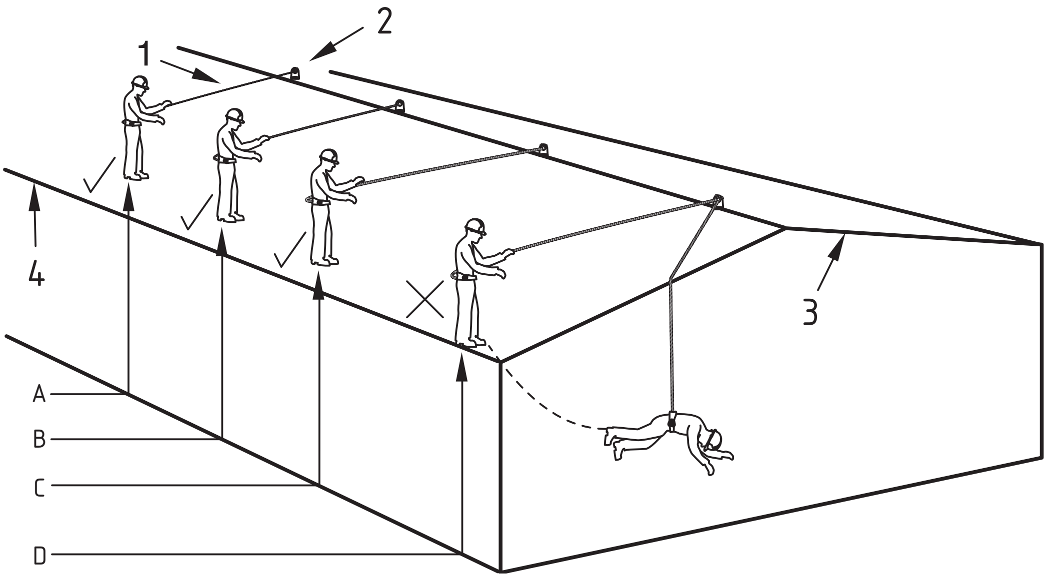
a) User prevented from reaching a zone from which there is the risk of a fall over an edge



b) User at risk of a fall through an unprotected roof light

Key
1 Anchor
2 Lanyard
3 Roof light

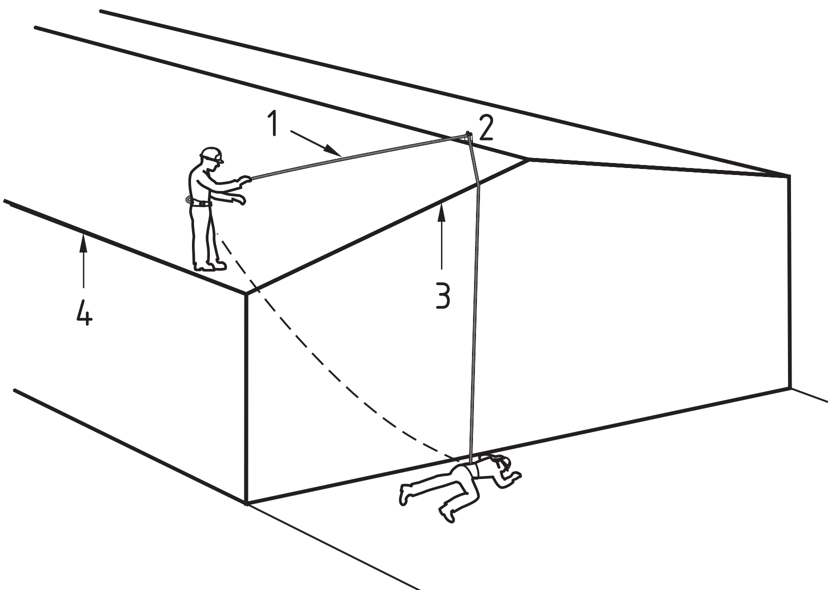
Figure 5 — Situation in which a restraint system should not be used because there is a risk of a fall through a fragile material



A, B, C Safe positions

D Position from which there is the risk of a fall arrest situation

a) Safe positions and position from which there is the risk of a fall arrest situation



b) Situation in which there is a risk of a fall to the ground

Key

1 Lanyard   3 Gable edge
2 Anchor   4 Gutter edge

Figure 6 — Limitations and dangers of using a restraint system on a sloping roof

9 Fall arrest systems

9.1 General

9.1.1 *Basic characteristics of a fall arrest system*

A fall arrest system physically links the user to the workplace structure by a series of interconnected components which arrests the free fall of the user, should a fall take place, by applying an arresting force and decelerating the user through a short arrest distance.

When a fall arrest system is used, there are four phases to a fall as follows:

— initiation, i.e. the cause;

— the fall itself;

— fall arrest, i.e. termination of the fall;

— suspension, after the fall.

Injury can occur in the following phases:

— during the fall itself, e.g. by impact with the structure;

— during fall arrest, e.g. by the violence of the impact as the fall is arrested;

— during the suspension phase, e.g. through suspension trauma (see Clause **11** and Annex D).

It is essential to use a fall arrest system that is suitable for the particular work situation in order to minimize the risk of such injuries should a fall occur.

There are four main types of fall arrest systems, as follows (see Figure 7):

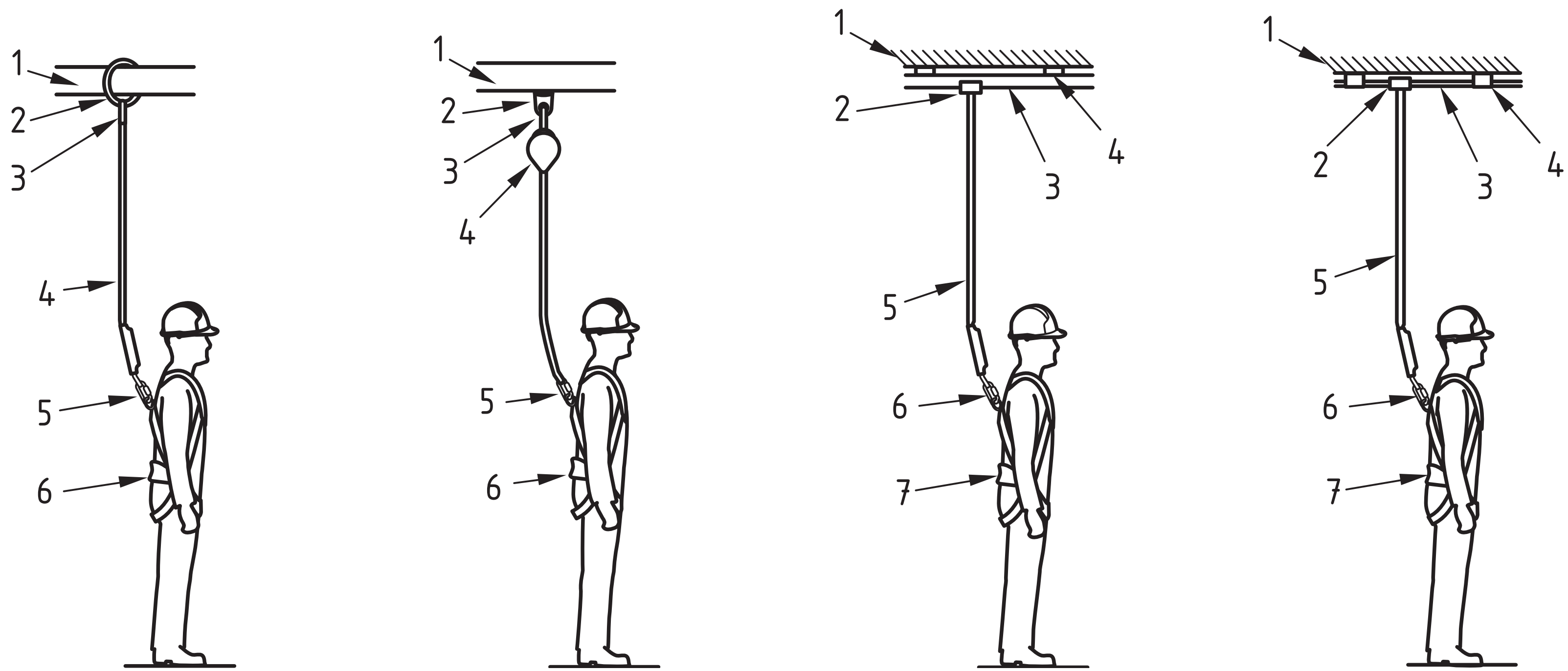
— systems based on one or more energy absorbing lanyards (see **9.2**);

— systems based on a retractable type fall arrester (see **9.3**);

— systems based on vertical anchor line and a guided type fall arrester, which includes systems with a rigid anchor line and systems with a flexible anchor line (see **9.4**);

— systems based on a horizontal anchor line with one or more travellers (see **9.5**).

NOTE BS EN 363 includes detailed examples of the first three types.



Key
1 Workplace structure
2 Anchor
3 Connector
4 Energy absorbing lanyard
5 Connector
6 Full body harness worn by user

a) Fall arrest system based on an energy absorbing lanyard

Key
1 Workplace structure
2 Anchor
3 Connector
4 Retractable type fall arrester
5 Connector
6 Full body harness worn by user

b) Fall arrest system based on a retractable type fall arrester

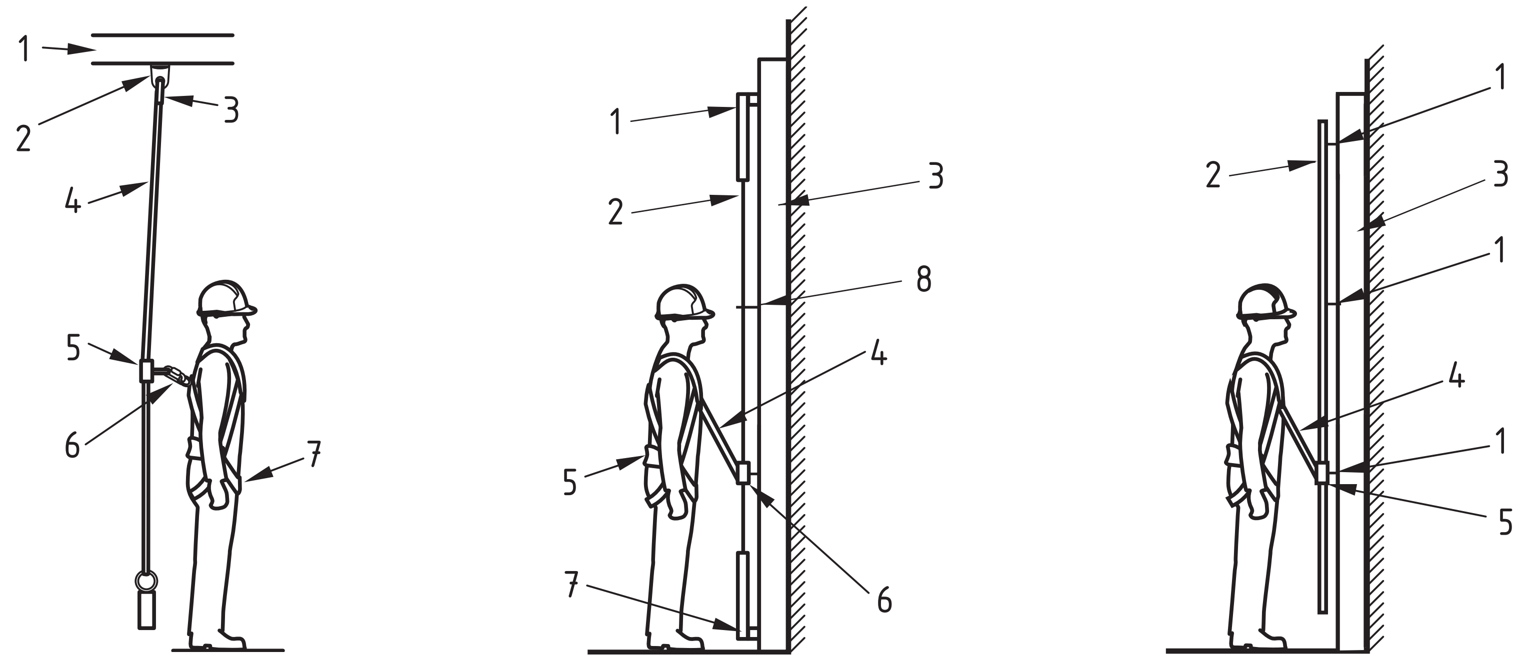
Key
1 Workplace structure
2 Traveller
3 Rigid horizontal anchor line
4 Intermediate anchor
5 Energy absorbing lanyard
6 Connector
7 Full body harness worn by user

c) Fall arrest system based on a rigid horizontal anchor line

Key
1 Workplace structure
2 Traveller
3 Flexible horizontal anchor line
4 Intermediate anchor
5 Energy absorbing lanyard
6 Connector
7 Full body harness worn by user

d) Fall arrest system based on a flexible horizontal anchor line

Figure 7 — Examples of different types of fall arrest system



Key
1 Workplace structure
2 Anchor
3 Connector
4 Flexible vertical anchor line
5 Guided type fall arrester
6 Short connecting lanyard
7 Full body harness worn by user

e) Fall arrest system based on a flexible vertical anchor line with an upper anchor

Key
1 Upper anchor
2 Flexible vertical anchor line
3 Permanently installed ladder
4 Short connecting lanyard
5 Full body harness worn by user
6 Guided type fall arrester
7 Lower anchor
8 Intermediate anchor

f) Fall arrest system based on a flexible vertical anchor line with an upper and a lower anchor

Key
1 Anchors
2 Rigid vertical anchor line
3 Permanently installed ladder
4 Short connecting lanyard
5 Guided type fall arrester

g) Fall arrest system based on a rigid vertical anchor line

Figure 7 — Examples of different types of fall arrest system (*continued*)

9.1.2 *Full body harnesses for fall arrest systems*

9.1.2.1 *General*

A full body harness should always be used in a fall arrest system. Under no circumstances should a waist belt or a chest harness be used on its own for fall arrest purposes. A full body harness conforming to BS EN 361 should be used. (See also **12.6.1**.)

9.1.2.2 *Use of full body harness attachment points*

Full body harnesses are equipped with one or more designated fall arrest attachment points for connecting the full body harness to the energy absorbing lanyard or retractable type fall arrester. It is essential that only the attachment points designated by the manufacturer for fall arrest purposes are used. Some full body harnesses are also fitted with side waist attachment points for work positioning. These side waist attachment points should not under any circumstances be used as attachment points for fall arrest purposes.

The designated fall arrest attachment points are as follows:

— a rear (dorsal) attachment point, which is arranged to lie centrally between the shoulder blades when the full body harness is worn;

— a front (sternal) attachment point, which is arranged to lie centrally at the bottom of the breastbone when the full body harness is worn.

The advantages and disadvantages of using each of these two attachment points are given in Annex E.

In the case of a full body harness for use with a retractable type fall arrester, where a rear attachment point on the harness is used, a short extension lanyard should be used (see Note). Where this is integral with the harness, the manufacturer can be expected to have tested the strength of this configuration. In the case of a harness without an integral extension lanyard a short detachable lanyard conforming to BS EN 354 should be used (see Figure 8).

NOTE It is difficult to reach behind the back to attach the swivel hook of the retractable type fall arrester to the rear attachment point on the full body harness. By attaching a short extension lanyard to this point before donning the harness, the free end of the lanyard becomes an extended attachment point, to which it is relatively easy to connect.

9.1.2.3 *Donning a full body harness*

A full body harness should be donned and correctly adjusted in accordance with manufacturers' instructions. It is important to check that the connections at the anchor point and at the attachment point on the full body harness have been made correctly. This involves checking that the gate mechanism of the connector is fully closed and locked and the connector is aligned properly within the anchor and attachment point. The purpose of these precautions is to avoid inadvertent disengagement of the connector during work (referred to as "roll-out"). For more details on connectors see **12.5**.

9.1.3 *Lanyards for fall arrest systems*

9.1.3.1 *General*

WARNING. A lanyard should never be used on its own for fall arrest purposes without any means of energy absorption in the fall arrest system.

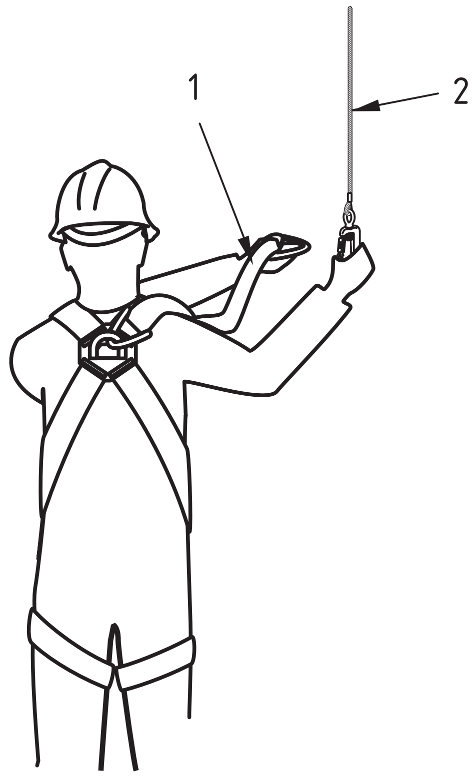
BS EN 363 specifies that a full body harness and a lanyard without an energy absorber shall not be used as a fall arrest system.

BS EN 354, which specifies requirements for lanyards for use in fall arrest systems specified in BS EN 363, requires that lanyards do not exceed 2 m in length, including the energy absorber, if applicable, and the connectors. Shorter lanyards should be used where possible, to minimize the free fall distance (see **9.7**) and swing fall problems (see **9.5.7.2**).

NOTE 1 BS EN 363 indicates that a retractable lanyard, which comprises the connecting element in a retractable type fall arrester, may be more than 2 m long.

NOTE 2 The free fall distance is that distance through which the user would fall before the fall arrest system begins to arrest the fall, measured from the user's position prior to the fall.

NOTE 3 A swing (or "pendulum") fall is a fall in which at the point of fall arrest the vertical trajectory of the user is diverted into a swing or pendular trajectory with significant horizontal velocity.



Key
1 Extension lanyard
2 Anchor line of retractable type fall arrester

Figure 8 — Use of an extension lanyard

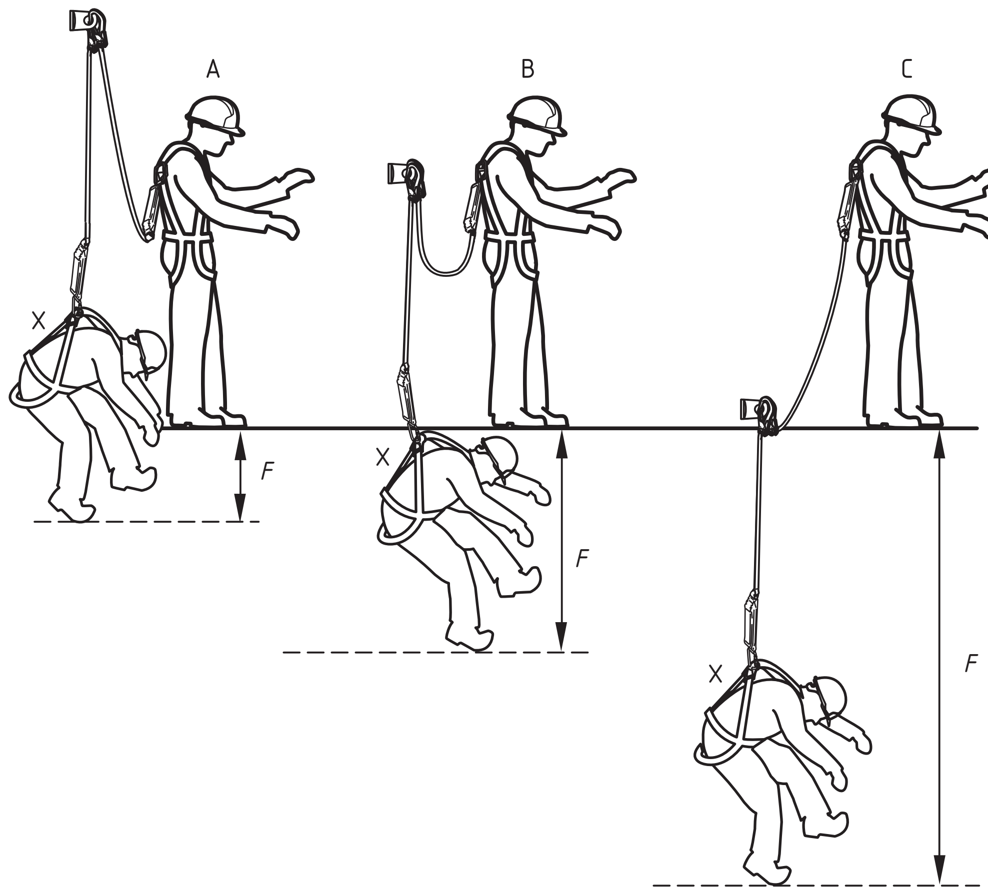
The position of the user's attachment point to the personal fall protection system in relation to the anchor point is of particular importance. This determines the "fall factor", which provides an indication of the length and severity of a potential fall.

This is illustrated in Figure 9, which shows three fall arrest situations. In each case the fall arrest system is based on a 1.5 m long energy absorbing lanyard and a distance between the attachment point on the user's harness and the user's feet of 1.5 m. The free fall distance is the vertical distance between the position of the user's feet immediately prior to the fall and the position of the user's feet at the point at which the lanyard has become taut and started to arrest the fall (distance *F* in Figure 9).

The fall factor is calculated by taking the free fall distance and dividing it by the length of lanyard available to arrest it (in this case the length of the energy absorbing lanyard prior to deployment of the energy absorber). In a normal work situation the maximum fall factor is 2. The fall factor should be kept as small as possible, i.e. the length of any potential fall should be minimized, for example by choosing an anchor point above the user, and the length of the lanyard should be kept as short as possible. As illustrated in Figure 9, an anchor point above the user gives the smallest fall factor, so is the safest, and is the preferred option; an anchor point at shoulder level gives a larger fall factor and should only be used as a second choice; an anchor point at foot level gives the maximum fall factor and should be avoided if possible (see also **16.6.1**).

In situations where the user is likely to need to turn round repeatedly under the anchor point, a lanyard incorporating a swivel fitting should be used to avoid the lanyard twisting, untwisting, hockling or birdcaging.

Knots should not be used to make a termination in a lanyard that is already supplied with terminations, or to shorten its length.



A Anchor point above user. (In this case 1 m above user's harness attachment point.) (*Preferred option*) Free fall distance: 0.5 m Fall factor = 0.5/1.5 = 0.3

B Anchor point at shoulder level. (*Non-preferred option*) Free fall distance: 1.5 m Fall factor = 1.5/1.5 = 1.0

C Anchor point at foot level. (*To be avoided*) Free fall distance: 3.0 m Fall factor = 3.0/1.5 = 2.0

NOTE 1 The lower human figure in each drawing indicates the position of the user at the end of the free fall, i.e. the point at which the energy absorber begins to deploy. This should not be confused with the position the user would be in at the end of the arrest of the fall.

NOTE 2 The drawings are not strictly to scale.

Key

F Free fall distance

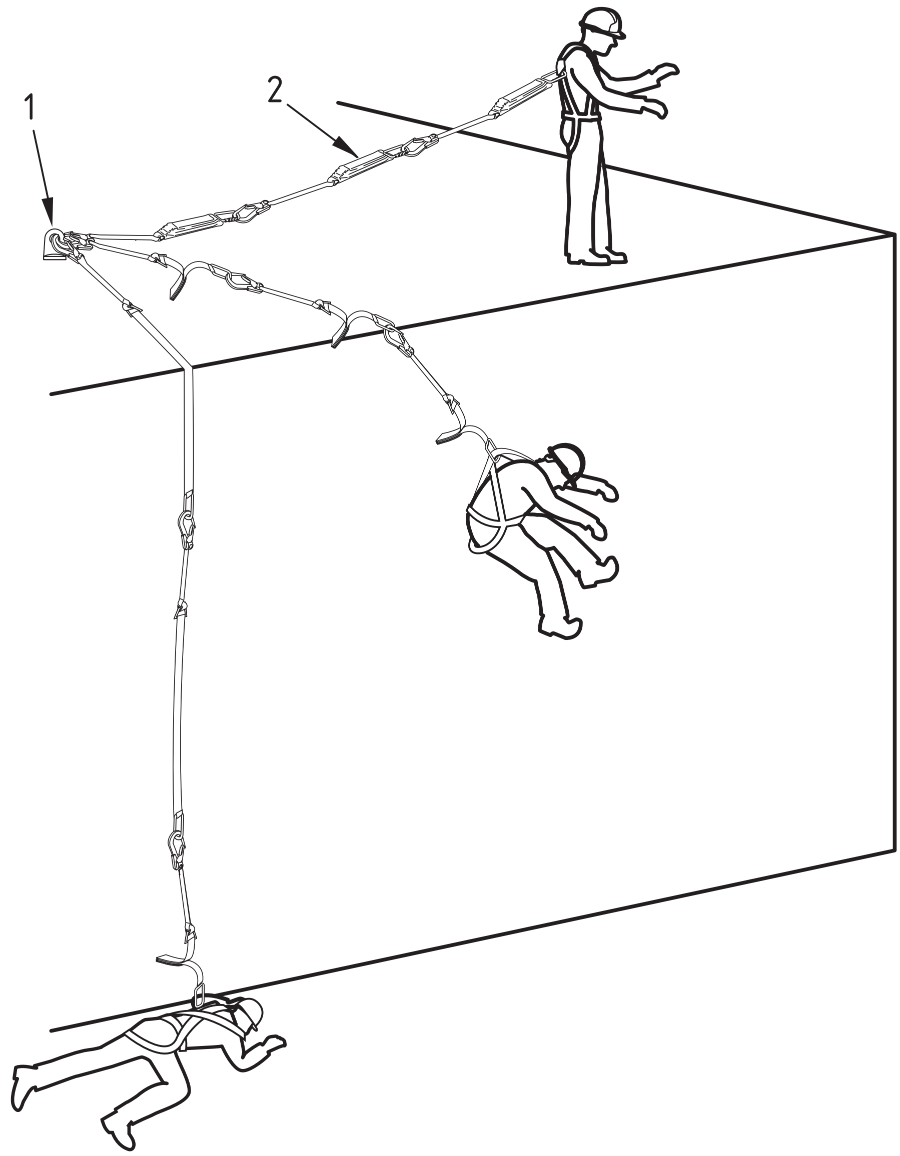
Figure 9 — Illustration of free fall distances and the calculation of fall factors

9.1.3.2 *Energy absorbing lanyards*

It is essential that an energy absorbing lanyard provides efficient energy absorption, i.e. the lanyard selected should be one that provides the lowest possible arrest force over the smallest possible arrest distance. Lanyards with tear-web type energy absorbers tend to have a smooth arrest force characteristic but since the energy is absorbed over a longitudinal tear in a strip of material the arrest distance is equal to twice the length of the tear. Lanyards with other types of energy absorbers tend to give smaller arrest distances but might not have such a smooth arrest force characteristic as those with the tear-web types. (See **12.8**.)

Energy absorbing lanyards should not be connected together in series to increase overall length, because on arrest of a fall the increased free fall distance could lead to the user being subjected to excessive arrest forces or could allow them to hit the ground (see Figure 10). If the work position cannot be reached when a single energy absorbing lanyard is connected to the anchor point, then an anchor point nearer the work position should be utilized.

An energy absorbing lanyard should not be connected in series with another fall arrest device, e.g. a retractable type fall arrester, because on arrest of a fall the increased free fall distance could produce excessive forces on the device and cause failure, or could allow the user to hit the ground.



Key

1 Anchor

2 Three energy absorbing lanyards connected in series to reach work position

WARNING. Energy absorbing lanyards should never be used like this.

Figure 10 — Illustration of the dangers of connecting energy absorbing lanyards in series to increase overall length

9.2 Fall arrest systems based on one or more energy absorbing lanyards

9.2.1 *Systems based on a single energy absorbing lanyard*

Fall arrest systems based on a single energy absorbing lanyard, as illustrated in Figure 11, are the most basic type. They can be used alone or as part of a more complex system, for example a system based on a vertical or a horizontal anchor line (see **9.4** and **9.5**).

A fall arrest system based on a single energy absorbing lanyard is temporary and mobile and is suitable as a back-up fall protection system for use with a work positioning system (see **10.2**). These systems can also be connected directly to the structure, eliminating the need for anchor points, which is useful in tower work (see **10.2.2.1**).

An energy absorbing lanyard comprises a lanyard terminated at one end with a connector for attachment either to an anchor point or directly to a structure. At the other end is an energy absorber, either integral with the lanyard or attached to it by means of a connector. The energy absorber is fitted with a connector for attachment to the user's harness. An example of an energy absorbing lanyard is shown in Figure 12a.

The energy absorbing lanyard remains unloaded during normal work at height. In the event of a fall, the sharp downward pull on the lanyard operates the energy absorber, which absorbs the energy generated by the fall, thus decelerating the user and bringing them to a stop within a short distance (see Figure 13). The user then remains suspended by the lanyard to await rescue.

For details of energy absorbers, see **12.8**.

When using a single energy absorbing lanyard, the user's range of movement is limited by the length of the lanyard, i.e. the limit of the range of movement is the point at which the lanyard becomes taut (see Figure 14a). To move beyond this point the user would need to disconnect the lanyard (see Figure 14b), move to the new position and then reconnect the lanyard (see Figure 14c). No fall protection would be provided during the period between disconnection and reconnection of the lanyard. Working in this way is not recommended.

9.2.2 *Systems based on two energy absorbing lanyards*

In situations where the user requires a range of movement greater than the lanyard length, for example when ascending, descending or traversing a structure, use of a fall arrest system based on two energy absorbing lanyards is necessary to enable the user to move safely, as shown in Figure 15.

The two lanyards are used in relay, being disconnected and reconnected in turn as the user proceeds so that at all times during the movement there is a connection between the user and the structure. The user is initially connected to the structure by the first lanyard. When the user reaches the point at which this lanyard is fully extended (see Figure 15, view A), the second lanyard is connected to the next anchor point on the user's route (see Figure 15, view B). The first lanyard is then disconnected to allow the user to move on (see Figure 15, view C). This procedure is repeated until the route has been safely negotiated (see Figure 15, view D).

These systems have the disadvantage that they can be slow and laborious to use. Also, carrying out repeated connection and disconnection can result in the user suffering musculo-skeletal problems.

Systems based on a vertical or a horizontal anchor line are more efficient (see **9.4** and **9.5**).

9.2.3 *Systems based on a twin-tailed energy absorbing lanyard*

NOTE This type of lanyard is sometimes referred to as a "Y-shaped" energy absorbing lanyard.

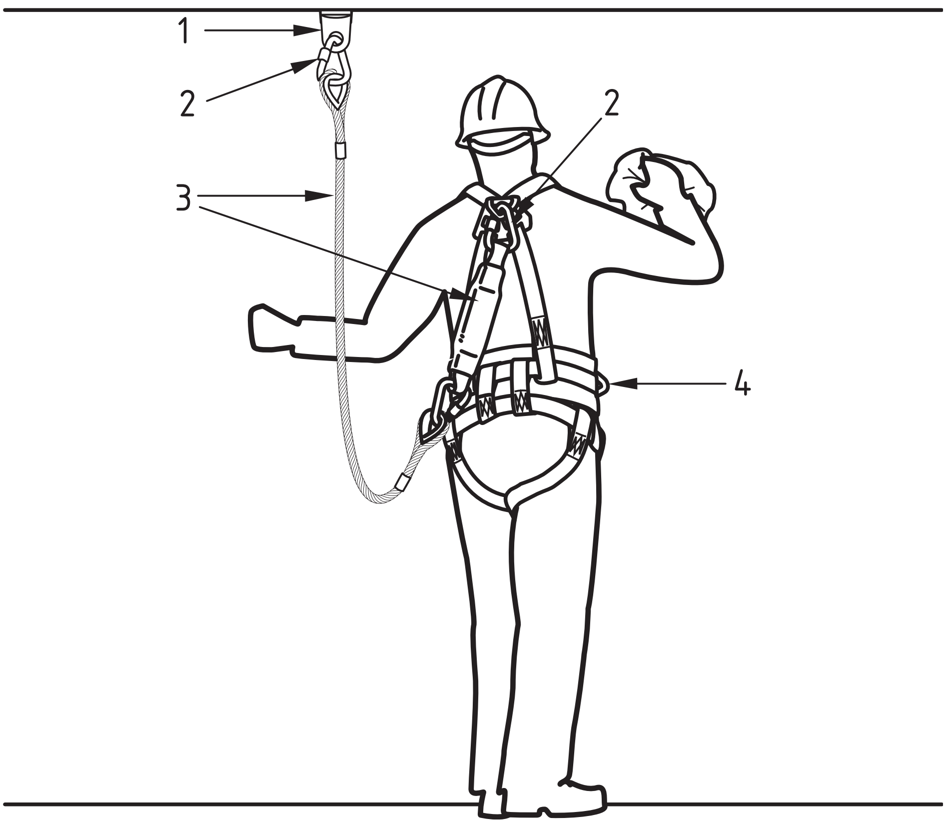
To make climbing with two lanyards more efficient, a system can be used which incorporates two lanyards combined with a single energy absorber, to save weight and thus improve climbing ergonomics (see Figure 16).

A twin-tailed energy absorbing lanyard comprises two lanyards each terminated at one end with a connector for attachment either to an anchor point or directly to a structure. The other end of each lanyard is attached to a single energy absorber in such a way that either lanyard can transmit a load to the energy absorber. The energy absorber is fitted with a connector for attachment to the user's harness. An example of a twin-tailed energy absorbing lanyard is shown in Figure 12b).

The two lanyards are used in relay as described in **9.2.2**.

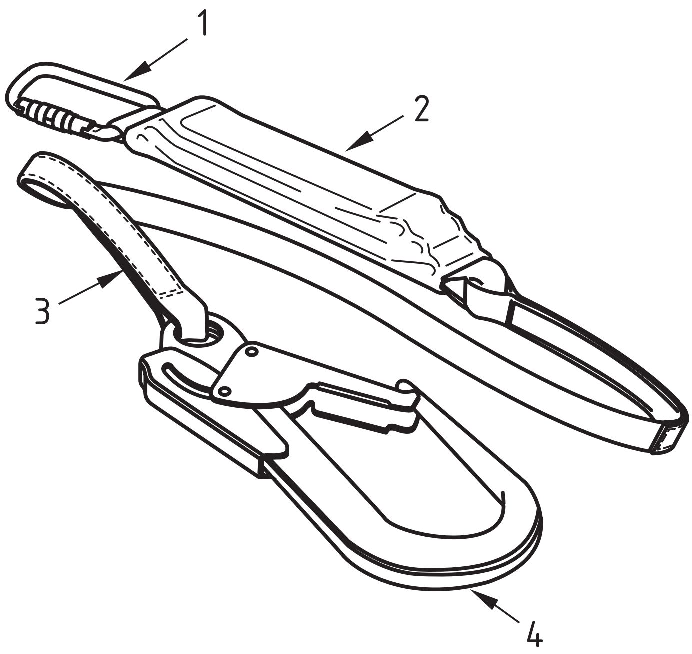
When only one of the lanyards is connected to the anchor point, the second lanyard should be left to hang free, or should also be connected to the anchor point. The second lanyard should not be attached to the user's harness or to their belt or clothing as this could limit the extension of the energy absorber in the event of a fall, which would cause excessive arrest forces to be applied to the user and to the fall arrest system. This is particularly important when the lanyards used are relatively short.

These systems have similar disadvantages to those described in **9.2.2**.

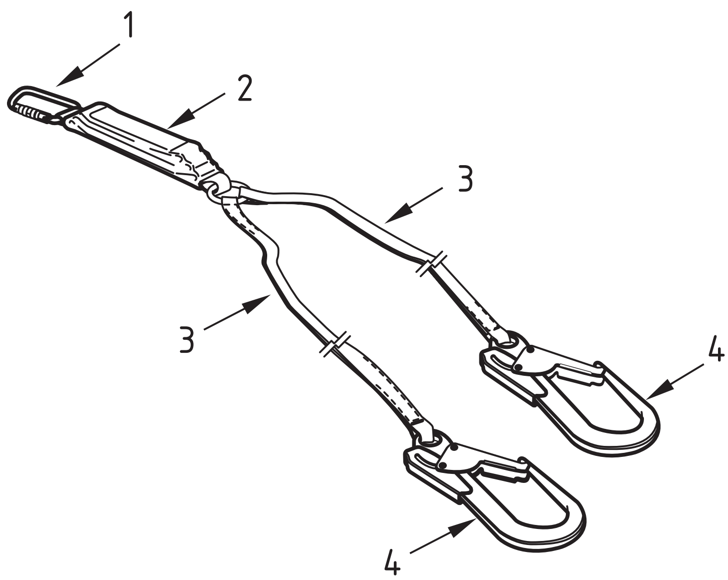


Key
1 Anchor
2 Connectors
3 Energy absorbing lanyard
4 Full body harness

Figure 11 — Example of a fall arrest system based on a single energy absorbing lanyard



a) Single energy absorbing lanyard



b) Twin tailed energy absorbing lanyard

Key

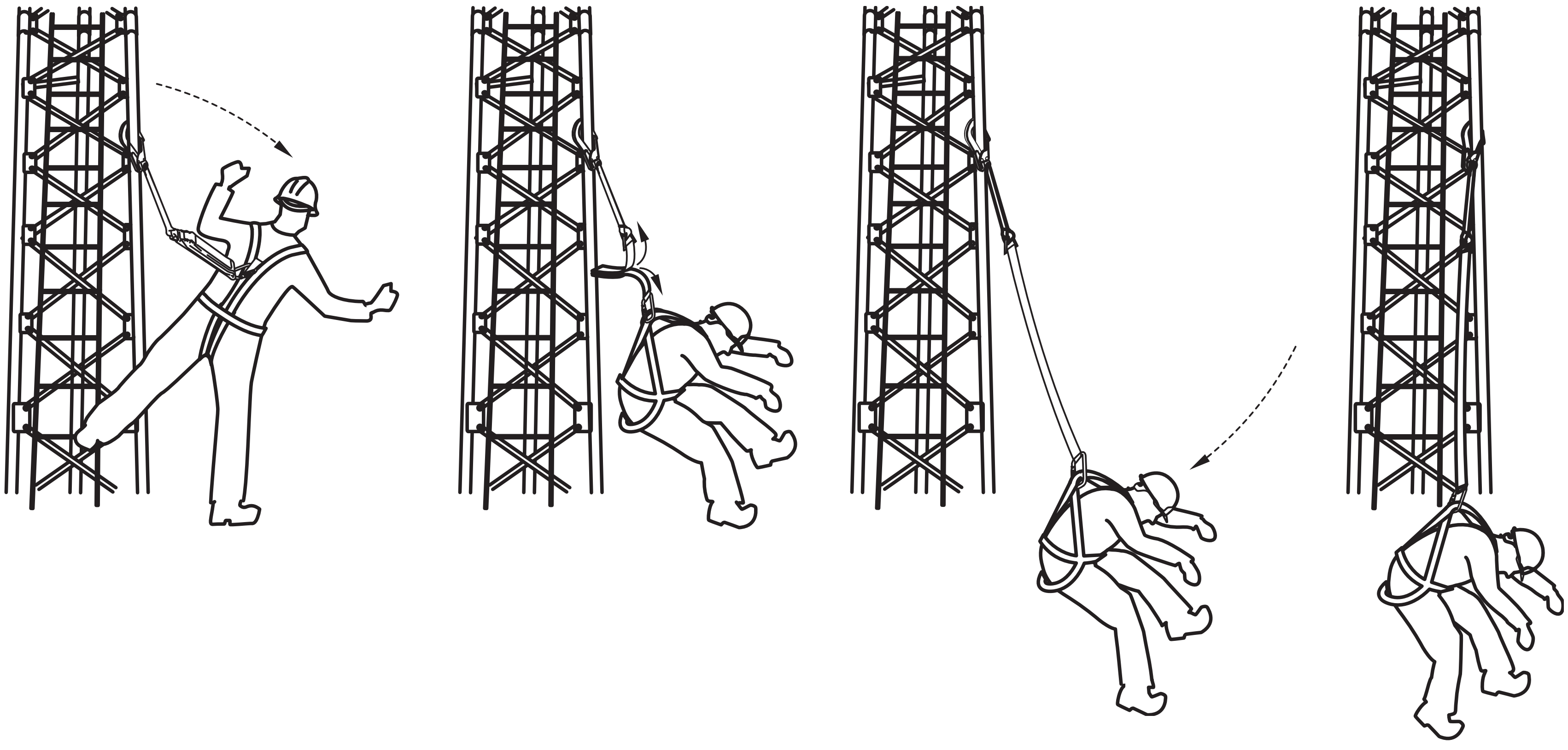
1 Connector for attachment to user's harness

2 Energy absorber

3 Lanyard

4 Connector for attachment to anchor

Figure 12 — Examples of energy absorbing lanyards



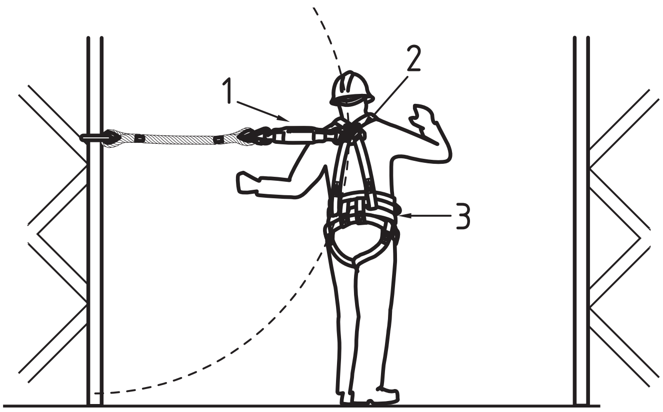
a) User suffers a fall

b) Energy absorber operates

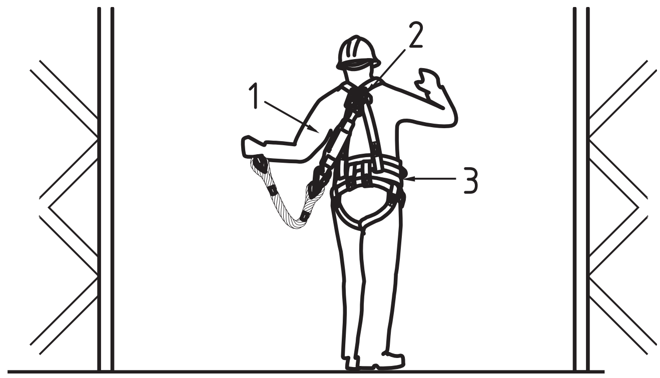
c) Fall is arrested

d) User remains suspended to await rescue

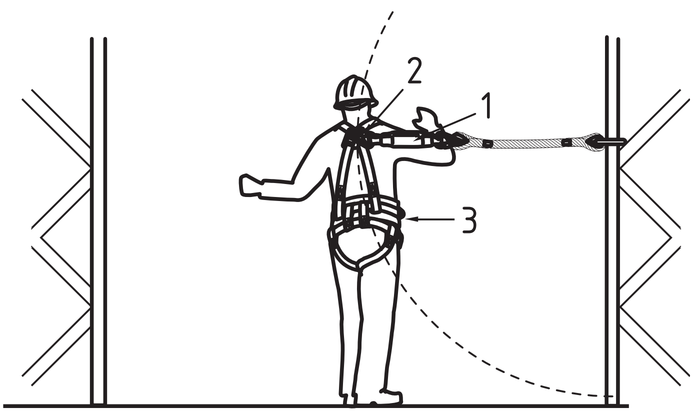
Figure 13 — Illustration of an energy absorbing lanyard operating to arrest a fall



a) User reaches position at full extent of lanyard



b) User disconnects lanyard and moves to new work position. During this period the user is without fall protection



c) User reconnects lanyard in new position.

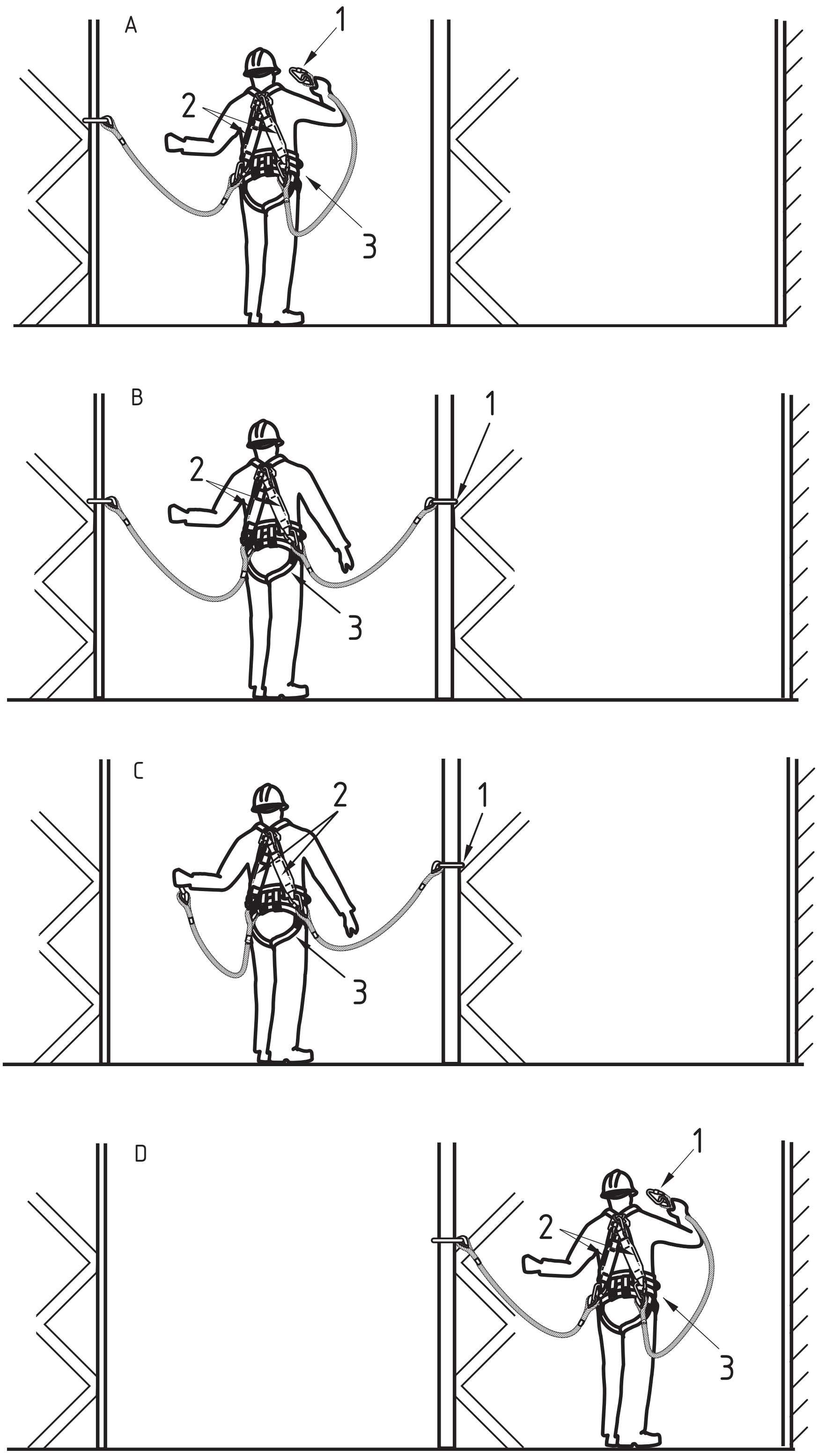
Key

1 Energy absorbing lanyard

2 Connector

3 Full body harness

Figure 14 — Limitations and dangers of using a single energy absorbing lanyard where a range of movement greater than lanyard length is required



Key

1 Connector 2 Energy absorbing lanyards 3 Full body harness

A, B, C and D Sequence of actions

Figure 15 — Ensuring continuous connection to the structure by using two energy absorbing lanyards in relay

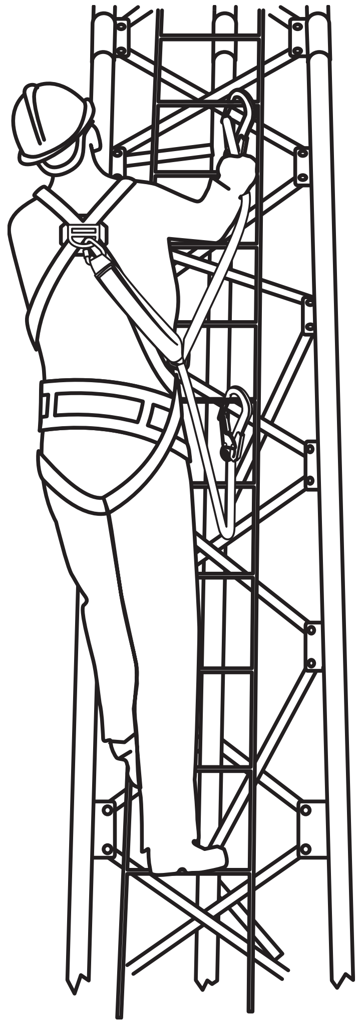


Figure 16 — Example of the use of a fall arrest system based on a twin-tailed energy absorbing lanyard while climbing

9.3 Fall arrest systems based on a retractable type fall arrester

9.3.1 *General*

A fall arrest system based on a retractable type fall arrester (see Figure 17), provides a temporary and mobile means of fall arrest where no permanently installed fall arrest system is available.

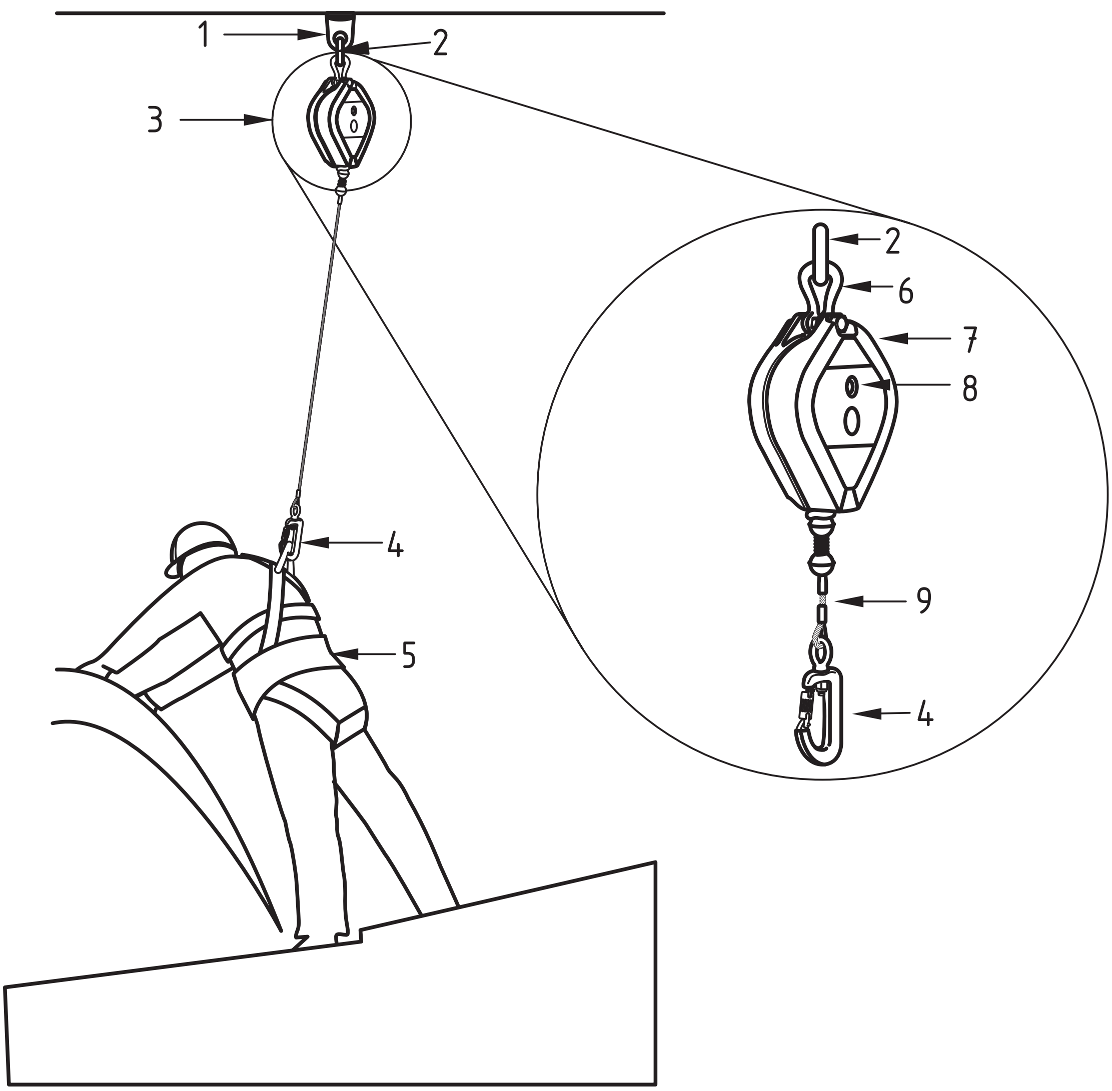
NOTE Retractable type fall arresters are also known in the industry as “retractable lifelines”, “self-retracting lifelines”, “retractable lanyards”, “retractable arresters”, “inertia reels” and “fall arrest blocks”.

Most retractable type fall arresters are designed for use only where the anchor point is directly above the user (see **9.3.7.3**).

Fall arrest systems based on a retractable type fall arrester have the following advantages over those based on energy absorbing lanyards (see **9.2**).

— They have a retractable lanyard which is kept under a light tension thus preventing slack from occurring in use. This minimizes the potential free fall distance, and consequently reduces the fall arrest distance. Thus the free space requirement is smaller.

— They provide a greater range of movement in the vertical plane which is useful when the user is climbing up or down a structure.



Key

1 Anchor point
2 Connector
3 Retractable type fall arrester
4 Swivel hook
5 Full body harness
6 Shackle
7 Housing
8 Fall arrest indicator
9 Retractable lanyard

Figure 17 — Fall arrest system based on a retractable type fall arrester

They have the following disadvantages and limitations.

— Their use is limited by the maximum working length of the retractable lanyard. As the length is increased, the devices become heavier and more unwieldy. The alternative is to continually relocate the device as climbing proceeds.

— They can only be used in a broadly vertical plane, although the range of horizontal movement can be extended by utilizing a horizontal rail system (see **9.5**).

— They are not usually suitable for use with flexible horizontal anchor lines.

— Their use is limited to situations where the anchor point is overhead.

Also, retractable type fall arresters have to be installed overhead before work commences. This may necessitate:

— climbing to the intended anchor point with the device whilst utilizing another form of fall protection (permanent or temporary);

— installing the device by a remote means and using a tag lead to extract the lanyard;

— using a mobile elevating work platform or a protected walkway.

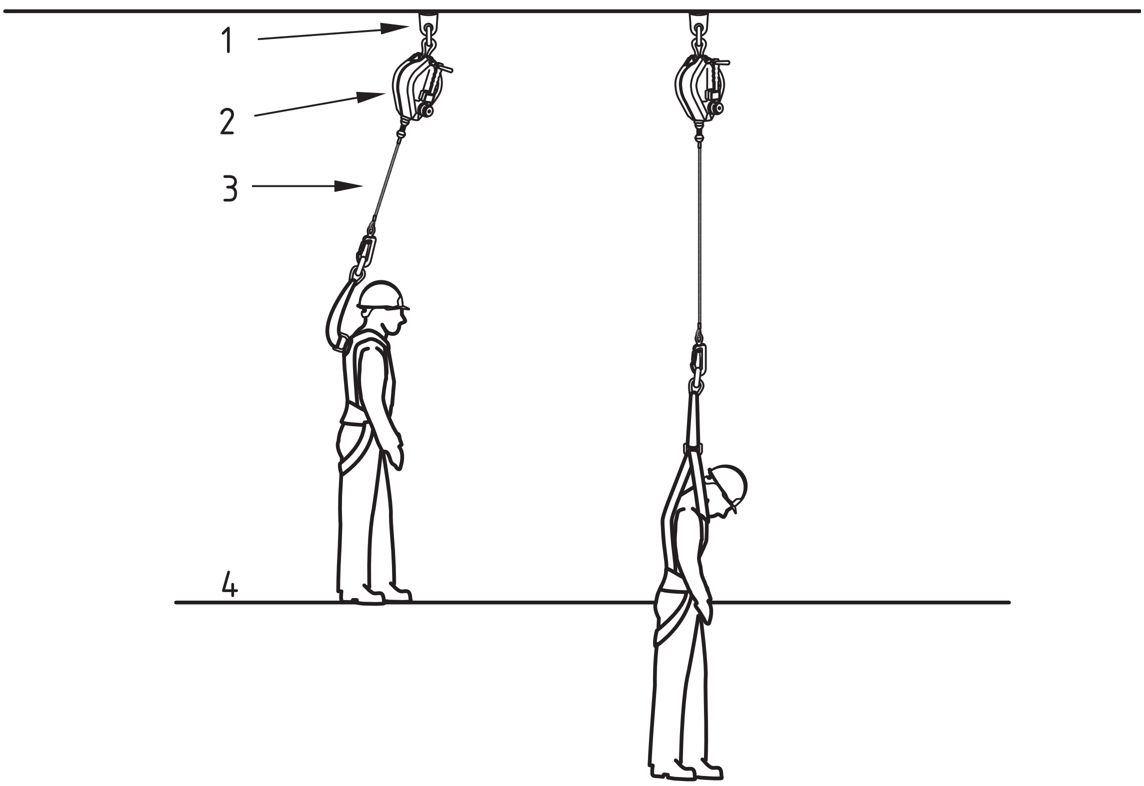
9.3.2 *Components of a retractable type fall arrester*

9.3.2.1 *General*

A retractable type fall arrester comprises a retractable lanyard made of wire rope, webbing or synthetic fibre rope which is stored on a reel within a protective housing. The reel is spring-biased so as to wind the retractable lanyard in, which ensures that it is always under a light restraining tension and there is the shortest possible length between the housing and the user. The reel incorporates an inertial clutch mechanism. This allows the lanyard to be slowly extracted and automatically retracted to accommodate the user's body movements while carrying out the work. In the event of a fall, the lanyard is rapidly extracted until it reaches a critical velocity (termed the "lock-on speed") at which point the clutch locks, simultaneously activating a braking mechanism that decelerates the user over a short distance, prevents further extraction of the lanyard and brings the user to a complete stop. The user then remains suspended by the retractable type fall arrester to await rescue (see Figure 18).

NOTE This mechanism is similar to that used in inertia reel seat belts fitted for occupant restraint in motor vehicles.

The end of the lanyard external to the housing is terminated with a connector which has a swivel joint. Such connectors are known as swivel hooks.



Key

1 Anchor
2 Retractable type fall arrester
3 Retractable lanyard
4 Walkway

Figure 18 — Example of a retractable type fall arrester operating to arrest a fall

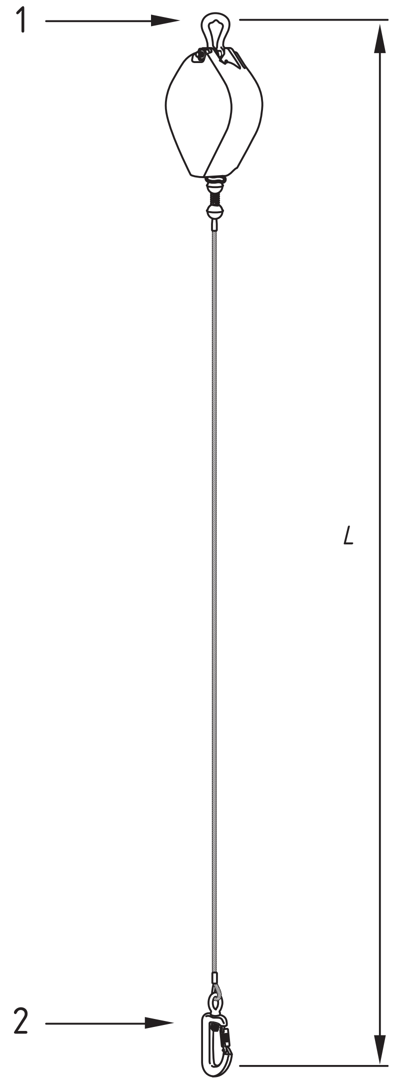
The swivel hook is used to connect the retractable lanyard to the user's harness, and has a stop to prevent the lanyard from being fully retracted into the housing. The swivel joint prevents twisting and untwisting of the lanyard as a result of the user turning repeatedly during the work.

The maximum working length of a retractable type fall arrester is the distance from the bearing point of the housing connector to the bearing point of the swivel hook measured with the retractable lanyard fully extracted (see Figure 19).

The maximum working length determines the size and mass of the retractable type fall arrester and the distance the user is able to move away from point at which the housing is connected. The maximum working length is usually in the range 2.0 m to 50.0 m.

The retractable type fall arrester selected should be such that when it is connected to an overhead anchor point, the maximum working length is sufficient to allow the user to reach the whole of the intended work area without continually having to relocate the device.

Retractable type fall arresters conforming to BS EN 360 should be used.



Key

1 Connector

2 Swivel hook

L Maximum working length of retractable type fall arrester (with retractable lanyard fully extracted)

Figure 19 — Maximum working length of a retractable type fall arrester

9.3.2.2 *Retention or reserve stop*

A retractable type fall arrester with a retention or reserve stop should be used. This is especially important in conditions in which the user might need to be near to, or at, the position at which the retractable lanyard is fully extended. A retention or reserve stop is a safety device which keeps a reserve length of lanyard on the reel which is not released when the lanyard is fully extracted during normal use. In the event of a fall, the stop releases the reserve length of lanyard and so prevents any "bottoming out" effects in which the user could be subjected to an excessive arrest force due to there not being enough lanyard around the reel to enable the device to operate correctly.

9.3.2.3 *Fall arrest indicator*

The fall arrester used should be one that has a fall arrest indicator mechanism. Operation of the indicator tells the user that the retractable type fall arrester has previously sustained a shock loading and that it needs to be taken out of service.

The fall arrest indicator may be mounted on the housing or on the lanyard connector. Housing mounted indicators are appropriate when the housing can be seen by the user. However, in some situations retractable type fall arresters are pre-installed at some height above the user, so it is virtually impossible for the user to see if an indicator has operated or not. In such situations, an indicator mounted on the lanyard connector is more appropriate since it can be checked prior to attachment of the lanyard to the user's harness.

9.3.2.4 *Tag leads*

In some situations, retractable type fall arresters are semi-permanently installed at a considerable height above the workplace. The user then cannot reach the swivel hook to pull out the lanyard in order to connect the swivel hook to his harness. In such circumstances a length of cord, known as a "tag lead", can be attached to the swivel hook and allowed to hang down to where the user can reach it. The user can pull out the lanyard by pulling on the tag lead. The tag lead can then be removed and the swivel hook connected to the user's harness in the usual way. Upon completion of the work, the tag lead can be reattached, and the lanyard can be allowed to retract back slowly.

9.3.2.5 *Webbing attachment strap*

When using a retractable type fall arrester with a wire rope lanyard, consideration should be given to using a short webbing attachment strap between the user's harness and the lanyard connector, as this would be easier to cut should this be necessary during a rescue.

9.3.3 *Additional components for larger retractable type fall arresters*

9.3.3.1 *General*

If a larger retractable type fall arrester is to be used it should be one which includes the following components:

— a retraction brake (see **9.3.3.2**), which is especially important in situations where the retractable lanyard is accessed remotely via a tag lead (see **9.3.2.4**);

— an integral means of rescue which is strong enough to support the weight of the user and is efficient enough to enable the user to be recovered rapidly in the event of an accident (see **9.3.5**).

9.3.3.2 *Retraction brakes*

A retraction brake is a device which prevents uncontrolled retraction of the retractable lanyard if it is inadvertently or deliberately released. Uncontrolled retraction of the lanyard causes it to rapidly recoil back into the housing, which can damage the retraction spring, cause the lanyard to get tangled up or cause the clutch to jam. All of these can either prevent subsequent extraction of the lanyard, or reduce the retraction performance.

A retraction brake automatically applies a restraining force to the lanyard if it is suddenly released so that it retracts slowly back into the housing under light tension.

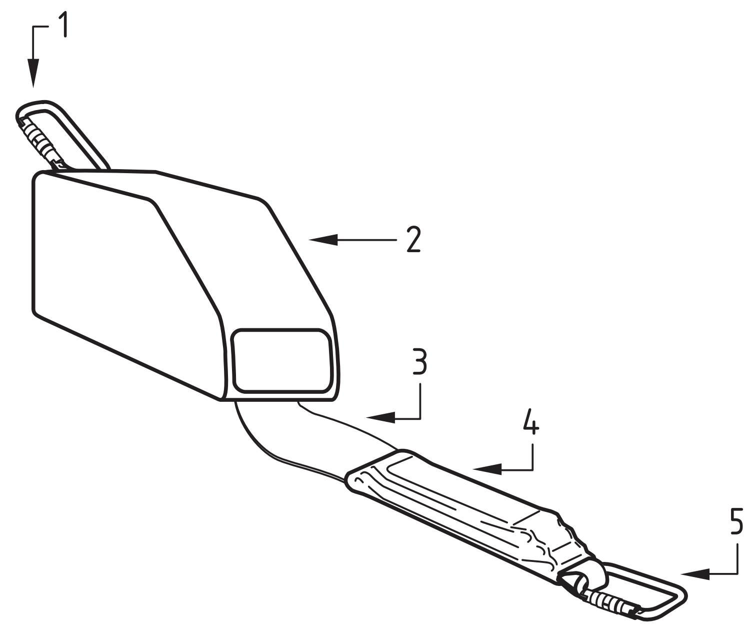
9.3.4 *Simple retractable type fall arresters*

There are very simple versions of retractable type fall arresters available with a maximum working length of 2.0 m (see Figure 20). These are also known as "miniblocks".

These devices work in the same way as the retractable type fall arresters described in **9.3.2** and **9.3.3** with the exception that the fall arrest function requires supplementary energy absorbing capability. This is typically achieved by the incorporation of an external tear-web type energy absorber into the retractable lanyard. The operation of the energy absorber is in all respects similar to that when it is incorporated in an energy absorbing lanyard (see **9.2**).

The main advantages of these devices are that they are relatively inexpensive and light, and in some cases can be mounted on the full body harness for ease of use.

However, these devices are commonly misused by having the anchor point horizontally to one side of, or behind, the user. Great care should be taken to ensure that the anchor point is above the user when using these devices (see **9.3.7.3**).



Key

1 Connector for connection to anchor
2 Housing
3 Webbing lanyard
4 Integral energy absorber
5 Connector for connection to user's harness

Figure 20 — Example of a simple retractable type fall arrester

9.3.5 *Retractable type fall arresters incorporating an integral means of rescue*

Some retractable type fall arresters incorporate an integral means of rescue (see Figure 21) which can be used by a rescuer to raise or lower an incapacitated user to a position of safety. This type of retractable type fall arrester is particularly useful when mounted on a tripod and employed by a user undertaking work in a confined space below the surface (see Figure 22).

A rescue procedure employing a retractable type fall arrester with an integral means of rescue requires a trained second person. It is essential that the retractable fall arrester is installed in such a position that the rescuer can access it in an emergency.

A limitation of this type of retractable type fall arrester is that if the rescue involves lowering the user, the distance through which they can be lowered is limited to the length of the retractable lanyard. Also it can sometimes be difficult for the rescuer to see where to lower the rescuee, especially if the distance between them is significant and/or there are obstructions in the rescue path.

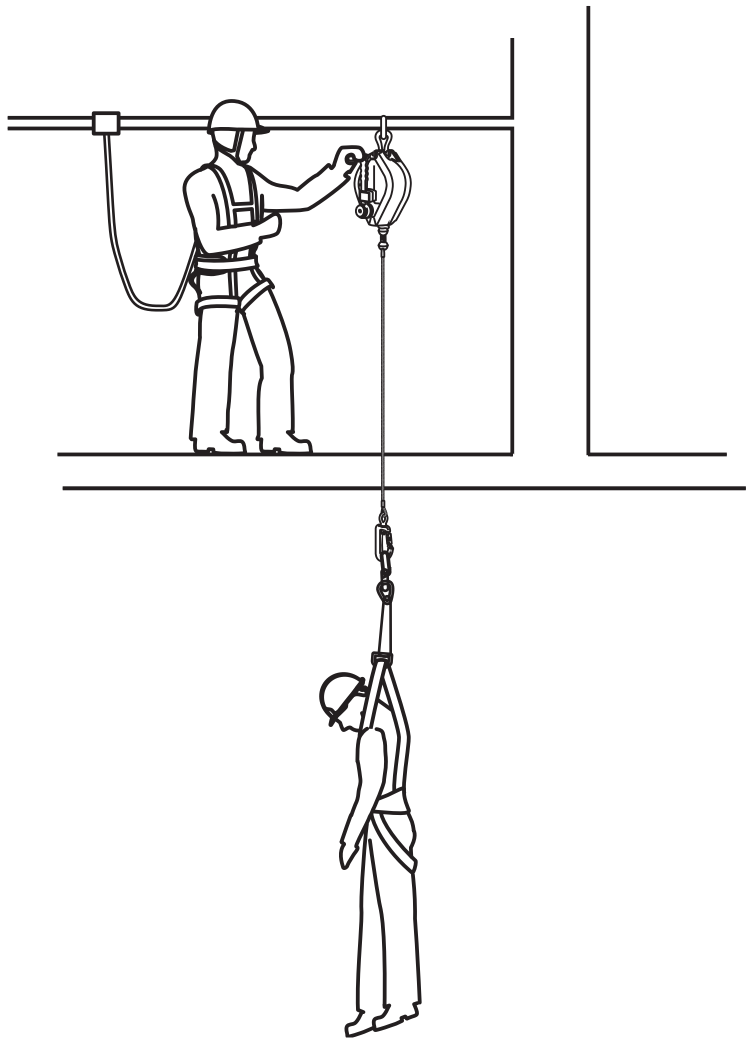


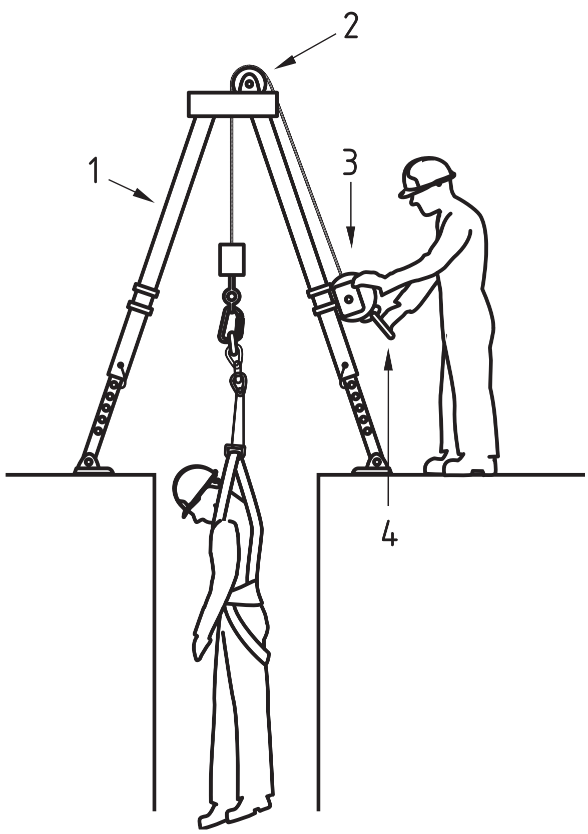
Figure 21 — Example of a retractable type fall arrester incorporating a rescue winch

9.3.6 ***Retractable type fall arresters incorporating an integral automatic descent facility***

Retractable type fall arresters are available which incorporate an integral automatic descent facility. Whereas a basic retractable type fall arrester arrests a fall and brings the user to a complete stop, a retractable type fall arrester with an integral automatic descent facility first arrests a fall of the user, and then automatically switches the motion into a relatively slow, constant speed descent. Thus, instead of being left in a suspended position after a fall, the user is lowered to a position of safety.

This type of retractable type fall arrester is particularly useful for work in situations where access to the user in the event of an accident might otherwise be difficult; and has the added advantage that it will work even if the user is unconscious following a fall.

Disadvantages are that the length of the descent is limited to the length of the retractable lanyard. Also, once commenced, the descent is automatic and cannot be stopped. Therefore, this type of device should not be used where there is anything hazardous below the user, e.g. a vat of toxic fluid.



Key

1 Tripod 3 Retractable type fall arrester mounted on tripod leg

2 Pulley wheel 4 Winching handle

Figure 22 — Example of a retractable type fall arrester incorporating a rescue winch being used in conjunction with a tripod for work in a confined space below the surface

9.3.7 *Use of fall arrest systems based on a retractable type fall arrester*

9.3.7.1 *Use of a tag lead to avoid permanent extraction of the retractable lanyard*

In a situation where the workplace is some distance below the retractable type fall arrester housing, the user should resist the temptation to tie off the swivel hook to the structure at the end of the working day to keep it ready for use for the following day. This reduces the tension in the retraction spring, thus reducing retraction performance. A tag lead should be used instead (see **9.3.2.4**).

9.3.7.2 *Avoidance of delayed or non-activation of the clutch*

9.3.7.2.1 *Environmental factors*

The effective locking of the clutch can be affected by environmental factors, especially extremes of cold, wet and dust. If the retractable type fall arrester is to be used in particularly arduous conditions, the manufacturer should be consulted.

Also, high wind speed can affect the fall arrest distance, especially with devices with a webbing lanyard. A high wind can have the effect of deflecting the retractable lanyard so that it forms a curved path away from the normal straight line path between the user and the anchor point. In the event of a fall, this can increase the length of the free fall that occurs before the rate of extraction of the lanyard reaches lock-on speed and causes the clutch to lock, because the slack in the lanyard has to be taken up first. Retractable type fall arrest devices with a webbing lanyard should not be used in very windy conditions.

9.3.7.2.2 *Mechanical factors*

Retractable type fall arresters should not be used in situations where, in the event of a fall, friction between the person falling and the structure, or between the lanyard and the structure, could prevent locking-on of the clutch, in particular in sloping roof situations.

Retractable type fall arresters are designed to lock-on after the user goes into free fall, i.e. the designer's assumption is that the person falling will accelerate under the force of gravity up to the instant of lock-on. Because lock-on will only occur and arrest a fall when the rate of extraction of the lanyard reaches lock-on speed, it follows that anything that prevents that speed being reached will delay or prevent lock-on. For example, in a fall situation on a sloping roof, depending on the pitch of the roof, friction between the user's body and the roof surface generated as the user slides down the roof can prevent the lock-on speed being reached. The retractable type fall arrester might eventually lock on and arrest the fall when the user falls over the roof edge, but this might be delayed by friction between the lanyard and the roof edge. Also, the lanyard might be weakened or might fail as a result of being stressed over such an abrupt edge.
(See also **9.3.7.3**.)

In the case of a swing fall, it might take longer for the retractable type fall arrester to lock on, leading to an excessive fall distance.

Retractable type fall arresters should also not be used in situations where the working surface consists of loose granular material, e.g. coal, sugar or pellets. In a fall situation caused by the slow collapse of the material, lock-on speed might not be reached, so the user could be immersed and be asphyxiated.

NOTE Loose granular materials stored in vats can contain many hidden voids below the surface, and so when walked upon can be very unpredictable in terms of stability. Persons walking on the surface of such materials have been known to stumble into these hidden voids and be suffocated by the ensuing collapse of loose material.

9.3.7.3 *Use of retractable type fall arresters in the correct plane*

Most retractable type fall arresters are only designed to work in the vertical plane, i.e. where the anchor point is directly above the user so that any force on the fall arrester acts in a direct vertical line between the user and the anchor point. If such a device is used in a plane other than the vertical there is a risk of the braking mechanism not working or of the anchor line passing over a sharp edge and failing as a result. (See also **9.3.7.2.2**.)

Exceptionally, some retractable type fall arresters may be suitable for use in planes other than the vertical, i.e. where the anchor point is not directly above the user. However, a retractable type fall arrester should be used only in the vertical plane unless the manufacturer's instructions indicate that it is suitable for use in other situations. In case of doubt the manufacturer should be consulted.

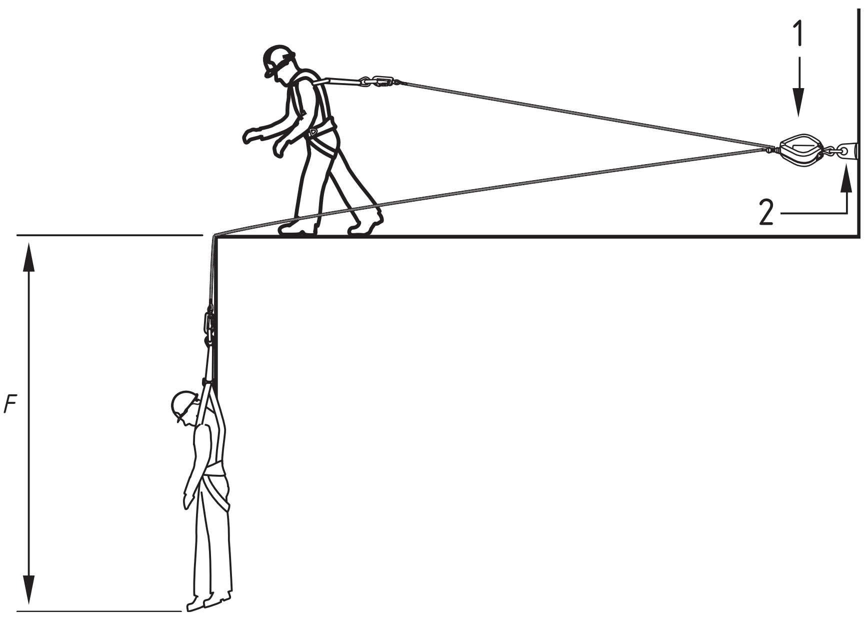
WARNING. It should be noted that at the date of publication of this British Standard there is no standard that specifies testing of a fall arrest system based on a retractable type fall arrester under conditions corresponding to a fall over an edge, as could occur when the device is used on a horizontal or sloping roof with an unprotected edge. The energy generated in such a fall can be over three times that occurring in the dynamic test specified in BS EN 360 because of the greater fall distance (see Figure 23a). In a fall over an edge the braking system might be overloaded to failure, or the fall might not be arrested in the distance available, or the retractable lanyard might break (see Figure 23b).

However, some manufacturers do carry out testing of retractable type fall arresters under conditions corresponding to a fall over an edge. Preferably, devices which have passed these additional tests should be selected.

9.3.7.4 *Problems with extraction or retraction of the lanyard during work at a height*

If problems with extraction or retraction of the lanyard are noticed during work at a height, the work should be stopped immediately. The retractable type fall arrester should be taken out of service and should be replaced with a serviceable one before work is allowed to continue.

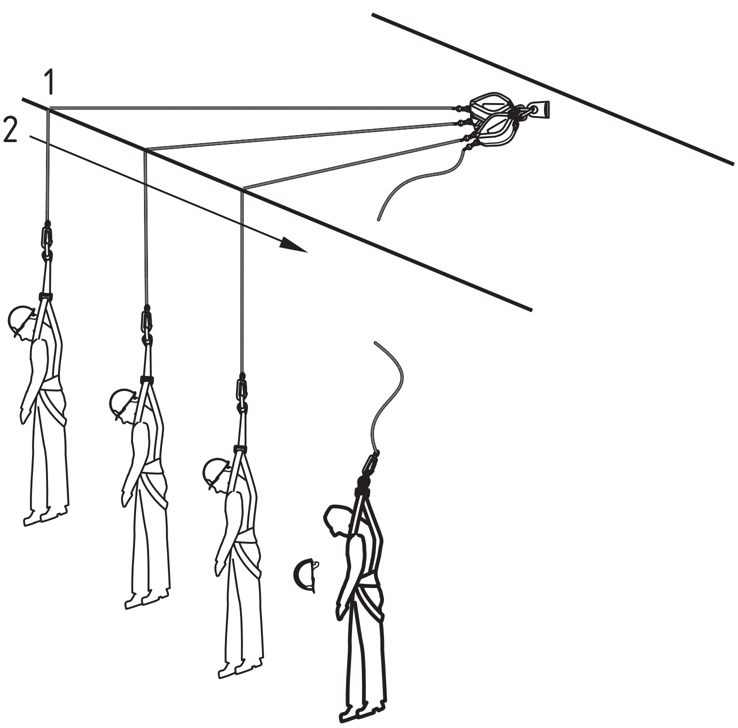
Problems with retraction of the lanyard are particularly serious because, if retraction is prevented, the lanyard will form a loop as the user ascends. Should a fall then occur, the energy generated might be too great for the energy absorbing capacity of the fall arrester, causing mechanical failure of the device which could result in serious or fatal injury to the user. Another risk is that the user could hit the ground before extraction of the lanyard can trigger locking of the clutch (see Figure 24). Problems with lanyard retraction during a climb are indicated by the lanyard no longer applying tension to the harness attachment point.



Key

1 Retractable type fall arrester 2 Anchor
F Free fall distance

a) User suffers a fall over an unprotected edge

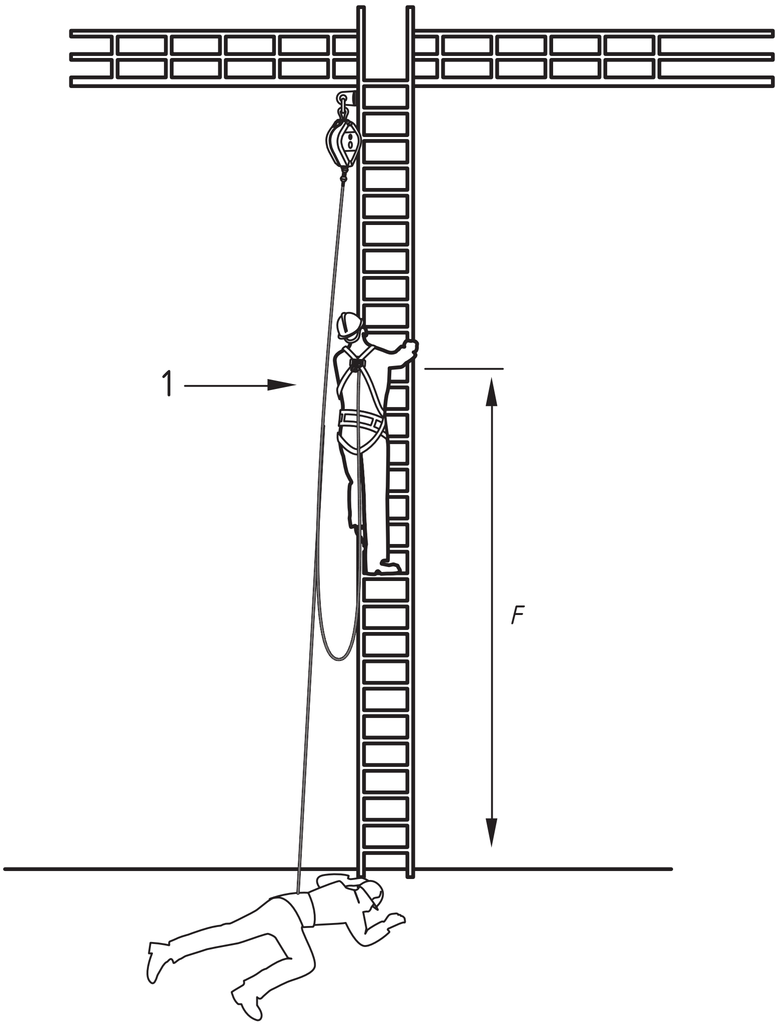


Key

1 Position from which user fell 2 Direction of swing fall. Lanyard pulled across edge in a slicing action

b) Retractable lanyard severed in a swing fall over an edge

Figure 23 — Dangers of using retractable type fall arresters in the horizontal plane



Key
1 Lanyard of retractable type fall arrester failing to retract
F Length of potential free fall

Figure 24 — Risk of a free fall if the lanyard of a retractable type fall arrester fails to retract

9.3.7.5 *Avoidance of knots and clips*

The retractable lanyard should not be knotted or clipped to shorten it or to prevent retraction of the lanyard.

NOTE In the past, knots have been tied in the lanyard to provide a line stop when tension in the lanyard became a nuisance for users who remained at one position for long periods of time. The knot effectively prevented the lanyard from retracting, thus relieving the user of the lanyard tension. The danger with this is that knots can seriously reduce the strength of the lanyard and, if the user starts to climb upwards, a dangerous amount of slack can form because the lanyard cannot be retracted (see Figure 24).

9.3.7.6 *Use of correct path for the retractable lanyard*

The user should ensure that the lanyard runs directly from the housing to the harness attachment point. Passing the lanyard beneath the armpits or between the legs whilst moving around or whilst stationary should be avoided, as this could result in injury in the event of a fall.

Where two or more users connected to retractable type fall arresters are working in the same vicinity care should be taken to avoid the lanyards crossing over one another.

9.3.7.7 *Flexible anchor points and "ratchet bounce"*

It is not normally advisable to attach a retractable type fall arrester to a flexible anchor point or one capable of springing, e.g. a cantilever beam or a horizontal anchor line, in order to avoid the phenomenon known as "ratchet bounce".

"Ratchet bounce" is a phenomenon peculiar to retractable type fall arresters in which, in a fall arrest situation, the clutch repeatedly engages and disengages due to components in the load path, in particular the anchor, acting like a spring. When it occurs, ratchet bounce applies several fall arrests to the user who is lowered incrementally between bounces.

Some retractable type fall arresters are fitted with an anti-ratcheting clutch in order to overcome this effect. A retractable type fall arrester of this type should be used if it is to be connected to an anchor point that is flexible or springy in nature.

9.4 Fall arrest systems based on a vertical anchor line and a guided type fall arrester

9.4.1 ***General***

This type of fall arrest system has two basic components, a vertical anchor line and a guided type fall arrester that runs up and down the anchor line and locks onto it if the user falls. The anchor line can be either rigid e.g. a rail (often referred to as an "anchor rail"), or flexible, e.g. a wire rope, and spans the entire access route and/or work area.

A fall arrest system based on a rigid vertical anchor line provides a permanently installed means of fall arrest which is usually fixed to a permanently installed access ladder (see Figure 25).

A fall arrest system based on a flexible vertical anchor line can provide either a permanently installed or a temporary means of fall arrest. A permanently installed flexible anchor line is usually fixed to a permanently installed access ladder (see Figure 26). A temporarily installed flexible anchor line can be used to cover any broadly vertical access route (see Figure 27).

A fall arrest system based on a permanently installed rigid anchor line has the following advantages over a system based on a retractable type fall arrester.

— Once installed it is ready for use whenever it is needed without the need for installation above the work area prior to the work and taking down again afterwards, which can necessitate the use of a second means of personal fall protection while this is being done, as is the case with a retractable type fall arrester.

— It can be cover the entire length of the access route and/or the work area so there is no need to relocate the fall arrester during the work.

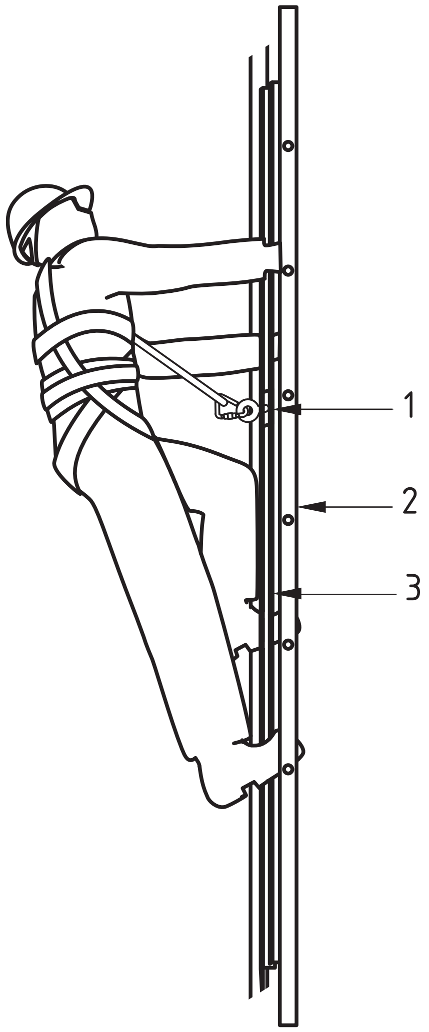
A fall arrest system based on a flexible anchor line has an important advantage over a system based on a retractable type fall arrester. A retractable type fall arrester has a fixed amount of line available for use, and if the structure to be climbed is of a greater height than this length, it means that the retractable type fall arrester has to be moved once its range is exhausted. A flexible anchor line can be as long as necessary and so enable work on taller structures without the need to relocate the system. Once the anchor line has been installed, any excess length can be left coiled on the ground.

Fall arrest systems based on a vertical anchor line and a guided type fall arrester have the following disadvantages.

— Movement on a rigid anchor line is confined to the vertical plane, although some horizontal movement is possible with flexible anchor line systems where the lower end is not fixed.

— Use of systems with a flexible anchor line is normally limited to those situations where the anchor point is overhead, as is the case with systems based on a retractable type fall arrester. As with these systems, this usually necessitates an initial climb to the intended anchor point with the anchor line whilst utilizing another form of fall protection.

— In the case of systems with a permanently installed anchor line it has to be possible for the guided type fall arrester to be got past the intermediate support brackets without detaching it from the anchor line.



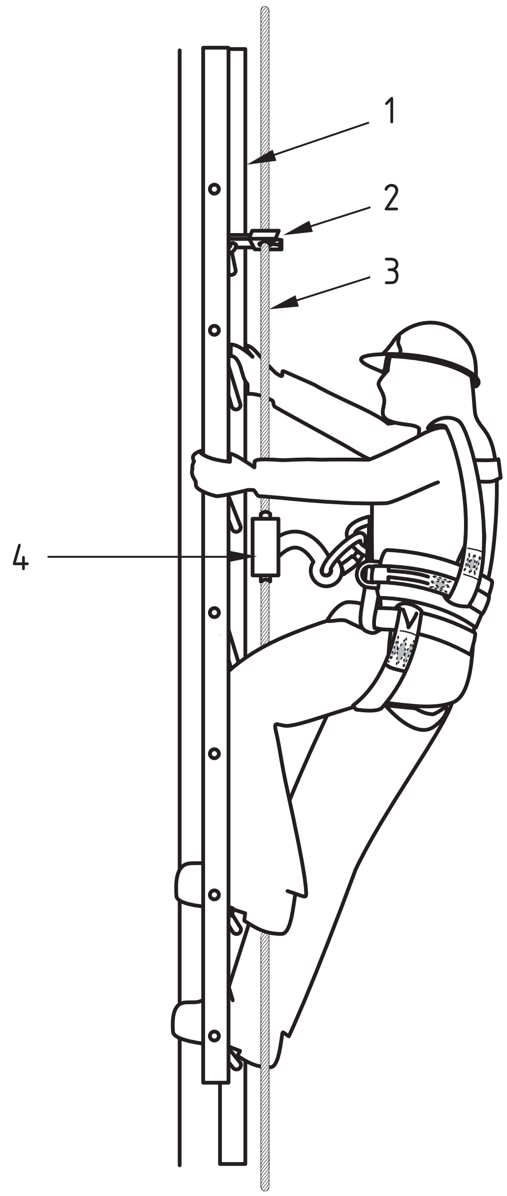
Key

1 Guided type fall arrester

2 Ladder

3 Rigid vertical anchor line

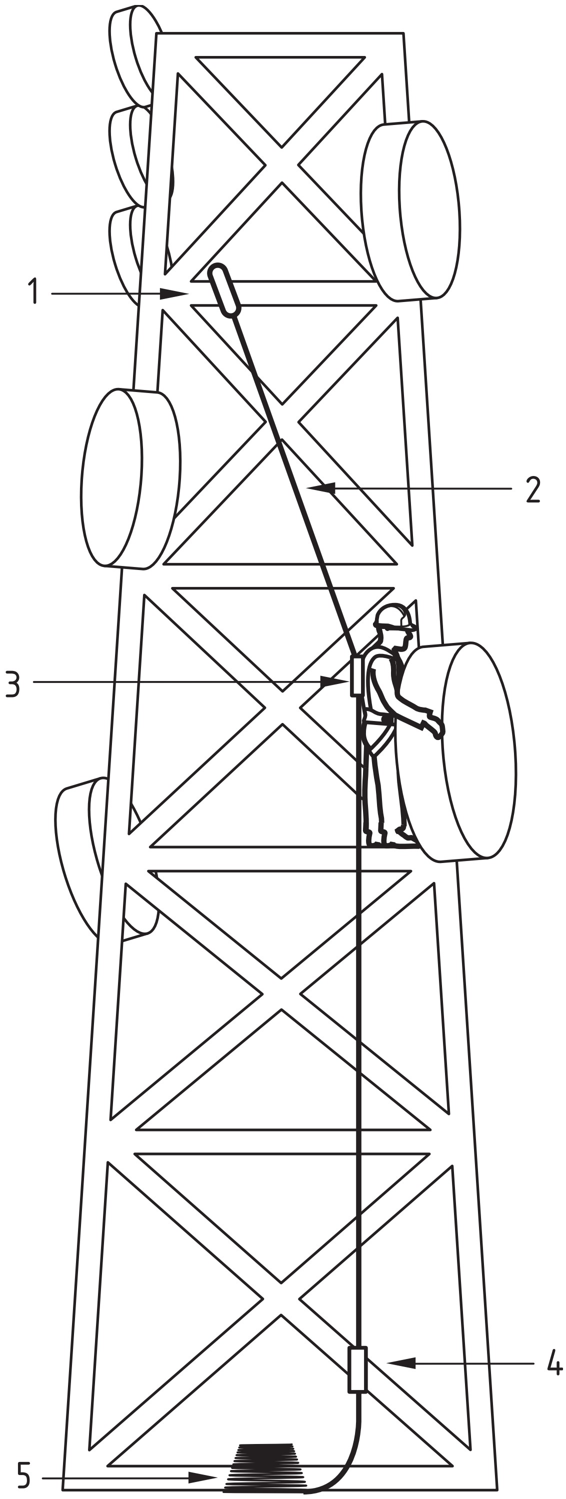
Figure 25 — Example of a fall arrest system based on a rigid vertical anchor line fixed to a permanently installed access ladder



Key

1 Ladder
2 Bracket
3 Permanently installed flexible vertical anchor line
4 Guided type fall arrester

Figure 26 — Example of a fall arrest system based on a permanently installed flexible vertical anchor line fixed to a permanently installed access ladder



Key

1 Upper anchor
2 Temporarily installed flexible vertical anchor line
3 Guided type fall arrester
4 Tensioning weight
5 Unused portion of anchor line

Figure 27 — Example of a fall arrest system based on a temporarily installed flexible vertical anchor line

9.4.2 *Permanently installed rigid vertical anchor lines*

A permanently installed rigid vertical anchor line usually comprises a rigid profiled rail consisting of a number of sections bolted together by joining plates and fixed at intervals by brackets to a permanently installed access ladder.

If a permanently installed rigid vertical anchor line is fixed to a permanently installed access ladder, the ladder should be of sufficient width to allow the anchor line to be mounted centrally on the ladder so as to enable the user to climb the ladder easily and prevent him or her being swung away from the ladder should they suffer a fall.

NOTE 1 Some rails are designed to be an integral part of a ladder, for example a ladder having a single, central stile which also houses the rail.

The guided type fall arrester (see **9.4.5**) is usually slid onto the bottom or top of the rail by aligning the mating feature in the fall arrester with the profile of the rail. Stops should be fitted to the ends of the rail, one on the bottom and one on the top, to stop the guided type fall arrester from accidentally running off.

NOTE 2 Ladders fixed to towers often run to structural platforms. Ladder runs and associated rigid anchor lines can be staggered at the platforms. The first run might reach the platform through a trap door arrangement and be discontinued at that point, next run starting at another point on the platform. In such cases the user needs to be able to fit the fall arrest device onto the rigid anchor line either at the bottom or at the top of a run.

In some situations it is necessary for the user to be able to leave the proximity of the rigid anchor line and move horizontally to a safe workplace, for example a workstation part-way up a structure. To do this the user needs to be able to remove the guided type fall arrester from the rigid anchor line.

For such situations rigid anchor lines should be used that have specially designed entry and exit fittings, guarded by a hinged gate with a locking mechanism, at appropriate points, to allow the fall arrester to be removed and refitted when necessary.

Alternatively, a guided type fall arrester incorporating such a fitting should be used.

9.4.3 *Permanently installed flexible vertical anchor lines*

A permanently installed flexible anchor line usually comprises a wire rope that is fixed at intervals by brackets to a permanently installed access ladder. The anchor line is tensioned by fixing the ends to an upper and a lower anchor.

If a permanently installed flexible vertical anchor line is fixed to a permanently installed access ladder, as in the case of a rigid anchor line, the ladder should be of sufficient width to allow the anchor line to be mounted centrally on the ladder so as to enable the user to climb the ladder easily and prevent him or her being swung away from the ladder should they suffer a fall.

The guided type fall arrester may be permanently fitted to the anchor line. Alternatively, an anchor line should be used which has a specially designed entry and exit fitting at the lower end to allow the guided type fall arrester to be put on and removed. Otherwise a guided type fall arrester incorporating such a fitting should be used.

9.4.4 *Temporarily installed flexible vertical anchor lines*

A temporarily installed flexible vertical anchor line usually comprises a fibre rope that is suspended vertically from an overhead anchor. The anchor line trails downwards following the access route, and a small weight is connected to the bottom to give it stability and to apply a small amount of tension.

The anchor line should be of sufficient length that when connected to the overhead anchor it allows the user to reach the whole of the intended work area without continually having to relocate the anchor line.

The guided type fall arrester may be permanently fitted to the anchor line or may be put onto the anchor line at the lower end before the stabilizing weight is attached. Alternatively a guided type fall arrester incorporating a specially designed entry and exit fitting should be used.

9.4.5 *Guided type fall arresters for use with vertical anchor lines*

A guided type fall arrester, also known as a “rope grab”, incorporates a mating feature which engages onto an anchor line and slides along it. It is fitted with a locking mechanism designed to lock the device onto the anchor line in the event of a fall. It also has a connector for attachment to the user’s harness.

The locking mechanism usually comprises a spring loaded lever, contained within the fall arrester, which bears upon and grips the anchor line, functioning as a “dead-man’s handle”. The spring is biased to return the lever to the locked-on position. While the user is climbing, the bias in the spring is overcome by upward or outward tension (depending on the design) in the connection between the fall arrester and the user's harness, allowing the fall arrester to slide up the anchor line with the user. In the event of a fall, the lever locks onto the anchor line, and arrests the fall. The user is brought to a complete stop and remains suspended to await rescue.

A guided type fall arrester is one type of anchor line device (see **12.10** and illustration in Figure 48).

NOTE 1 If the fall arrest system is installed on, or in close proximity to, a ladder or structure, in the event of a fall the user might be able to recover him or herself to a safe position.

A guided type fall arrester conforming to BS EN 353-1 or BS EN 353-2 should be used, as applicable.

The guided type fall arrester used should be one that includes an indication of the correct orientation of the fall arrester on the anchor line.

NOTE 2 This is essential because with some guided type fall arresters it would otherwise be possible to fit the fall arrester to the anchor line upside down, in which case it would not lock onto the anchor line in the event of a fall.

A useful safety feature is a means of indicating when the fall arrester has been used to arrest a fall.

The correct operation of some fall arresters can be prevented if the user grabs the fall arrester in a panic during a fall. It is therefore preferable for fall arresters to be used which function in such a way that this cannot happen.

In the case of permanently installed vertical anchor lines it has to be possible for the guided type fall arrester to pass the intermediate support brackets. Intermediate support brackets on vertical rails are mounted on the back of the rail, which allows the fall arrester to run freely without obstruction. Intermediate support brackets on wire rope anchor lines have to either totally or partially encircle the wire rope, which prevents the fall arrester passing these points.

One solution is to use brackets that act as retaining clips for the anchor line, so the user can pull the anchor line out of the clip and, after climbing past it, fit the anchor line back in. However, this is a nuisance for the user.

The best option is to use a specially designed fall arrester that can pass through the brackets without the need for unclipping of the anchor line.

9.4.6 *Use of fall arrest systems based on a vertical anchor line and a guided type fall arrester*

9.4.6.1 *Compatibility of the guided type fall arrester with the vertical anchor line*

It is essential to ensure that a guided type fall arrester is compatible with the anchor line with which it is to be used. Tests have demonstrated catastrophic system failure when particular fall arresters were used with types of rope with which they were not compatible. For example the sheath of a kernmantel rope has been stripped by a fall arrester with a strong locking-on grip.

In the case of permanently installed systems, generally guided type fall arresters from one manufacturer are not compatible with anchor lines from another manufacturer. In the case of temporarily installed systems, guided type fall arresters from one manufacturer often are compatible with anchor lines from another manufacturer. However, in both cases, advice should be sought from the manufacturers before items from different manufacturers are used together.

9.4.6.2 *Avoidance of delayed or non-activation of the locking mechanism*

9.4.6.2.1 *Environmental factors*

The operation of the locking mechanism of guided type fall arresters can be affected by environmental factors, especially extremes of cold, wet and dust. If a guided type fall arrester is to be used in particularly arduous conditions, the manufacturer should be consulted.

9.4.6.2.2 *Mechanical factors*

Vertical anchor lines with guided type fall arresters should not be used in situations where the working surface consists of loose granular materials, e.g. coal, sugar or pellets. In a fall situation caused by the slow collapse of the loose granular material, activation of the locking mechanism of the guided type fall arrester might not be triggered so the user could be immersed and asphyxiated. (See also Note to **9.3.7.2.2**.)

9.4.6.3 *Use of correct path for temporarily installed flexible anchor lines*

Where two or more users connected to temporarily installed flexible anchor lines are working in the same vicinity care should be taken to avoid the anchor lines crossing over one another.

9.4.6.4 *Use of vertical anchor lines by multiple users*

Multiple use of a permanently installed vertical anchor line carries risks. If two users climb the ladder in close proximity, then if the leading user falls, the lower user will almost certainly be knocked off the ladder also. In circumstances of multiple use, therefore, it is essential to ensure that there is always an adequate gap between users.

In the case of temporarily installed vertical anchor lines, in the event of a user suffering a fall, it is very likely to be a swing fall. In a multiple use situation, if one user falls the swinging action of the anchor line would tend to pull the other users attached to that anchor line off balance. In view of this, in situations where two or more users require personal fall protection each should be connected to a separate vertical anchor line.

9.4.6.5 *Length of connection between the fall arrester and the user's harness*

The length of the connection between the guided type fall arrester and the user's harness should not exceed the length of the connector supplied with the fall arrester or, if a connector is not supplied, should not exceed the length specified in manufacturer's instructions.

If a longer connection is used this will increase the free fall distance and the arrest force in the event of a fall, which could cause system failure or injury to the user, or both.

NOTE Incidents of this type have occurred in the past with fatal consequences.

Permanently installed vertical anchor lines are particularly prone to problems if a connection is used that is too long. It has been demonstrated that use of a connection of excessive length can interfere with operation of the fall arrester in the event of a fall, which can result in the user falling to the ground.

9.5 Fall arrest systems based on a horizontal anchor line and one or more travellers

9.5.1 *General*

A fall arrest system based on a horizontal anchor line and a traveller comprises either a rigid anchor line, e.g. a rail (often referred to as an "anchor rail"), or a flexible anchor line, e.g. a wire or textile rope, which spans the entire access route and/or work area, onto which is fitted a traveller, e.g. a trolley, which can slide along the anchor line.

The traveller has a means for connection of another fall arrest system, for example an energy absorbing lanyard, which, in turn, is attached to the user's harness.

A rigid horizontal anchor line and traveller provides a permanently installed mobile anchor point for the attachment of a fall arrest system. Such systems are tailor-made and are individually configured to suit the access route contours of the workplace and typically include bends and curves.

A system based on a flexible horizontal anchor line can provide either a permanently installed or a temporary mobile anchor point. A temporarily installed flexible horizontal anchor line can be installed to cover any straight line horizontal access route and its length can be adjusted, within the limits given by the manufacturer, to suit the workplace geometry.

Examples are shown in Figure 28, Figure 29 and Figure 30.

Fall arrest systems based on a horizontal anchor line have the following advantages.

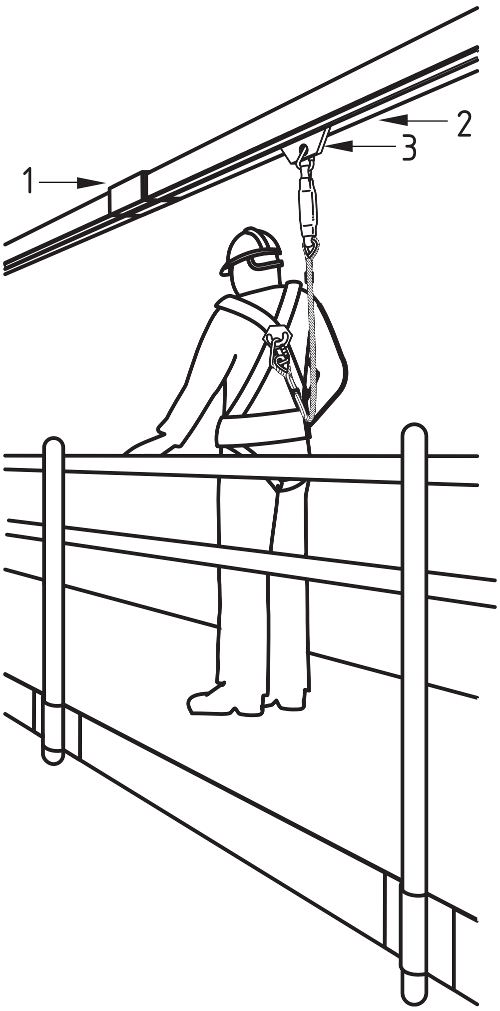
— Once a horizontal anchor line has been installed, it provides a continuous means of fall protection along the full length of the access route. This is an advantage over other methods of fall protection provision along a horizontal access route which require the repeated connection, disconnection and reconnection of two energy absorbing lanyards (see **9.2.2**).

— Subject to certain controls, a range of vertical movement can be provided by means of the other fall arrest equipment connected to the horizontal anchor line.

— Temporarily installed horizontal anchor lines can be utilised to bridge gaps and therefore provide fall protection where there is no intermediate supporting structure. The length of the anchor line can be varied, within the limits given by the manufacturer, to suit the particular span.

Fall arrest systems based on a horizontal anchor line have the disadvantage that temporarily installed horizontal anchor lines require use of an alternative means of fall protection during installation and removal.

Temporarily installed flexible, horizontal anchor lines with a single span have the disadvantage, compared with multi-span systems, that they are likely to require a greater amount of free space beneath the user to enable a fall to be arrested before the user hits the ground or other substantial object in the fall path, for example a part of the building (see **9.7**), and, in the event of a fall, are more likely to cause a swing fall situation (see **9.5.7.2**).



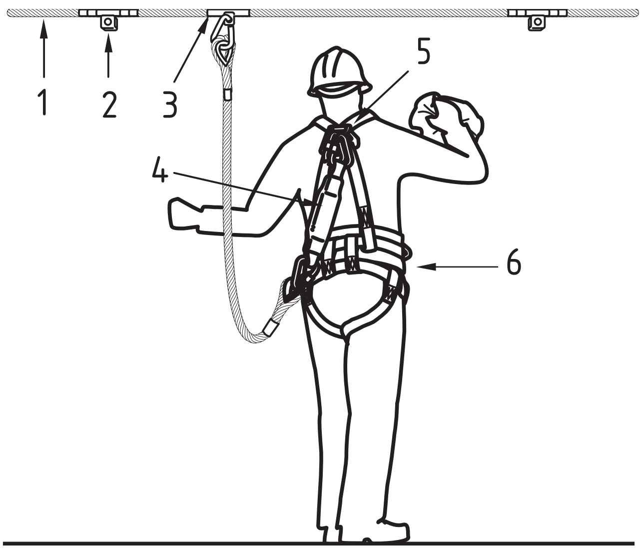
Key

1 Intermediate support

2 Horizontal rail

3 Traveller

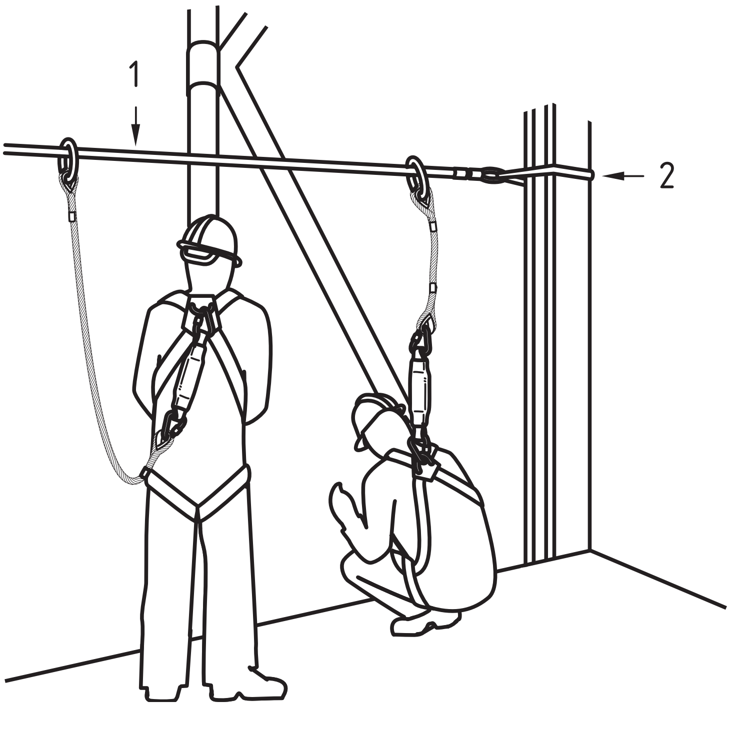
Figure 28 — Fall arrest system based on a permanently installed rigid horizontal anchor line comprising a rail



Key

1 Permanently installed flexible horizontal anchor line
2 Intermediate support bracket
3 Traveller
4 Energy absorbing lanyard
5 Connector
6 Full body harness

Figure 29 — Fall arrest system based on a permanently installed flexible horizontal anchor line comprising a wire rope



Key

1 Temporarily installed flexible horizontal anchor line
2 End anchor point

Figure 30 — Fall arrest system based on a temporarily installed flexible horizontal anchor line

9.5.2 *Permanently installed rigid horizontal anchor lines*

A permanently installed rigid horizontal anchor line usually comprises a rigid profiled rail consisting of a number of sections bolted together by joining plates, typically fixed at intervals to the structure by brackets.

The traveller (see **9.5.5**) is usually slid onto one end of the rail by aligning the mating feature in the traveller with the profile of the rail. Stops should be fitted to the ends of the rail to prevent the traveller from accidentally running off.

Alternatively, anchor lines should be used which have specially designed entry and exit fittings, guarded by a hinged gate with a locking mechanism, at appropriate points, to allow the traveller to be removed and refitted when necessary.

Otherwise, travellers incorporating such a fitting can be used.

9.5.3 *Permanently installed flexible horizontal anchor lines*

A permanently installed flexible horizontal anchor line usually comprises a wire rope held at intervals by brackets attached to the structure, and tensioned between two anchor points. Only the manufacturer's designated traveller should be used. This will either permit attachment/detachment at any point along the system or will have designated exit/entry points on the system.

9.5.4 *Temporarily installed flexible horizontal anchor lines*

A temporarily installed flexible horizontal anchor line usually comprises a fibre rope, wire rope or webbing construction that is tensioned between two anchor points. The anchor line may have intermediate supports.

NOTE A horizontal anchor line with intermediate supports is termed a "multi-span system" and one without intermediate supports a "single-span system".

A temporarily installed flexible horizontal anchor line should be of sufficient length to enable the user to reach the whole of the intended work area without having continually to relocate the anchor line.

9.5.5 *Travellers*

A traveller, e.g. a trolley, has a mating feature which engages onto an anchor line and runs along it. It also has an attachment point for connection of other fall arrest equipment which is in turn connected to the user's harness.

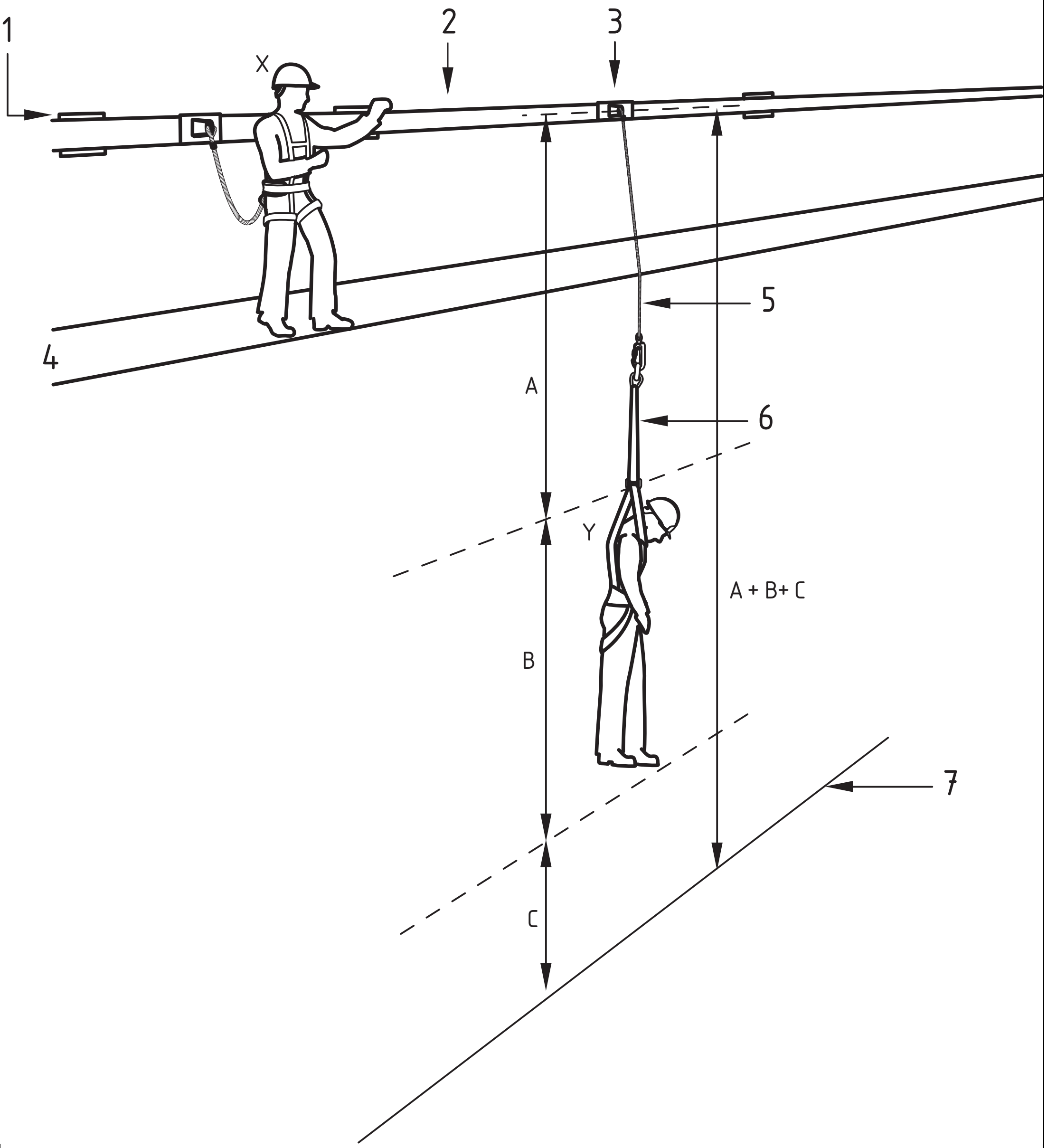
In the event of a fall, the resulting forces act in a direction perpendicular to the anchor line, so no locking device is required on the traveller.

In the case of a rail, the point at which the traveller is located acts as a fixed anchor point and the fall arrest forces act through this point (see Figure 31a). In the case of a wire or fibre rope, the region on which the traveller is located is deflected downwards into a characteristic "V"-shape, either between the anchor points in the case of a single-span system (see Figure 31b) or between the intermediate support brackets in the case of a multi-span system (see Figure 31c). In either case, the additional fall arrest equipment attached to the traveller arrests the fall. The user is brought to a complete stop and remains suspended to await rescue.

In addition to the fall arrest equipment attached to the traveller, in-line energy absorbing components may be fitted to the ends of the anchor line at the anchor points, and may also be fitted to intermediate anchor line supports.

The traveller used should have some means of preventing it from being incorrectly engaged onto the anchor line at either end or, in the case of a removable traveller, at any point on the anchor line.

In the case of permanently installed horizontal anchor lines it has to be possible for the traveller to pass the intermediate support brackets. Intermediate support brackets on horizontal rails are mounted to the back of the rail, which allows the traveller to run freely without obstruction. Intermediate support brackets on wire rope anchor lines have to either totally or partially encircle the wire rope, which might prevent the traveller passing these points. This problem should be overcome by the use of a specially designed traveller that can pass through the brackets without the need for disconnection of the traveller from the anchor line.



Key

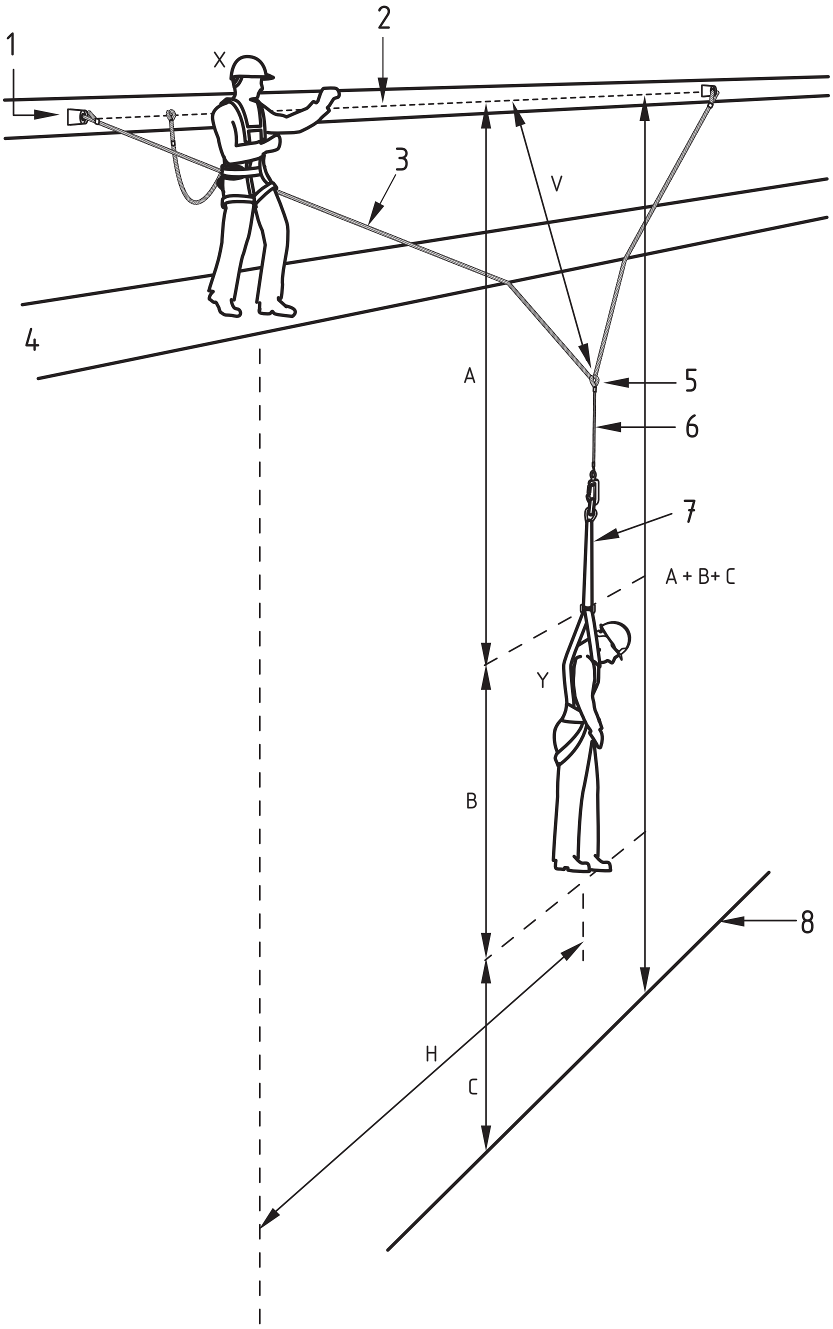
1 Intermediate support bracket
2 Anchor rail
3 Traveller
4 Walkway
5 Lanyard
6 Extended energy absorber
7 Ground level

A, B, C See Table F.4
X Position of user before fall
Y Position of user after fall

NOTE Drawing is not to scale.

a) System with a horizontal rail

Figure 31 — Examples of fall arrest systems based on a horizontal anchor line and an energy absorbing lanyard operating to arrest a fall, also illustrating free space requirements (see **9.7.5** and Annex F)



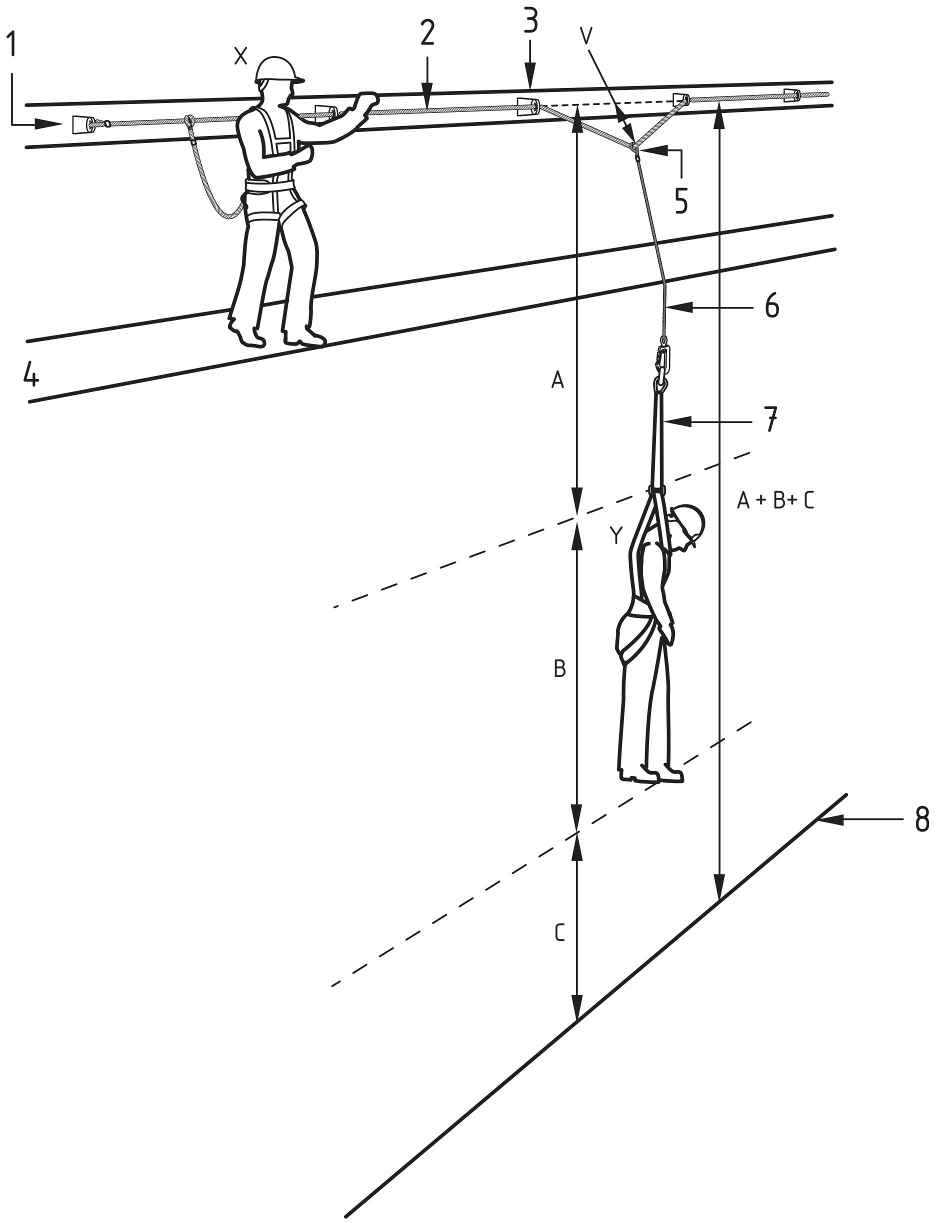
Key

1 End anchor
2 Position of anchor line prior to fall
3 Position of anchor line after fall
4 Walkway
5 Traveller
6 Lanyard
7 Extended energy absorber
8 Ground level
A, B, C See Table F.4
X Position of user before fall
Y Position of user after fall
V "V"-deflection of anchor line
H Horizontal displacement of user during fall

NOTE Drawing is not to scale.

b) System with a single span flexible horizontal anchor line

Figure 31 — Examples of fall arrest systems based on a horizontal anchor line and an energy absorbing lanyard operating to arrest a fall, also illustrating free space requirements (see **9.7.5** and Annex F) (*continued*)



Key

1 End anchor
2 Anchor line
3 Intermediate support bracket
4 Walkway
5 Traveller
6 Lanyard
7 Extended energy absorber
8 Ground level

A, B, C See Table F.4
X Position of user before fall
Y Position of user after fall
V "V"-deflection of anchor line

NOTE Drawing is not to scale.

c) System with a multi-span flexible horizontal anchor line

Figure 31 — Examples of fall arrest systems based on a horizontal anchor line and an energy absorbing lanyard operating to arrest a fall, also illustrating free space requirements (see **9.7.5** and Annex F) (*continued*)

9.5.6 *Use of fall arrest systems based on a horizontal anchor line and one or more travellers*

9.5.6.1 *Multiple use*

Multiple use, i.e. a situation in which two or more users are connected to the same anchor line at the same time, should only be permitted where manufacturer's instructions indicate that the anchor line is suitable for this. In such cases, the number of users should not exceed the maximum number indicated in the manufacturer's instructions. Where manufacturer's instructions do not make specific reference to multiple use, the manufacturer should be consulted. It should never be assumed that an anchor line is necessarily suitable for multiple use.

9.5.6.2 *Fall arrest equipment for attachment to a horizontal anchor line*

Only the fall arrest equipment specified in the anchor line manufacturer's instructions should be attached to a horizontal anchor line.

Fall arrest systems based on a horizontal anchor line are designed as unique configurations for each workplace in conjunction with the fall arrest equipment (usually an energy absorbing lanyard) intended for attachment to them. Calculations of system performance are based on the characteristics of the anchor line together with those of the fall arrest equipment. If the latter is altered, these calculations might no longer be valid. Attachment of longer lengths or different types of fall arrest equipment than that specified in the manufacturer's instructions could cause system failure or injury to the user, or both, in a fall arrest situation. Fall arrest equipment other than that specified in the manufacturer's instructions should never be used without consultation with the manufacturer and/or installer. For example, if longer lanyards are to be used the anchor line might need to be moved, and use of different lanyards might mean there is a need for stronger anchors.

NOTE Certain kinds of fall arrest equipment with locking mechanisms might be incompatible with horizontal anchor lines. For example, certain kinds of retractable type fall arresters are not recommended because of the phenomenon of ratchet bounce (see **9.3.7.7**).

9.5.6.3 *Attachment of fall arrest equipment to a horizontal anchor line*

Generally, attachment of fall arrest equipment to a horizontal anchor line should be made by connecting it to the traveller by means of a connector (see **12.5**). The fall arrest equipment should not be connected directly to the anchor line unless the manufacturer's instructions clearly specify this. In such a case only the connector specified in the manufacturer's instructions should be used.

NOTE Accidents and near-accidents have occurred when connectors have become weakened as a result of wear from an anchor line. In other situations, the concentrated stress on an anchor line caused by localised loading through a connector has resulted in anchor line failure.

Travellers from one manufacturer should not be used with anchor lines from another manufacturer. In particular, the type of anchor line used in conjunction with a particular traveller should be strictly in accordance with the traveller manufacturer's instructions. Similarly, different models of traveller from the same manufacturer should not be used interchangeably without written agreement from the manufacturer.

9.5.7 *Particular considerations when using single-span temporarily installed horizontal anchor lines*

9.5.7.1 *Installation*

Installation should only be carried out by trained personnel and it is essential that it is carried out strictly in accordance with the manufacturer's installation instructions.

NOTE 1 A case has occurred where insufficient tension was applied to the anchor line, even though it assumed a near horizontal position after installation. In on-site testing, using two test weights attached via lanyards to the anchor line, which were raised and released to simulate a two-user simultaneous fall, excessive "V"-deflection in the anchor line resulted in the test weights impacting the ground.

Correct connection of the anchor line to the anchors, via connectors, is critical and connections should only be made as specified in the manufacturer's instructions (see **12.5** and Clause **16**).

Connection of anchor lines to structural anchors which have sharp or abrupt edges should be avoided, because passing the anchor device, for example an anchor sling, over or around such edges, e.g. girder flange edges, can have a weakening effect on it. If it is necessary to connect the anchor line to such a structure anchor devices should be used which are resistant to failure in such situations.

Only the method of tensioning the anchor line specified in the manufacturer's installation instructions should be used during the installation process. Use of other methods of tensioning could damage the anchor line or cause it to lose tension.

NOTE 2 An incident has occurred where an inappropriate tensioning mechanism was used to tension an anchor line. During fall arrest testing with a test weight the tensioning mechanism released the tension in the anchor line in a series of incremental steps, giving rise to "ratchet bounce" as described in **9.3.7.7**.

9.5.7.2 *Swing fall risks*

There is a potential for swing falls when single-span temporarily installed horizontal anchor lines are used. If a user falls whilst at a position between the end of the anchor line and mid-span (see Figure 31b), there is a tendency for the traveller to be pulled down towards the bottom of a "V"-shaped deflection in the anchor line.

NOTE 1 The extent to which this occurs depends on an number of factors including the design of the traveller and anchor line, the tension in the anchor line, the friction between the traveller and the anchor line, the maximum distance between the two most widely spaced adjacent support brackets, and the horizontal distance between the traveller and the mid-span point at the time of the fall.

Movement of the traveller into the "V"-shaped deflection has a horizontal component as well as a vertical one, as shown in Figure 31b. The horizontal displacement of the traveller imparts a horizontal momentum to the user and when the traveller reaches the bottom of the "V"-shaped deflection this momentum causes the user's movement to continue with a swinging action in the horizontal plane. This puts the user at risk of colliding with the surrounding structure with a high impact velocity. It is essential, therefore, before installing such as system, to assess the potential hazard of a horizontal swing fall causing the user to collide with the surrounding structure.

NOTE 2 Multi-span systems are much less likely to cause swing fall problems owing to the anchor line being supported at intermediate positions and hence having a series of shorter spans (see Figure 31c). To limit swing falls, single-span systems should be installed with the smallest possible span.

NOTE 3 The risk of swing falls is greater in cases of multiple use. If two users attached to the same single span horizontal anchor line both fall, with a time interval between their falls, then a "V"-deflection in the anchor line is produced by the fall of the first user, and the second user's traveller will slide rapidly down this so their horizontal momentum will be greater, increasing their risk of a swing fall. There is also the additional risk of the users being injured by colliding with each other.

9.5.7.3 *Multiple use*

A disadvantage of multiple use of a single-span temporarily installed horizontal anchor line is that, where there are two users, and particularly where they are in close proximity, if one of them falls the resulting "V"-shaped deflection generated in the anchor line can pull the second user off balance and hence cause an additional fall.

NOTE In this situation the second user suffers a longer free fall due to the deflection of the anchor line from its original position.

9.6 Use of fall arrest systems

9.6.1 *General*

It is essential that a fall arrest system is always used in accordance with the manufacturer's instructions.

9.6.2 *Checking system limitations*

Checking system limitations and compatibility is a critical aspect of determining whether a particular fall arrest system design is capable of safely arresting a fall. It is essential that any limitations, compatibility criteria and recommendations given by the manufacturer are strictly adhered to. If a fall arrest system is used outside the manufacturer's limitations or in situations not covered by the manufacturer's recommendations the performance of the system cannot be predicted with any certainty. Such use could have the following consequences in the event of a fall:

— an excessive arrest distance, i.e. insufficient free space between the user and the ground to allow the fall arrest to take place safely, resulting in the user striking the ground or other substantial surface before the arrest is completed;

— an excessive arrest force, resulting in the user suffering internal injury or the fall arrest system itself failing, causing separation of the user from the system and a subsequent fall to the ground;

— localized overstressing of components of the fall arrest system, causing mechanical failure; for example, an incompatible connector might fail causing separation of the user from the system and a subsequent fall to the ground.

9.6.3 *Use of systems by users with different body masses*

9.6.3.1 *Users with a mass greater than 100 kg*

Use of a fall arrest system should be limited so that the manufacturer's limit for the total mass of the user is not exceeded. This is usually 100 kg (220 lb) for a single user (see Note 1) and includes clothing and equipment. In cases where the body mass of the potential user exceeds the manufacturer's limit the fall arrest system should not be used until the manufacturer has been consulted for advice. The manufacturer might be able to offer specific energy absorbers appropriate to the user's mass, or a system with a smaller fall arrest distance. Exceeding the manufacturer's limit could generate excessive arrest force and arrest distance levels or system failure in fall arrest situations and should never even be contemplated.

NOTE 1 The test methods for dynamic performance of the components of a fall arrest system given in BS EN 355, BS EN 360, BS EN 353 and BS EN 795, and in the test method standard BS EN 364, simulate a fall by dropping a 100 kg steel weight. The dynamic performance specified in these standards is a minimum. The use of 100 kg is based on published data which show that 95 % of the adult male population of the UK have a mass of up to 95 kg, without clothes, so in theory the test method encompasses the majority of likely users of fall arrest systems. However, there can be cases where the mass of the user and their equipment is significantly in excess of 100 kg. Because the relationship between the dynamic performance of the system and the force to which it is subjected is not necessarily linear, it would be dangerous to extrapolate from the dynamic performance values obtained with a 100 kg weight to obtain dynamic performance values for the system when subjected to the force from a larger weight. Because of this, some manufacturers test their fall arrest systems with larger test weights, for example up to 136 kg.

NOTE 2 A retractable type fall arrester with an integral rescue facility might also have a maximum rating in terms of the mass of an individual that can be raised or lowered.

9.6.3.2 *Users with a mass less than 80 kg*

In cases where the mass of the potential user is less than 80 kg the fall arrest system should not be used until the manufacturer has been consulted for advice. The manufacturer might be able to offer specific energy absorbers appropriate to the user's mass. A mass less than 80 kg might not be sufficient to activate a standard energy absorber. This could result in the failure of the energy absorber to deploy or an excessive arrest force on the user, in the event of a fall.

9.7 Free space

9.7.1 *General*

When a fall arrest system is used, it is essential to ensure that adequate free space is provided to enable a fall to be arrested before the user hits the ground or other substantial object in the fall path, for example a part of the building. The free space requirement should be calculated by adding together the parameters given for the relevant type of fall arrest system in **9.7.2** to **9.7.5**.

NOTE Examples of these calculations, strictly for illustration purposes only, are given in Annex F.

The calculated free space requirement should be compared with the actual free space available measured from the upper datum point. If the available free space is less than the free space requirement, the system should not be used.

WARNING. A fall arrest system should never be used in a situation where there is insufficient free space available.

9.7.2 *Systems based on a single fixed anchor and an energy absorbing lanyard*

For a system based on a single fixed anchor and an energy absorbing lanyard, the following distances should be added up, taking the anchor point and ground level as the datum points (see Figure 32):

a) length of the lanyard plus length of the extended energy absorber as given in the manufacturer's information, allowing for the mass of the intended user;

NOTE 1 If the mass of the intended user is greater or less than that used by the manufacturer to calculate the length of the extended energy absorber as given in the manufacturer's information (which is normally 100 kg), the manufacturer should be consulted (see **9.6.3**).

b) harness stretch distance plus distance between the connection point of the lanyard on the harness and the user's feet;

NOTE 2 The distance recommended to take these two factors into account is 2.0 m.

c) safety clearance, as recommended by the manufacturer.

NOTE 3 The distance usually recommended for safety clearance is 1.0 m.

NOTE 4 An example is shown in Table F.1.

9.7.3 *Systems based on a retractable type fall arrester*

For a system based on a retractable type fall arrester the following distances should be added up, taking the surface on which the user is to be standing and ground level as the datum points (see Figure 33):

a) free fall distance plus brake operation distance plus harness stretch distance; plus

b) safety clearance, as recommended by the manufacturer.

NOTE 1 The distance usually recommended for safety clearance is 1.0 m.

NOTE 2 An example is shown in Table F.2.

9.7.4 *Systems based on a vertical anchor line (rigid or flexible) and a guided type fall arrester*

For a system based on a vertical anchor line (rigid or flexible) and a guided type fall arrester the following distances should be added up, taking the surface on which the user is to be standing and ground level as the datum points (see Figure 34):

a) free fall distance, plus fall arrester operation distance, plus length of extended energy absorber (if included in the system) plus anchor line extension distance (in the case of a flexible anchor line), plus harness extension distance; plus

b) safety clearance, as recommended by the manufacturer.

NOTE 1 The distance usually recommended for safety clearance is 1.0 m.

NOTE 2 An example is shown in Table F.3.

NOTE 3 In temporarily installed vertical anchor line systems the anchor line extension distance might have to be calculated from the rope manufacturer's data especially where significant lengths of anchor line are being used at the workplace. This is because anchor line lengths used for dynamic testing at test establishments are limited by the height of the building in which testing is carried out.

9.7.5 *Systems based on a horizontal anchor line and traveller and an energy absorbing lanyard*

For a system based on a horizontal anchor line and traveller and an energy absorbing lanyard the following distances should be added up, using the anchor line level and ground level as the datum points (see Figure 31):

a) length of lanyard, plus length of extended energy absorber, plus "V"-deflection of anchor line (if a flexible anchor line is used); plus

b) harness stretch distance, plus distance between the connection point of the lanyard on the harness and the user's feet;

c) safety clearance, as recommended by the manufacturer.

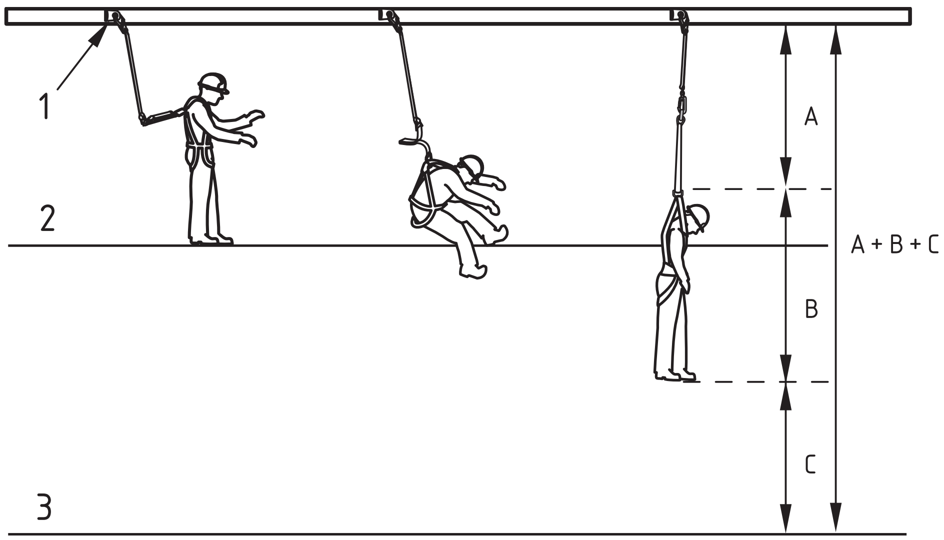
NOTE 1 The distance usually recommended for safety clearance is 1.0 m.

NOTE 2 An example is shown in Table F.4.

9.7.6 *Effect of the body mass of the users*

In single-user systems the greater the body mass of the user the more the energy absorber has to extend or the anchor line has to pull out in order to arrest a fall and so the greater the free space requirement. If a system is to be used by a user with a body mass in excess of 100 kg, the manufacturer should be consulted (see **9.6.3.1** and **9.7.2**).

In a multi-user system, for example a system based on a horizontal anchor line, the greater the body mass and number of users, the larger the deflection of the anchor line in the event of a fall and the greater the free space requirement. If a system is to be employed by multiple users the manufacturer should be consulted.



Key

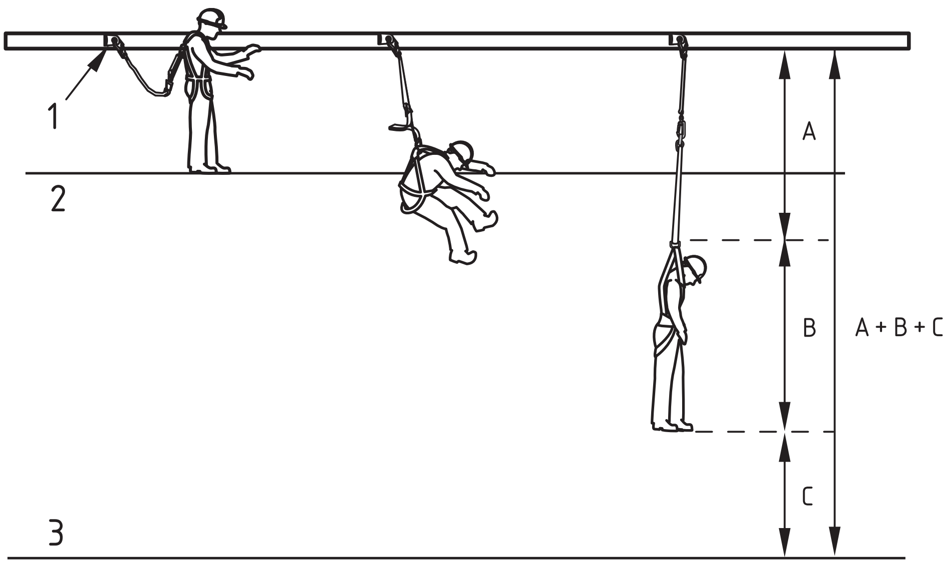
1 Anchor point   3 Ground level   A, B and C see Table F.1

2 Walkway

NOTE 1 This is the preferred situation, with the anchor point above the user and with minimal slack in the lanyard. The free space requirement is minimized and in the event of a fall the user might be able to get back onto the walkway.

NOTE 2 This drawing and Table F.1 are for illustration only and the drawing is not strictly to scale.

a) Anchor point above user



Key

1 Anchor point   3 Ground level   A, B and C see Table F.1

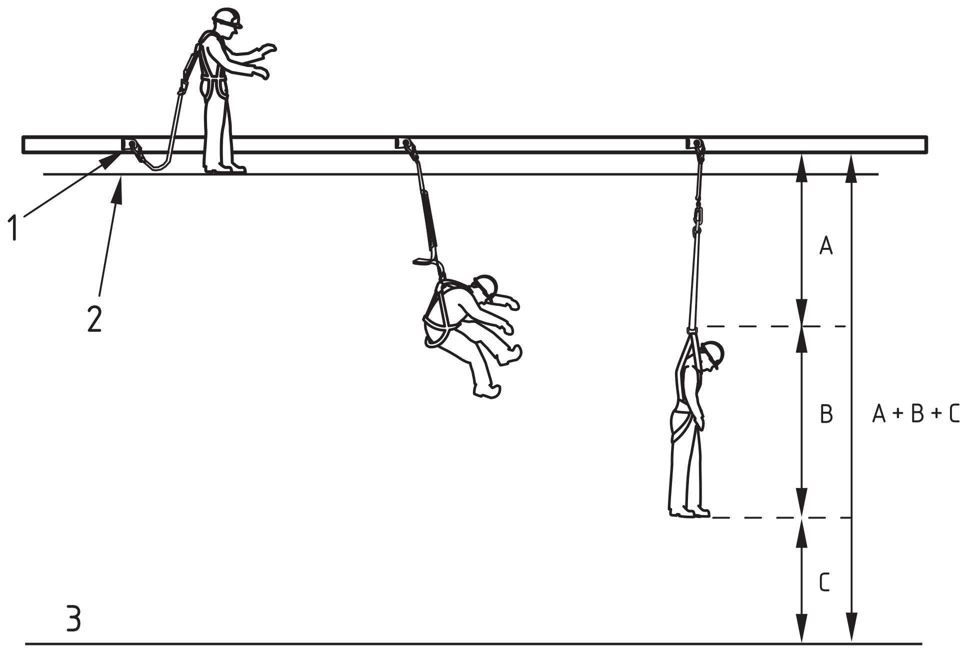
2 Walkway

NOTE 1 This situation, with the anchor point at shoulder level, comes next in the order of preference after that shown in Figure 32a). A larger free fall distance results in an increased free space requirement.

NOTE 2 This drawing and Table F.1 are for illustration only and the drawing is not strictly to scale.

b) Anchor point at shoulder level

Figure 32 — Illustration of minimum free space requirements when using a fall arrest system based on an energy absorbing lanyard



Key

1 Anchor point 3 Ground level A, B and C see Table F.1

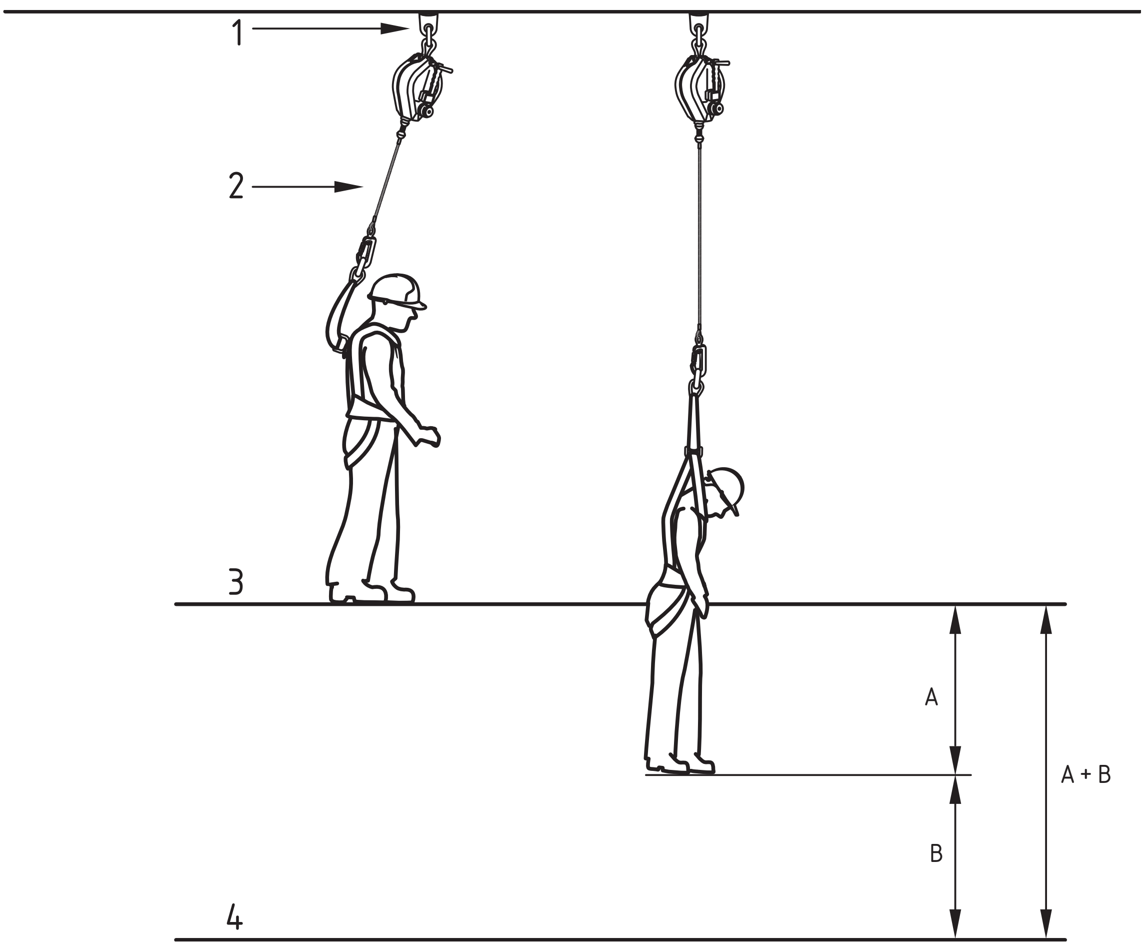
2 Walkway

NOTE 1 This is the least preferred anchor point position and should only be used as a last resort. In this situation the free space requirement is at its greatest.

NOTE 2 This drawing and Table F.1 are for illustration only and the drawing is not strictly to scale.

c) Anchor point at foot level

Figure 32 — Illustration of minimum free space requirements when using a fall arrest system based on an energy absorbing lanyard (*continued*)

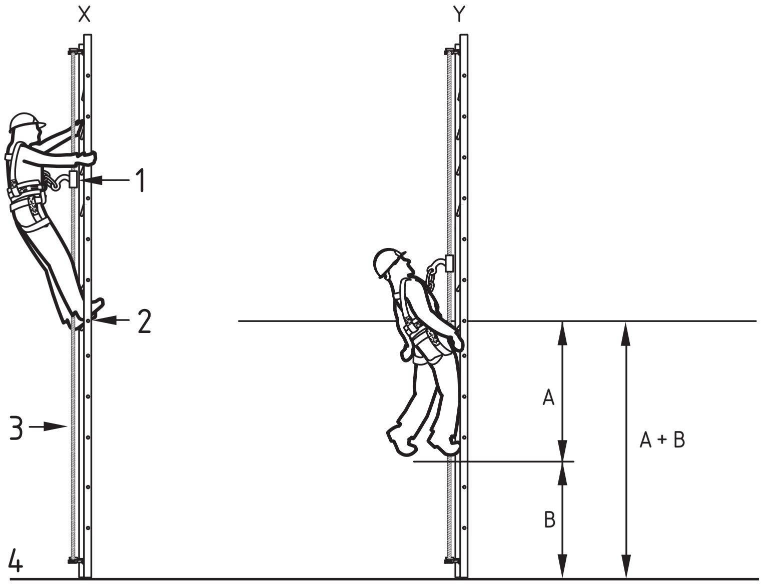


Key

1 Anchor
2 Retractable lanyard
3 Walkway
4 Ground level
A and B see Table F.2

NOTE This drawing and Table F.2 are for illustration only and the drawing is not strictly to scale.

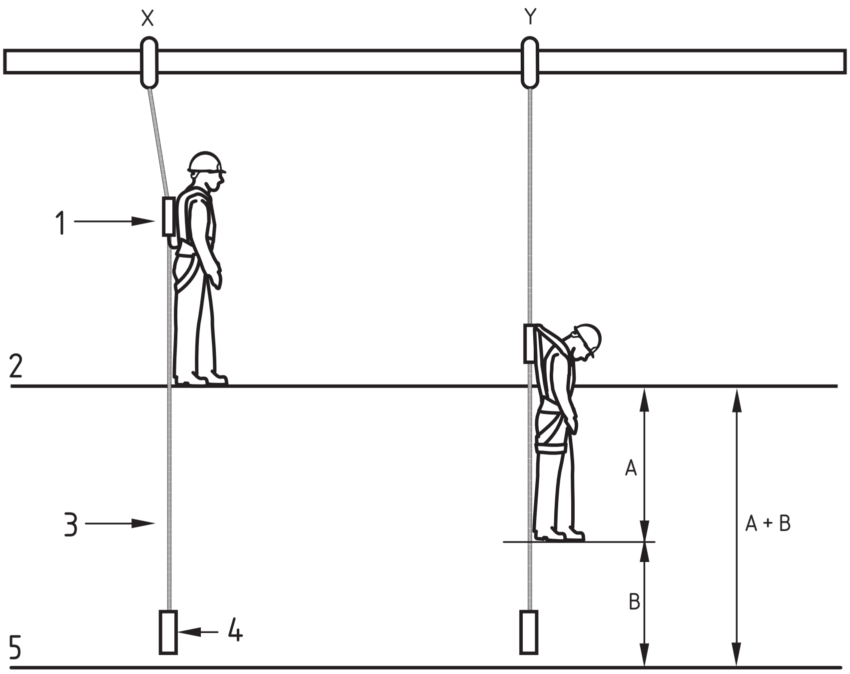
Figure 33 — Illustration of minimum free space requirement when using a fall arrest system based on a retractable type fall arrester



Key

1 Guided type fall arrester
2 Position of user's foot on rung of ladder
3 Rigid vertical anchor line
4 Ground level
X User's position before fall
Y User's position after fall
A and B see Table F.3

a) System with a rigid vertical anchor line



Key

1 Guided type fall arrester
2 Walkway
3 Flexible vertical anchor line
4 Tensioning weight
5 Ground level
X User's position before fall
Y User's position after fall
A and B see Table F.3

b) System with a flexible vertical anchor line with an upper anchor

NOTE These drawings and Table F.3 are for illustration only and the drawings are not strictly to scale.

Figure 34 — Illustration of minimum free space requirement when using a fall arrest system based on a vertical anchor line

10 Work positioning systems

10.1 General

Work positioning systems can be classified into two main types:

— systems that provide partial support for the user, i.e. the user is supported in tension, part of the user's weight being supported by the work positioning system and the remainder by the surface on which the user is standing (see **10.2**);

— systems that provide complete support to the user, i.e. the user is in suspension and their weight is fully supported by the work positioning system (see **10.3**).

10.2 Work positioning systems for partial support

10.2.1 *General*

There are two different techniques for work positioning in a partially supported position and a different work positioning system is needed for each. Technique 1 is used in the case of a vertical structure around which a lanyard can be passed (see **10.2.2**) and technique 2 is used in the case of a sloping structure, for example a roof (see **10.2.3**).

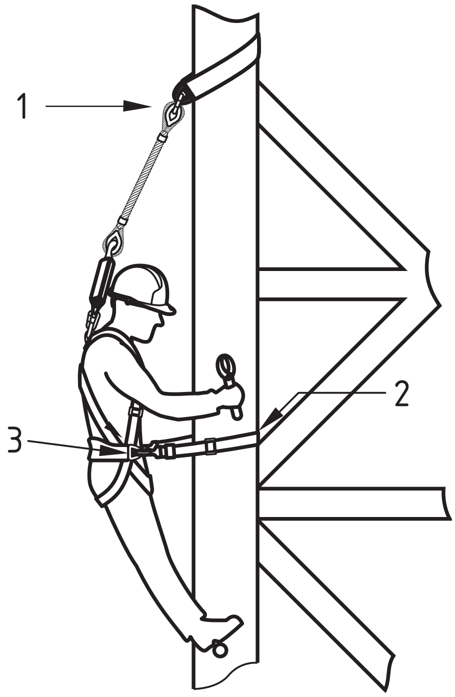
NOTE Methods of work using work positioning systems for partial support are given in Annex G.

10.2.2 *Technique 1*

10.2.2.1 Technique 1 entails passing a work positioning lanyard (often known as a pole strap) around the structure and connecting it to the two side waist attachment points or a central abdominal attachment point on the user's harness (see Figure 35). This allows the user to lean backwards in a partially supported position, with their feet braced against the structure and with their hands free for work. An independent safety back-up personal fall protection system is also attached to the structure. An example is shown in Figure 35.

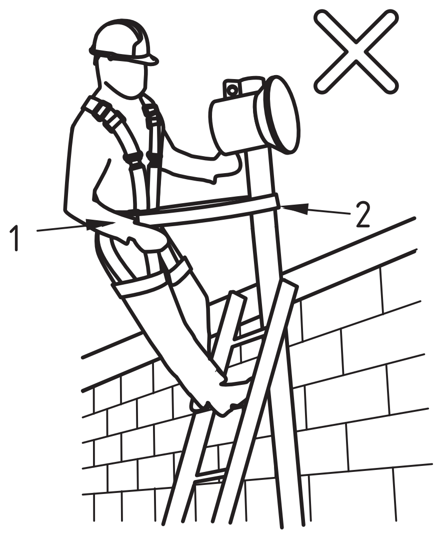
The work positioning lanyard alone should not be relied upon to arrest a fall, because its energy absorbing capacity might not be sufficient and so the impact forces on the user in the event of a fall might be too high. Also, the work positioning lanyard might be cut by the structure, causing it to break. This is why it is essential for the user also to be connected to a safety back-up personal fall protection system.

NOTE Figure 36, shows a user attached to a work positioning lanyard, but without a safety back-up fall protection system. In this situation, if a fall were to occur, the lanyard would slip down the pole until it was stopped by the top of the wall, and the user would continue falling until stopped by the work positioning lanyard. This would probably entail a free fall of around 1.0 m and would apply significantly high arrest forces, possibly in the region of 10 kN to the side waist harness attachment points. In this situation the shoulder and leg straps would not take any of the arrest forces, all of which would be applied to the user's body by the waist belt of the harness. This could produce serious if not fatal injuries.



Key
1 Safety back-up personal fall protection system attached to structure
2 Work positioning lanyard looped round the structure
3 Work positioning lanyard attached to side waist attachment points on user's harness

Figure 35 — Partially supported work positioning technique 1



Key
1 Work positioning lanyard attached to side waist attachment points on user's harness
2 Work positioning lanyard looped round pole

NOTE The user had the mistaken belief that the work positioning system would arrest a fall should one occur.

Figure 36 — Illustration of a real situation showing incorrect use of a work positioning lanyard without a safety back-up personal fall protection system

10.2.2.2 A work positioning system for technique 1 should comprise the following components:

— a full body harness (see **12.6**);

NOTE If a rope access system is used for this technique the body holding device needs to be that recommended in BS 7985.

— an adjustable work positioning lanyard which is passed around the structure (see **10.2.4.1** and **12.7**);

— connectors, for joining the work positioning lanyard to the harness (see **10.2.4.1** and **12.5**);

— an independent back-up personal fall protection system, e.g. a fall arrest system based on an energy absorbing lanyard, to protect the user in the event of the work positioning lanyard slipping or failing, or a fall occurring while work is being undertaken.

10.2.3 ***Technique 2***

10.2.3.1 Technique 2 is used in applications such as work on a relatively steep or slippery roof with no safe footholds. Technique 2 entails attaching an anchor line to an anchor point above the user and attaching the other end to a central abdominal attachment point on the user's harness. This allows the user to stand and lean back in a partially supported position, with their hands free for work (see Figure 37a and Figure 37b, views A and B). An independent safety back-up personal fall protection system is attached to a separate anchor point as shown in Figure 37a.

10.2.3.2 In a situation where it is not possible to have an anchor point above the user or to have the work positioning anchor line without slack, a work positioning system should not be used. In such a situation a fall arrest system is needed.

10.2.3.3 A work positioning system does not prevent the user from falling from a standing to a prone position (known as a "fall on the level"), see Figure 37b, views C and D.

10.2.3.4 A work positioning system for technique 2 should comprise the following components:

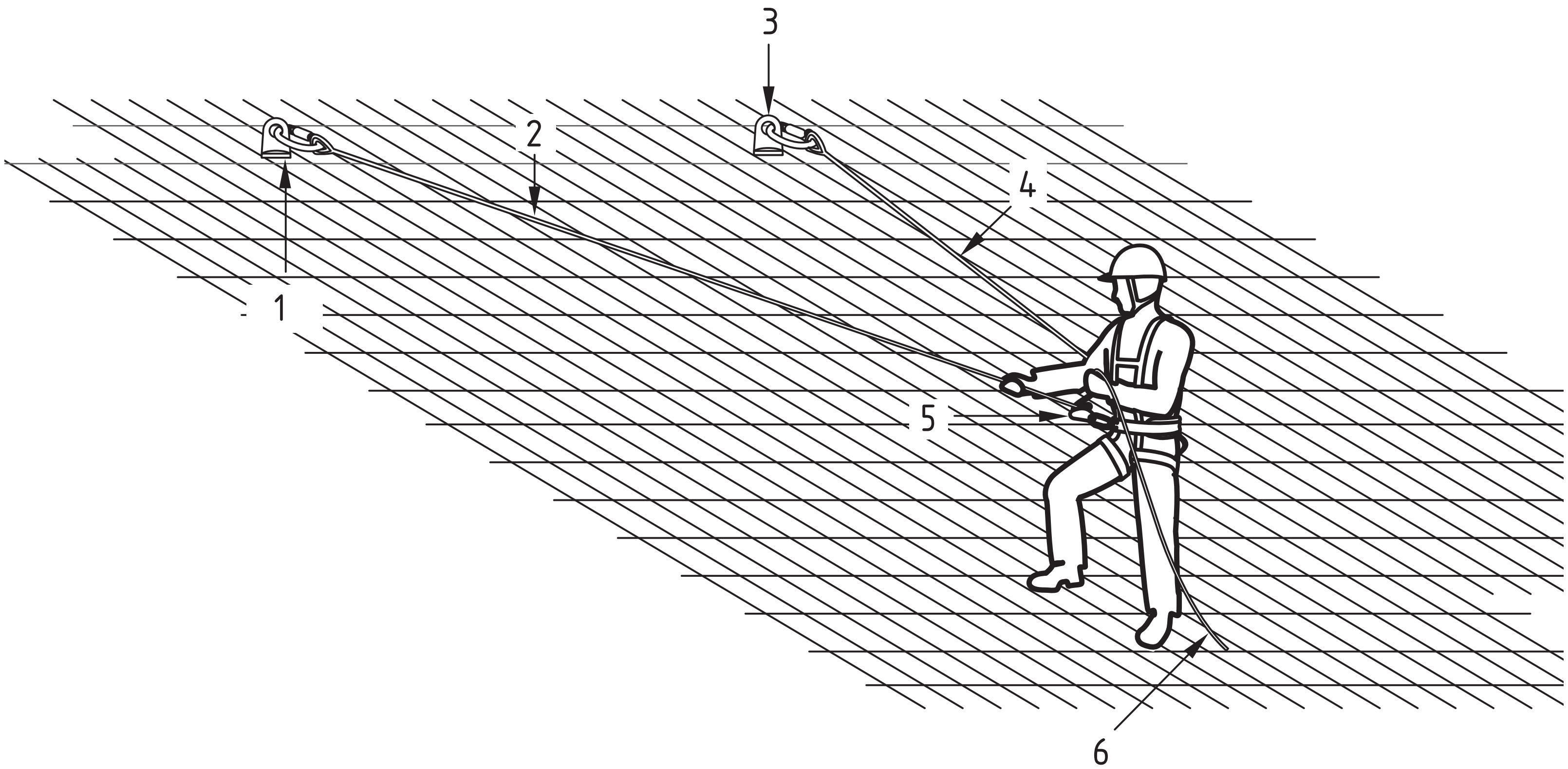
— a body-holding device, e.g. a full body harness or a sit harness, with a central abdominal attachment point (see **12.6**);

— an anchor point or anchor points, installed in such a way that the anchor lines reach the user from above the work area;

— an adjustable anchor line which is attached to the anchor point and is long enough to reach from the anchor point to the user in the work area;

— connectors and/or lanyards, for joining the anchor line to the anchor point and to the user's body-holding device;

— an independent back-up personal fall protection system, e.g. a fall arrest system based on a guided type fall arrester on a flexible anchor line.



Key

1 Anchor

2 Anchor line

3 Second anchor for safety back-up personal fall protection system

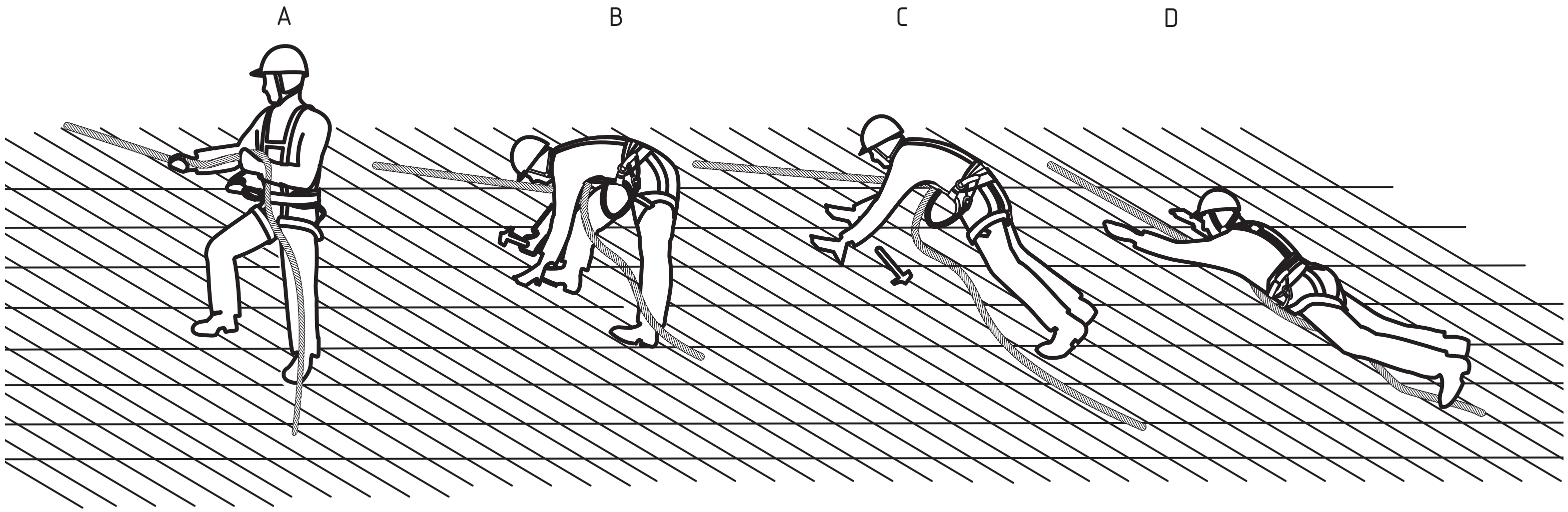
4 Anchor line of safety back-up personal fall protection system

5 Adjustment device

6 Spare length of anchor line

a) User attached to work positioning anchor line and anchor line of safety back-up personal fall protection system

Figure 37 — Partially supported work positioning technique 2



Key

A User supported by work positioning system

B User working

C User slips

D User suffers a fall on the level

NOTE Back-up personal fall protection system not shown for clarity.

b) User in position to carry out work, and suffering a "fall on the level"

Figure 37 — Partially supported work positioning technique 2 (*continued*)

10.2.4 ***Selection of components for work positioning systems for partial support***

10.2.4.1 *Work positioning lanyards and connectors for technique 1*

A work positioning lanyard conforming to BS EN 358 should be used, which comprises an adjustment device threaded onto a length of rope or webbing (see Figure 38), to allow adjustment of the length of the lanyard; the lanyard being terminated at one end with an integral connector and finished at the other with a stop that prevents it from being pulled right through the adjuster.

Lanyards used for work positioning technique 1 should be of more substantial material than normal lanyards because they are vulnerable to wear where they pass around the support structure. For example, rope lanyards should be made of large diameter rope, e.g. in the range 11 mm to 16 mm diameter, the larger the better. To provide additional protection against wear, lanyards fitted with protective sleeves should be used. The protective sleeve should be of a design that assists gripping to the support structure when the lanyard is looped around it. The work positioning lanyard used should be long enough to pass around the support structure.

NOTE BS EN 358 specifies a maximum length of 2 m for integral and detachable work positioning lanyards, but does not specify a maximum length for what it calls detachable (and independent) work positioning lanyards.

The work positioning lanyard should not be unduly difficult to adjust. Preferably it should be possible to adjust it with one hand. Adjustment devices on ropes tend to be easier to adjust in use than adjustment buckles on webbing.

Connectors used with work positioning lanyards for technique 1 usually need to be connected and disconnected several times over the course of the work. Therefore, connectors should be used which are easy to unlatch and re-latch while not being prone to accidental disengagement. Connectors of the automatic closing and automatic locking type are recommended.

10.2.4.2 *Work positioning anchor lines for technique 2*

Work positioning anchor lines for technique 2 should be suitably terminated at one end for a connector, to enable the anchor line to be attached to a suitable anchor point or points. The other end of the anchor line should be finished with a stop to prevent the rope adjustment device from being pulled off the anchor line inadvertently.

NOTE A typical work positioning anchor line for technique 2 is similar to that shown in Figure 38, but longer, having to reach from the anchor point to the work area, and is not normally fitted with a protective sleeve. It consists of a rope adjustment device connected to an anchor line, which travels with the user and which allows movement in one direction and grips the anchor line in the other (also known as a "rope grab"). This arrangement allows the distance between the user and the anchor point to be varied while the anchor line remains under tension, thus effectively adjusting the length of the anchor line.

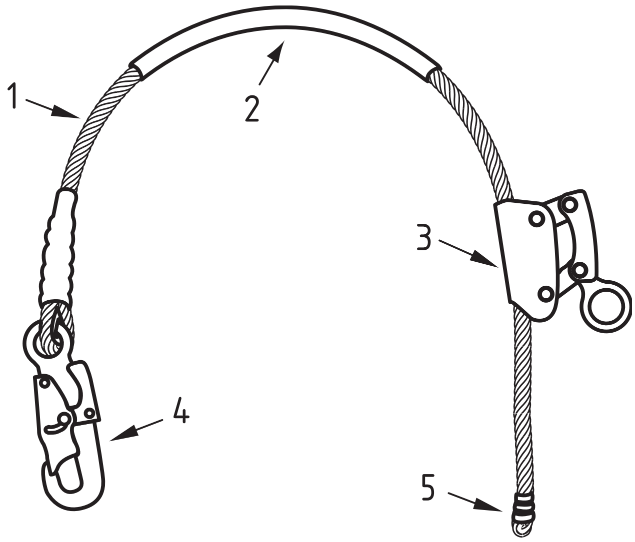
It is essential to ensure that the overall length of a work positioning anchor line is such that the user cannot reach a point where they can move over an exposed edge and into a suspended position.

10.2.5 ***Use of work positioning systems for partial support***

Work positioning technique 2 can only be used where there is no risk of the user falling through the roof itself (e.g. through a roof light or a weak section). The Work at Height Regulations 2005 (Regulation 6) require that fragile material be covered by a platform or covering or provided with a guard rail.

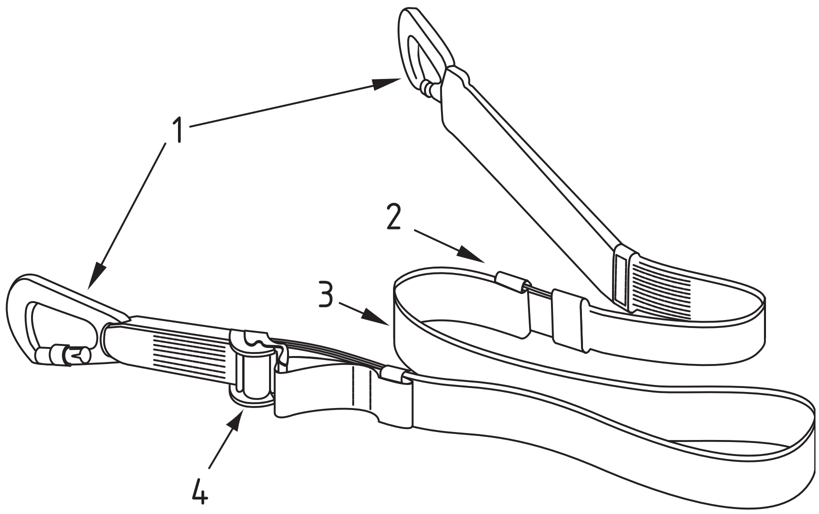
10.3 Work positioning systems for work in suspension

For work positioning in suspension it is essential that a rope access system is used in accordance with BS 7985.



Key
1 Rope lanyard
2 Protective sleeve
3 Adjustment device
4 Connector
5 Stop

a) Example of rope lanyard



Key
1 Connectors
2 Stop
3 Webbing lanyard
4 Adjustment buckle

b) Example of webbing lanyard

Figure 38 — Examples of lanyards for work positioning technique 1

11 Rescue

11.1 General

11.1.1 It is essential that there is a specific rescue plan and resources in place for each worksite and that these are regularly assessed, and updated where necessary. Resources should include not only equipment but also trained personnel (see **11.5** and Clause **15**). Rescue methods which do not require a rescuer to be exposed to risk are preferable.

11.1.2 When planning for rescue, consideration should be given to the type of situation from which the person might need to be recovered and the type of fall protection equipment which they would be using. The rescue plan should identify appropriate equipment and suitable methods of use. Some work situations can create special difficulties for rescue, for example, attaching a rescue device to a person who is suspended out of reach. Such factors should be considered when deciding on a safe system of work (see **6.1**). Individual solutions for rescue should be planned for each work situation and taking into account the personal fall protection system to be used.

11.1.3 In all rescue planning and rescue operations, assessments should be made of the following:

— the anchor points that are available (see **11.2**);

— the method that can be used to attach the person to be rescued to the rescue equipment;

— any particular needs of the person being rescued with respect to injuries they might have suffered or the risk of suspension trauma (see **11.4.2**);

— whether the situation dictates that the person being rescued has to be lowered or to be raised;

— the possible needs of the person following the rescue (see **11.4**).

11.2 Anchors

11.2.1 Special consideration should be given to available anchor points, both during the planning stage and during the rescue operation. It is essential that anchor points are suitably positioned for the intended operation, are unquestionably sound and, where necessary, suitable for two-person use.

11.2.2 If a rescue procedure requires a rescuer to descend to recover a casualty, there might be additional loading on the anchor system, which might be required to support the load of two persons. Therefore it is necessary to have either an anchor device with sufficient capacity to support two users, or two anchor devices.

11.2.3 Some special types of anchor (e.g. temporarily installed horizontal anchor lines or portable dead weight anchors) might not be suitable for such applications and, in the case of dead weight anchors, the performance of the anchor could be affected by environmental conditions, such as rain. Users of such systems should consult the manufacturer for guidance.

11.3 Edges

The possibility that the person who is to be rescued could be hanging over an edge, or located below an edge, should be considered. Recovery over an edge will increase the effective load in a lifting operation and might cause cutting or abrasion of the anchor line. Edges can also interfere with the operation of rescue equipment which utilizes pulley systems.

11.4 Care of individuals requiring rescue

11.4.1 Provision should be made to ensure that help is provided promptly to any individual who needs it or who is unable to communicate and might be in danger. The survival of an injured person after an accident often depends on the speed of rescue and on the care given to them during and after rescue. This applies equally to a person who is left suspended after an incident, e.g. after a fall from a height, whether or not they have suffered injuries. The suspended phase of an incident can be the most dangerous part of it, particularly for a person who is motionless (for example, because they are badly injured or unconscious), owing to the effects of suspension trauma, which can be life threatening (see Annex D).

11.4.2 All users of personal fall protection systems, and others involved with work at a height, should be aware of the following precautions that might need to be taken in the event of a casualty being in a suspended position.

a) The longer the casualty is suspended without moving, the greater the chances are of suspension trauma developing and the more serious it is likely to be. Therefore, an injured person hanging in a harness awaiting rescue should be removed from upright suspension as quickly as possible. The aim should be to do this within 10 minutes. This is particularly important for a casualty who is motionless.

b) A conscious casualty should be encouraged to exercise their legs gently, to stimulate circulation of the blood.

c) Regarding the position of the casualty:

1) during rescue, the casualty might be better off in a substantially horizontal position (but not totally horizontal) or with the knees elevated;

2) after rescue, it could be advisable not to allow the casualty to become totally horizontal, but to be in a sat-up position, with the knees bent, to avoid a rapid return of venous blood to the heart;

3) the eventual movement of the casualty to the horizontal position might need to be carried out very slowly over an extended period of around 30 minutes to 40 minutes;

4) the casualty might need dialysis to protect the kidneys.

Medical advice should be obtained on all these points before the casualty is moved.

Medical help should be sought immediately if suspension trauma is suspected (see Annex D).

11.4.3 There might be a small risk that users of personal fall protection equipment could suffer suspension trauma while working in a suspended position, although the evidence does not support this. The following precautions should be taken to minimize any risk.

— Users should carry out frequent "pumping" movements of the legs, preferably against a firm surface, to activate the muscles and so reduce the risk of venous pooling.

— Harness leg loops should be well padded and as wide as possible to spread the load and reduce any restriction of the user's movements or blood flow.

— The use of a workseat might be advisable if work in one position is to be sustained for an extended period.

11.4.4 The number of incidents of suspension trauma in a normal working environment appears to be minimal, as there is little evidence of it occurring in such an environment. However, it is clear that an effective rescue plan is essential to ensure that, following an accident, the casualty is:

— removed from the suspended position and cared for in a proper manner;

— taken to hospital as quickly as possible.

11.4.5 It is also essential that other persons who are suspended and require help, for example, after a fall, are removed from the suspended position as soon as possible. Consequently, great importance should be attached to examining the worksite at appropriate times, for example, each day or at each change of job, to assess all possible emergency scenarios, and to plan how any resulting rescues would be carried out. Users of personal fall protection equipment should be trained in rescue techniques (see **15.2.4**). In addition, a specially trained rescue team could be established, to be on site or available at short notice.

11.5 Rescue equipment

11.5.1 Specific rescue equipment should always be present at the worksite. This equipment should be sufficient to carry out a rescue of an individual from any situation on the site.

11.5.2 Rescue systems are available which have been designed specifically for rescue or specifically for evacuation. Some allow only lowering, some only raising and some allow both. The manufacturer should be consulted to establish the suitability of a particular rescue system for the situation in which it is to be used. Where a casualty needs to be raised during a rescue, a rescue lifting device conforming to BS EN 1496 might be appropriate (see Figure 21 and Figure 22).

11.5.3 If a casualty is badly injured, the use of a stretcher might need to be considered.

11.6 Harness for rescue

11.6.1 Apart from waist belts for restraint, all types of harness worn on the worksite are likely to be capable of being used as part of the rescue system.

11.6.2 Should there need to be a harness on site dedicated to rescue, a harness should be selected which has attachment points in positions suitable for the type of rescues for which it is to be used.

11.6.3 Special harnesses might be appropriate for particular circumstances. For example, where speedy donning is required a rescue loop conforming to BS EN 1498 might be appropriate, and where a special orientation of the casualty is necessary, e.g. a vertical position for rescue from a narrow space, a harness conforming to BS EN 1497 might be appropriate.

11.7 First aid

There should be a first aid kit at each worksite and, at all times, a person with specific responsibilities for administering first aid. It is recommended that all users of personal fall protection equipment have at least some knowledge of the symptoms and dangers of suspension trauma, and that the person responsible for first aid has enough knowledge to be able to recognize the symptoms and treat it or advise treatment accordingly.

NOTE Attention is drawn to the Health and Safety (First Aid) Regulations 1981.

12 Components

12.1 General

12.1.1 All components used in a fall protection system require adequate static and dynamic strength to withstand any loads or forces that might be imposed on them, with an adequate safety margin in addition (see **12.2**). Such components should only be loaded in accordance with the manufacturer's user instructions.

12.1.2 Most personal fall protection equipment is tested using the minimum breaking loads specified in the relevant standards. Some standards require the minimum breaking load to be marked on the component, others do not. Some components are supplied with a safe working load (SWL), a working load limit (WLL) or a rated load, which can be a minimum rated load or a maximum rated load. These are sometimes in addition to the minimum breaking load and sometimes in place of it.

12.1.3 Apart from safe working loads, working load limits and rated loads, static strength requirements specified in standards for personal fall protection equipment are usually minimum values. Components with a higher static strength are likely to be safer and have a longer lifespan.

12.1.4 It is essential that components used in a personal fall protection system are compatible with one another, i.e. that the safe function of any one component in the system is not adversely affected by, and does not interfere with, the safe function of another. It is also essential that the components are compatible with, and do not interfere with, other items of equipment, including safety equipment, and clothing, with which they are to be used. The latter is particularly important for body holding devices.

12.1.5 All components chosen to protect a person working at height should be such that they cannot be accidentally removed, dislodged or become unfastened.

12.1.6 All components should carry marking to allow traceability to, for example, a test, inspection or certificate of conformity. If the manufacturer or supplier has not already provided such marking, care should be taken not to mark the components in a manner that impairs their integrity.

12.1.7 Components should be traceable to the relevant test certificates or certificates of conformity, and matched to the record of their use, in order to facilitate their proper care. Connectors and other metal items should be indelibly marked in a manner that does not affect their integrity. Metal items should not be marked by stamping, unless by agreement with the manufacturer. Textile items such as lanyards and harnesses can be indelibly marked by various methods, for example, by marking their identification on a tape, which is then fixed in place by a heat-shrunk, clear plastics cover. (Care should be taken to ensure that the plastics cover does not cause abrasion.)

12.1.8 Components used in personal fall protection systems should have the following characteristics.

— They should be appropriate for the particular job for which they are to be used.

— They should be suitable for the environment in which they are to be used. Where this environment presents specific hazards, components which are suitably resistant to these hazards should be selected, e.g. ones with resistance to ultraviolet light, corrosion, extreme environmental conditions, chemicals or oils.

12.1.9 BS EN 353-1 and -2, which specify requirements for guided type fall arresters, and BS EN 360, which specifies requirements for retractable type fall arresters, specify additional testing for durability and reliability of the locking mechanism, and also of the retraction mechanism in the case of retractable type fall arresters, if the manufacturer claims these features in the information supplied with the device. In addition, BS EN 360 gives the option of additional testing for resistance to dusty and oil contaminated conditions. Where relevant, devices which have passed these additional tests should be selected.

12.2 Strength of components

12.2.1 The performance requirements specified for components of personal fall protection systems and equipment (in, for example, BS EN 353-1, BS EN 353-2, BS EN 354, BS EN 355, BS EN 360, BS EN 363 and BS EN 795) are based on the need to ensure that the impact force on the user in the arrest of a fall (a dynamic force) does not exceed 6 kN.

NOTE As dynamic forces greater than this can be generated in a fall, personal fall protection systems incorporate one or more components with an energy absorbing capacity to ensure the 6 kN limit is not exceeded.

12.2.2 Theoretically, therefore, the components of personal fall protection systems and equipment need to be strong enough to withstand a dynamic force of 6 kN, for single person use. However, while some standards (for example BS EN 353-1 and -2, which specify guided type fall arresters, and BS EN 360 which specifies retractable type fall arresters) specify a maximum braking force of 6 kN in a dynamic test, other standards (for example BS EN 354, which specifies lanyards and includes a requirement for the dynamic strength of adjustable lanyards) specify only that the component shall not fail in a dynamic test. Resistance of components to a specific dynamic force is not specified as such.

12.2.3 Static strength is specified for all components, and a safety factor is included to allow for the fact that the components would be subjected to a dynamic force in the event of a fall being arrested. A safety factor of 2.5 is usually adopted, but a factor of 2 or less has sometimes been used. Thus the minimum static strength specified for most components of personal fall protection equipment is 15 kN. For example, BS EN 354 specifies a minimum static strength of 15 kN for lanyards made of metallic material. However, for some components a minimum static strength of 12 kN is specified. For example, BS EN 360 specifies a minimum static strength of 12 kN for retractable type fall arresters made of wire rope. For some textile components a higher minimum static strength is specified. This is to take some account of degradation, for example that caused by abrasion and ultraviolet light. For example, BS EN 354 specifies a minimum static strength of 22 kN for lanyards made from textile material.

12.3 Textiles used in components

12.3.1 Textile components used in personal fall protection equipment are usually made from artificial fibres, often polyester or polyamide. All textile components should be chosen and used with particular care as they are susceptible to varying types and amount of damage, some of it not very easy to identify (see **13.3** and also HSE reports *Assessment of factors that influence the tensile strength of safety harness and lanyard webbings* [8] and [9]).

NOTE For further information see HSE publication *Issues surrounding the failure of an energy absorbing lanyard* [10].

12.3.2 Components made from textile materials other than polyamide or polyester might be more suitable for certain working conditions. For example components made from high performance polyethylene or high tenacity polypropylene more are suitable where there is severe chemical pollution, although polyethylene and polypropylene have much lower melting temperatures than polyamide or polyester and are more easily affected by frictional heat (dangerous softening of polypropylene occurs at temperatures as low as 80 °C). Aramid, which is resistant to high temperatures, is more suitable where components with a high melting point are required; however it has low resistance to abrasion, repeated bending and to ultraviolet light.

12.3.3 Artificial fibres react very differently to exposure to different chemicals at different concentrations and temperatures. For example, polyamide has good (but not total) resistance to some alkalis, but not all, and not at all concentrations or at all temperatures. The same caveats apply to polyester, which has good resistance to some acids. Textile components should be selected which are made from materials that are resistant to the chemicals present in the environment in which the work is to be carried out. Some data on the resistance to chemicals of some of the artificial fibres used in the manufacture of personal fall protection equipment are given in Annex H.

12.3.4 When selecting textile components made of the appropriate material for use in a particular environment, account should also be taken of other properties including the melting point, resistance to abrasion and flexing, resistance to ultraviolet light and the elongation characteristics. Some data on other properties of artificial fibres used in the manufacture of personal fall protection equipment are also given in Annex H.

12.3.5 Confirmation should be obtained from the manufacturer or supplier that all fibres in textile components, including sewing threads, contain sufficient ultraviolet inhibitor for the conditions in which the components are to be used and that the components have not been subjected to any dyeing or finishing process that could have reduced the level of protection. However, even textiles with ultraviolet inhibitor are not usually totally protected, so users should not subject textile components to unnecessary exposure to sunlight, or to fluorescent light which also contains ultraviolet.

12.3.6 Some materials change character when wet. For example, polyamide fibre loses between 10 % and 20 % of its strength in such a condition (see Annex H), and static tests on dynamic ropes made from polyamide have shown a strength loss of up to 30 %. Fortunately, the loss is not permanent and the strength is recovered when the material dries. In dynamic (drop) tests on dynamic rope that has been soaked in water for varying periods, the impact forces increased by up to 22 % above those for dry ropes, and typically by between 8 % and 12 %. These might seem unexpected results, because water absorbed *by* the fibres increases elongation, and increased elongation should reduce the impact force. The increase in impact forces is said to be due to water *between* the fibres affecting the elongation process during a dynamic test (or during a fall). The use of components made of webbing or rope in wet conditions does not usually need to be a cause for concern, although it would be wise to take extra care, particularly if the components are being used under conditions in which they are loaded close to their maximum rated load.

12.4 Metals used in components

12.4.1 Most metal components are made of steel or of aluminium alloys, although some are made of other metals such as titanium. Aluminium alloys all look the same, at least to the non-specialist, as do most steels, with the exception of stainless steels. However, the performance of these metals can vary greatly, particularly with respect to their susceptibility to corrosion, so it is essential that the user knows what the components he is using are made of so that appropriate precautions can be taken (see **12.4.2** to **12.4.8**).

12.4.2 Some components made from aluminium alloys have a polished surface finish, but most are anodized. Anodized components have a thin electrochemical coating which is harder than the base material and which protects against corrosion and also, to a small extent, against wear.

12.4.3 Different aluminium alloys used in fall protection equipment have different characteristics. Generally, the stronger they are, the more susceptible they are to corrosion, so they require greater care in use. Aluminium alloys are particularly susceptible to corrosion caused by seawater.

12.4.4 Contact between components made of different metals can give rise to galvanic corrosion as a result of electrolytic action, especially when wet. This is why equipment should never be stored wet (see **13.8**). Galvanic corrosion can affect many metals, including aluminium and some stainless steels and can cause the rapid deterioration of protective coatings such as zinc. Long term contact of dissimilar metals (e.g. copper and aluminium) should be avoided especially in wet conditions and in particular in a marine environment[2)]. Commentary on bi-metallic corrosion is given in PD 6484.

12.4.5 Some metals that are under tensile stress in a corrosive environment develop surface cracks, a phenomenon known as stress corrosion cracking. It is time dependent and can take months to develop. This is one reason why regular inspection of components is so important (see Clause **13**).

12.4.6 Some chemical products used in building work can cause corrosion of items made from aluminium alloys. Advice on dealing with this should be obtained from the chemical product manufacturer.

12.4.7 Aluminium alloys are usually softer than steel and are more prone to damage by abrasion, e.g. by a gritty rope running through a connector. However, components made from aluminium alloys are usually lighter than their steel counterparts, and consequently are easier to handle.

12.4.8 While steels are heavier than aluminium alloys, they are more robust and have better resistance to abrasion. When selecting steel components, users should consider whether, in order to ensure that the components are adequately protected, components with additional protection, for example galvanizing or zinc plating, are required, or, alternatively, a hot applied plastics coating. Users should be aware that if a plastics coating has not been correctly applied, or if it becomes damaged, it can allow the ingress of water and corrosion can begin, often undetected.

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2) A table giving the galvanic series of metals in seawater is available on: www.corrosion-doctors.org/Aircraft/galvseri-table.htm

12.5 Connectors

12.5.1 Connectors are openable components used to link together other components in a personal fall protection system, for example, to link a lanyard to an anchor. Some connectors are designed for general use and some for specific applications (see **12.5.3**).

12.5.2 Connectors conforming to BS EN 362 should be used. In addition, connectors conforming to certain classes of connector in BS EN 12275 also meet the requirements of BS EN 362, and these connectors are also suitable. In the case of such connectors, conformity to BS EN 362 should be confirmed before use.

12.5.3 There are five classes of connector described in BS EN 362:2004, which are suitable for use in personal fall protection systems, as follows:

— Class B. Basic connectors. Connectors for general use;

— Class M. Multi-use connectors. Connectors for general use which may be loaded on the major axis and on the minor axis;

— Class T. Termination connectors. Connectors with a captive eye;

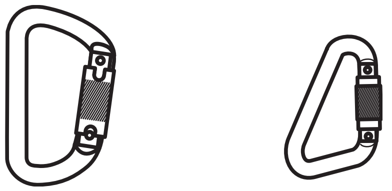
— Class A. Anchor connectors. Connectors intended to be linked directly to a specific type of anchor;

— Class Q. Screwlink connectors. Connectors which are closed by a screw-motion gate, which is a load bearing part of the connector.

Examples of different types of connectors are illustrated in Figure 39.

12.5.4 Only connectors which have a closure that provides protection against inadvertent opening of the gate, for example by means of a screwed sleeve or an automatic locking device, should be used.

12.5.5 Connectors that are to be attached to an anchor point (e.g. an eyebolt or a shackle) should be of a material that will not be damaged by the surface of the anchor point. For example, an aluminium connector should not be connected to a steel anchor point. Steel connectors should be used for connecting to steel cables, shackles or eyebolts. The connectors used should be of a design and size such that the connector can rotate freely in the anchor point without hindrance and without loosening the anchor, and so that the connector is free to align with the direction in which the dynamic load would be applied in the event of a fall. The connector selected should be one that allows sufficient clearance to allow the gate mechanism to fully close and lock after the connection to the anchor point or position has been made. Correctly selected connectors are illustrated in Figure 40, views A, B, C and D. In the case of the connector illustrated in Figure 40, view F the gate mechanism cannot be closed and locked. A connector should never be used in this way. A connector should not be connected to an anchor point in a position such that in the event of a fall the connector would be bent over an edge (see Figure 40, views K and L). A connector should not be connected to an anchor point or anchor position with a rough edge (see Figure 40, view J).

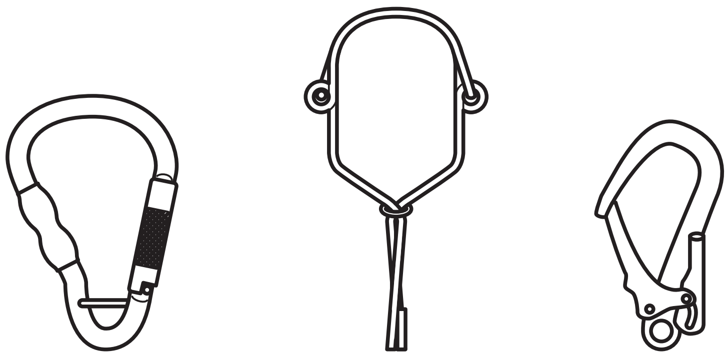


Karabiner (autolock) Offset D karabiner (screwgate)

a) Examples of multi-use connectors (Class M)

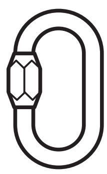
Captive eye karabiner (screwgate) Small snaphook (autolock)

b) Examples of termination connectors (Class T)



Scaffold hook (autolock) Manucreche scaffold hook (autolock) Large snaphook (autolock)

c) Examples of anchor connectors (Class A)



Oval screwlink

d) Example of a screwlink connector (Class Q)

Figure 39 — Examples of various types of connectors

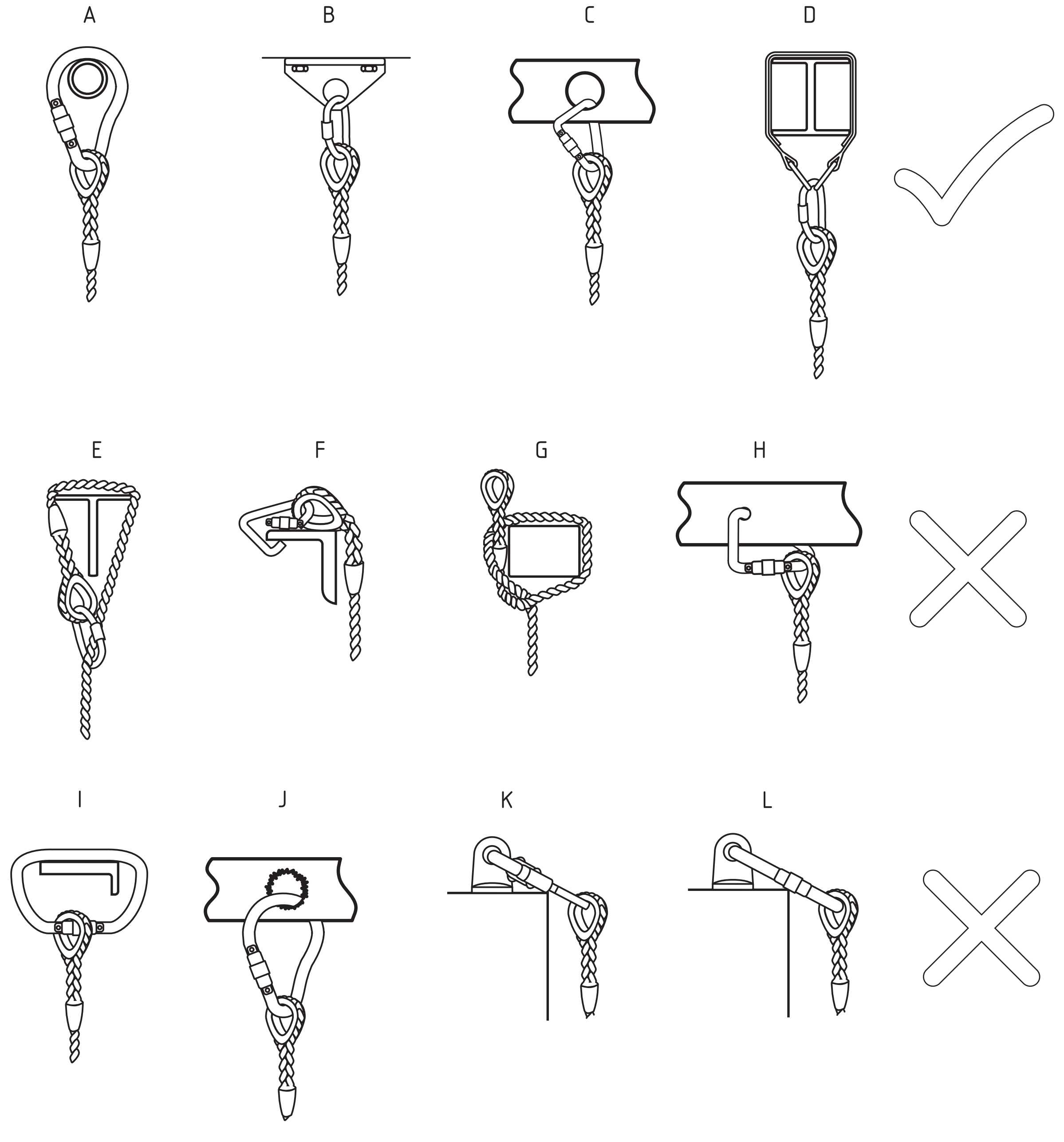


Figure 40 — Examples of correct and incorrect methods of connecting to an anchor point or position

Key

A, B, C, D	*Correct*. Examples of correct connections to anchor points and anchor positions
E	*Incorrect*. Choke hitching of the anchor line through the connector. Connectors should not be used like this
F	*Incorrect*. The connector gate cannot close owing to the shape of the anchor position. Connectors should not be used like this
G	*Incorrect*. Anchor line tied round the anchor position. Connections should not be made in this way
H	*Incorrect*. Connector cannot rotate freely in the anchor point and would not be free to align with the direction of the dynamic load in the event of a fall. Connectors should not be used like this
I	*Incorrect*. Anchor line termination bearing on the connector gate mechanism. Connectors should not be used like this
J	*Incorrect*. Connector bearing against a rough edge. Connectors should not be used like this
K, L	*Incorrect*. Connectors positioned such that they would be bent over an edge if subjected to a dynamic load. Connectors should not be used like this

NOTE View D illustrates the use of a girder strap (see **16.1.2**, Note 2) in a situation where the structure is too large for a normal size connector.

Figure 40 — Examples of correct and incorrect methods of connecting to an anchor point or position (*continued*)

12.5.6 In most connectors the gate is the weakest point, so loading against the gate should be avoided as this can cause breakage of the connector, or roll-out (see **12.5.7**). When a connector is in use, loading against the gate can occur accidentally usually through the migration of straps or other connecting components from their intended position during an unloaded period. Where there is a risk of this happening, use of a screwlink connector with a triangular shape, or a connector with a captive eye to hold the lanyard or other component in the intended position, might be appropriate.

12.5.7 When selecting a connector, users should take note of the type of gate locking system employed and should consider how and where the connector will be used in the fall protection system. This is with a view to protecting against the possibility of roll-out. Roll-out is the result of pressure on the gate by a connecting component, such as an anchor, a harness attachment point (especially if made from metal), webbing, rope or another connector. If the safety catch mechanism on the locking gate is tripped during the time that this pressure is applied, it can cause the accidental opening of the gate and the release (roll-out) of the connecting component from the connector.

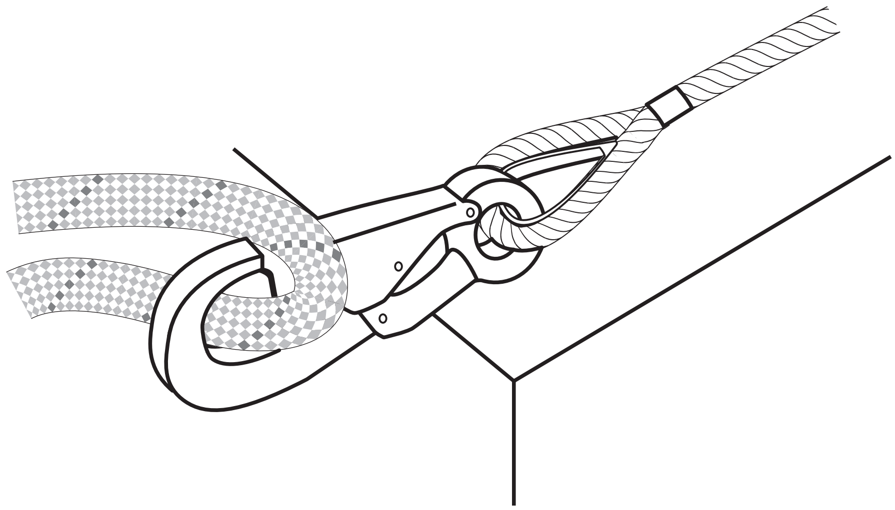
The safety catch mechanism can be accidentally tripped typically in one of two ways, depending upon the type of locking gate. These are as follows:

— the action of rope or webbing running over the top of some types of gate which incorporate a twist-action safety catch (see Figure 41a);

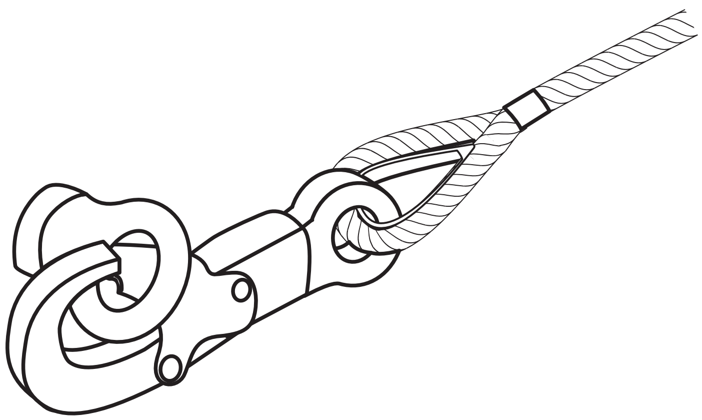
— the unintentional pressing of a safety catch on so-called double-action safety hooks against the user's body or the structure (see Figure 41b).

The potential problems of loading against the gate and roll-out can be largely avoided by consideration of how loads could be inadvertently applied to the connector during use, and then choosing the correct connector for the particular application.

WARNING. Early versions of autolock connectors with a sprung sleeve and many models of the sprung lever type of autolock connector are susceptible to roll-out in certain situations.



a) Rope running over top of gate



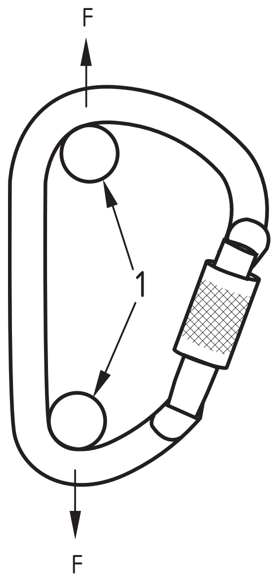
b) Safety catch pressed unintentionally

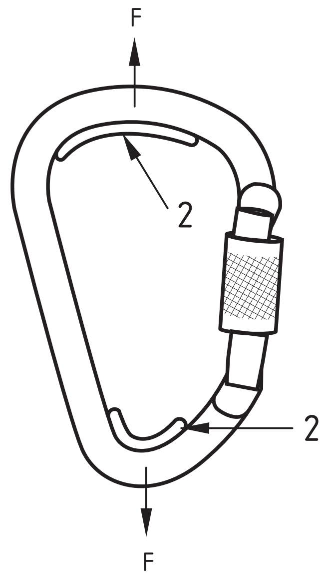
Figure 41 — Examples of ways in which the safety catch on a connector can be tripped accidentally

12.5.8 The strength of a connector specified in BS EN 362 is determined by pulling between 12 mm diameter bars. If the connector is an asymmetrical shape, the test load is normally applied parallel to and close to the spine. If the load in use is not so positioned, for example because of the use of wide webbing slings or double ropes, the weaker, gated, side of the connector will take more of the load and its breaking load might be less than specified (see Figure 42). Static strength tests have shown that the strength loss can be as high as 45 %. Therefore, care should be taken when using asymmetrical connectors to ensure that they are likely to be loaded as in the standard test, or that this potential loss of strength is taken into account when selecting connectors, for example by choosing connectors with a higher static strength than the minimum specified in BS EN 362. Care should also be taken not to insert too many components into a connector such that they could interfere with the keeper or locking mechanism (see Figure 43).

NOTE In the 1993 edition of BS EN 362 the minimum static strength specified for connectors was 15 kN. This has been increased to 20 kN (25 kN for screwlink connectors) in the 2004 revision of BS EN 362.

12.5.9 It is essential to avoid side loadings on connectors, as these can lead to cross-gate failure (see Figure 40, views H, I, K and L).





a) Loading during static testing

b) Possible loading during use with a webbing lanyard

Key

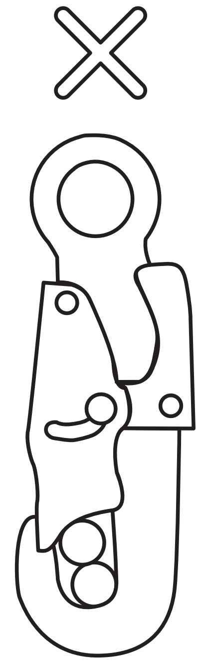
1 Bars 12 mm diameter

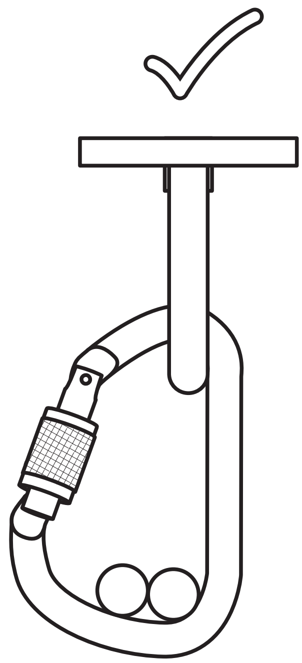
2 Webbing lanyard

F Direction of force

NOTE In the situation shown in b) the loading is closer to the gate.

Figure 42 — Difference in the loading of a connector in a static test and when used with a wide webbing sling





a) *Incorrect*. The anchor lines place too much loading on the latch of the snaphook.

b) *Correct*. The anchor lines do not interfere with the keeper or locking mechanism.

Figure 43 — Correct and incorrect ways of inserting two anchor lines into a connector

12.5.10 Connectors are available with gates with the following types of closing and locking mechanisms.

a) *Manual closing and manual locking*. The gate is closed by a screwed sleeve which links the keeper to the body, which is screwed manually to close and open it and thus protects the keeper from inadvertent opening. This type of mechanism is used in screwlink connectors. (See Figure 39d.)

b) *Automatic closing and manual locking*. The keeper is spring loaded to hold it in the closed position and has to be depressed to open it. The keeper is protected from inadvertent opening by a manually screwed sleeve that links the keeper to the body. This type of mechanism is used in screwgate karabiners. (See Figure 39a.)

c) *Automatic closing and automatic locking, with spring loaded sleeve*. In most designs, the keeper is spring loaded to hold it in the closed position as described in item b). A spring loaded locking sleeve automatically links the keeper to the body. This type of mechanism is used in autolock karabiners. (See Figure 39a.)

NOTE There are two common types of autolock karabiners:

— those in which a spring loaded locking sleeve automatically links the keeper to the body;

— those in which a spring loaded lever automatically prevents the keeper from opening.

d) *Automatic closing and automatic locking with spring loaded sleeve and additional safety mechanism*. In addition to the features described in item c), the sleeve itself is automatically locked into place on the body to prevent roll-out.

e) *Automatic closing and automatic locking with spring loaded lever*. The keeper is spring loaded to hold it in the closed position as described in item b) and a spring loaded lever automatically prevents the keeper from opening.

f) *Automatic closing and automatic locking with a special design*. Specifically designed for attachment to certain types of anchor. An example of this type is manucreche connectors for attachment to round bar or tubing (e.g. scaffolding). (See Figure 39c.)

12.5.11 The advantages and disadvantages of the different types of closing and locking mechanisms are listed in Table 2. Care should be taken to select a connector with a gate closing and locking mechanism suitable for the intended application.

12.5.12 Screwlink connectors (see **12.5.10**a) are most suitable for permanent and semi-permanent connections, where the connectors do not need to be removed and reconnected several times a day. The design of the gate allows screwlink connectors generally to be more compact than other connectors.

12.5.13 Screwgate karabiners are available in several shapes, including pear-shaped, oval, D-shaped and triangular, and offset versions of most of these are also available.

12.6 Body-holding devices

12.6.1 *General*

The body-holding device selected should have the following characteristics.

— It should fit the intended user, with adequate allowance for adjustment.

— It should have a rating sufficient to support the weight of the intended user.

— It should have at least one attachment point which is suitable for connection to personal fall protection equipment with which it is to be used (see **12.6.2**, **12.6.3** and **9.1.2**).

12.6.2 *Body-holding devices for restraint systems*

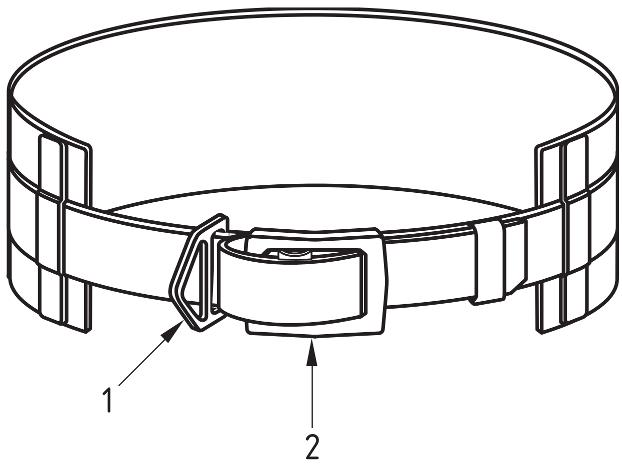
The body-holding device should be a waist belt conforming to BS EN 358, a sit harness conforming to BS EN 813 or a full body harness conforming to BS EN 361.

A waist belt comprises a strap that encircles the waist, with an attachment point (see Figure 44) and can include shoulder straps. If a waist belt is to be used, it is strongly recommended that a belt should be used which incorporates sub-pelvic support, e.g. leg loops as specified in BS EN 813.

NOTE Use of a waist belt or a sit harness is acceptable for restraint purposes since fall arrest forces are not applied in restraint situations. These devices have the advantage of being less cumbersome than a full body harness.

Table 2 — Advantages and disadvantages of various connector gate closing and locking mechanisms

Connector gate closing and locking mechanism	Advantages	Disadvantages
a) Manual closing and manual locking (as in screwlink connectors)	No possibility of roll-out. Usually provides a stronger gate area than other connectors. Unlikely to become accidentally undone. Better for three-way loading than other connectors.	These connectors are usually very weak in the unlocked position. Therefore, it is essential that the user remembers to close the keeper. Slow to open and close.
b) Automatic closing and manual locking (as in screwgate karabiners)	Very low possibility of roll-out. Very low possibility of other types of inadvertent opening.	The user has to remember to lock the gate.
c) Automatic closing and automatic locking with spring loaded sleeve (as in autolock karabiners)	The user does not have to remember to lock the gate.	Does not provide complete protection against inadvertent opening (e.g. roll-out). Slightly awkward to operate when intentionally opening the gate.
d) Automatic closing and automatic locking with spring loaded sleeve and additional safety mechanism	The user does not have to remember to lock the gate. No, or very low, possibility of inadvertent opening (e.g. roll-out).	Awkward to operate when intentionally opening the gate.
e) Automatic closing and automatic locking with spring loaded lever	The user does not have to remember to lock the gate.	Does not provide complete protection against inadvertent opening (e.g. roll-out). Slightly awkward to operate when intentionally opening the gate.
f) Automatic closing and automatic locking with a special design (e.g. manucreche connectors)	The user does not have to remember to lock the gate. No, or very low, possibility of inadvertent opening (e.g. roll-out).	Limited use for special applications.



Key
1 Attachment point 2 Fastening buckle

Figure 44 — Example of a waist belt for use with a restraint system

12.6.3 ***Body-holding devices for work positioning systems for partial support***

12.6.3.1 For work positioning technique 1 (see **10.2.2**) the body-holding device should be a full body harness conforming to BS EN 361 (see Figure 45), with two side waist attachment points or a central abdominal attachment point, plus an attachment point for the back-up personal fall protection system. If a full body harness with an incorporated waist belt is chosen, it is recommended that the waist belt is fitted with a back support conforming to BS EN 358:2000, **4.1.1.6**.

12.6.3.2 For work positioning technique 2 (see **10.2.3**), the body holding device should be a full body harness conforming to BS EN 361 or a sit harness conforming to BS EN 813 (see Figure 46). The harness should include a central abdominal attachment point for work positioning and an attachment point for the back-up personal fall protection system (which could be the same attachment point, depending on the back-up system to be used).

12.6.3.3 The body holding device selected should be one that does not cause undue discomfort to the user when they are in the work positioning stance. The most comfortable designs are those which have shaped pads in the back and buttock areas and have the attachment point or points located so that the user can adopt a comfortable sitting position. Designs that are less comfortable are those which incorporate only webbing back pads and have the attachment point or points located so that the user's weight is taken only on the back of the harness. For a harness for technique 1, comfort can be assessed by the user donning the harness, passing an anchor sling around a vertical structure, at ground level, connecting the anchor sling to the harness attachment point or points and then leaning back and adopting a work positioning posture.

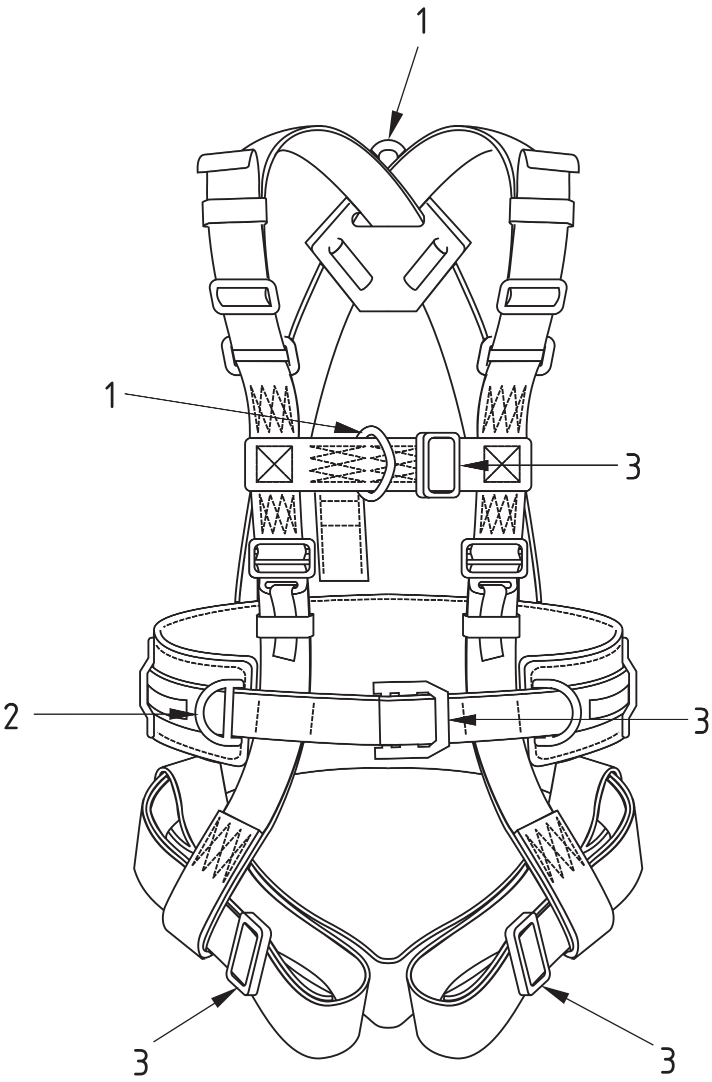
12.6.4 ***Active and passive harnesses***

Harnesses can be divided into two categories, active and passive. Active harnesses are those where the user uses the harness for support while working, as well as it being part of the personal fall protection system. Examples of active harnesses are those used for work positioning, including rope access (see Clause **10**). Passive harnesses are those that only support the user (usually in suspension) after a fall. An example of a passive harness is one used in a fall arrest system (see Clause **9**).

Most active harnesses give a greater degree of comfort than passive harnesses. This is necessary because the user of an active harness is likely to be supported by their harness for a large part of their working day. This is not the case for passive harnesses, because the only time that the user is likely to be supported by the harness is after a fall. However, this is not a good time for the user to discover that the harness is uncomfortable or even unbearable. This is why it is important to test harnesses for comfort and adjustability before they are used (see **5.3.5** and Annex B).

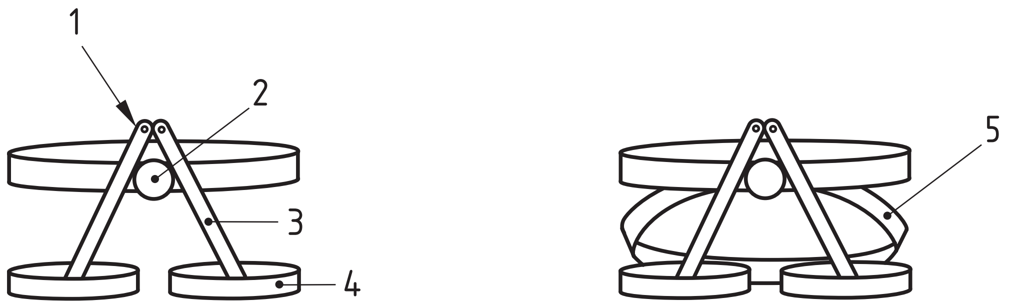
12.6.5 ***Use of side waist attachment points***

Some sit harnesses and full body harnesses are equipped with two side waist attachment points, for use for work positioning, but which may also be used for restraint. If the side waist attachment points are used, it is essential to ensure that both are connected to the work positioning or restraint system. A connection should never be made to just one side waist attachment point because in the event of the user losing their footing their full weight would be taken at the side of the waist, which could result in internal injuries; none of the user's weight would be supported by the sub-pelvic straps.



Key
1 Attachment points for fall arrest purposes
2 Attachment points for work positioning purposes
3 Fastening and adjustment buckles

Figure 45 — Example of a full body harness



a) Example of a sit harness with leg loops

b) Example of a sit harness with leg loops and a sit strap

Key

1 Attachment element

2 Fastening and adjustment element

3 Strap connecting leg loop to waist belt

4 Leg loop

5 Sit strap

Figure 46 — Examples of sit harnesses

12.7 Lanyards

12.7.1 Lanyards are made from synthetic fibre webbing or rope (e.g. polyamide or polyester) or from steel wire rope or chain. They are terminated at each end with a loop for attachment of other components, or the lanyard itself can take the form of a continuous loop.

12.7.2 Termination loops in textile webbing lanyards are usually formed by sewing, those in textile rope lanyards by splicing or sewing, and those in wire rope lanyards by means of a special type of clamp, known as a swage. Termination loops should be protected against wear, which is often not obvious, particularly if it occurs on the inside of a loop. Wire rope lanyards with termination loops should incorporate thimbles in the loops to provide protection against wear on the inside of the loop. For certain uses textile lanyards with termination loops should also incorporate thimbles in the loops, e.g. where connections are to be made frequently and, therefore, it is important to have an easily accessible attachment point (see Figure 47).

12.7.3 Lanyards conforming to BS EN 354 should be used. Each lanyard selected should have the following characteristics.

a) It should have terminations suitable for connection to other components of the personal fall protection system, e.g. the anchor point and the user's body-holding device.

b) It should be compatible with, and not interfere with, other items of equipment, including safety equipment, and clothing, with which it is to be used.

12.7.4 If textile lanyards are to be used, lanyards should be selected that have protection against the ingress of dirt, against UV and chemical degradation and, preferably, against cuts. (See also **12.3**.)

12.7.5 BS EN 354 specifies a minimum static strength of 15 kN for lanyards made of wire rope or chain and a minimum static strength of 22 kN for lanyards made of textiles. For particularly arduous conditions, lanyards with a greater static strength should be used. This applies particularly to lanyards made of textiles. This might mean it is necessary to consult the manufacturer for advice regarding a specific product.

12.7.6 Wire rope lanyards should not be allowed to become kinked or twisted as this causes weakening.

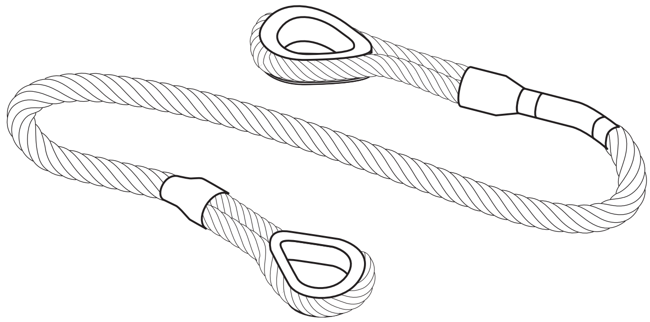


Figure 47 — Example of a lanyard with thimbles in the termination loops

12.8 Energy absorbers

12.8.1 An energy absorber is activated by the application of a sharp downward force, as occurs in the event of a fall. This causes it to deploy and absorb the energy generated by the fall, decelerating the user over a short distance and thus reducing the impact force to which the user is subjected in the arrest of the fall to a safe level (which is considered to be 6 kN or below, see **12.2.1**).

NOTE 1 If a 100 kg mass attached to a 2 m textile webbing lanyard were to fall 4 m without an energy absorber, the impact force on arrest of the fall would be 18 kN to 20 kN. Tests carried out by the American and French military have shown that even young, fit, trained parachutists can only withstand impact forces up to 12 kN.

NOTE 2 It should be noted that an energy absorber can be activated partially by being subjected to a force above 2 kN without a fall having occurred. To avoid this the user should take care not to put their weight suddenly on any component including an energy absorber.

12.8.2 The two most common types of energy absorber are the following.

a) *Tear-web type*. These are made of webbing with a weave which fails progressively when subjected to a load. Energy is absorbed in the breaking of the fibres.

b) *Rip-stitch type*. These are made of webbing which is folded and stitched together, and which separates when subjected to a load. Energy is absorbed in the breaking of the stitching.

12.8.3 Other types employ friction-inducing devices, for example special buckles, through which webbing or rope reeves rapidly when subjected to a load. Energy is absorbed by the friction.

12.8.4 The energy absorber is usually encased in a protective cover and is terminated with a connector for attachment to the user's harness. Energy absorbers are available as individual components and also incorporated into energy absorbing lanyards.

NOTE An example of an energy absorbing lanyard is shown in Figure 12a.

12.8.5 Energy absorbers conforming to BS EN 355 should be used. In order to limit the impact force on the user to 6 kN or below, in a worst case fall, BS EN 355 allows the energy absorber to extend to a maximum of 1.75 m. The length of the extended energy absorber needs to be taken into account when calculating the free space required below the user to prevent them hitting the ground or the structure in the event of a fall (see **9.7** and Annex F).

12.8.6 It is essential that an energy absorber does not deploy while the personal fall protection system is supporting the user but only begins to deploy in the event of a fall. For this reason BS EN 355 specifies that energy absorbers have to resist a force of 2 kN without deploying.

12.9 Anchor lines

12.9.1 An anchor line provides a link between the user and the anchorage. The effective length of the anchor line can be altered by use of a mobile anchor line device (see **12.10**).

12.9.2 Each anchor line used should have the following characteristics.

— It should have a rating high enough to withstand the tension expected to be generated in it when it is in use.

— It should be compatible with, and not interfere with, other items of equipment, including safety equipment, and clothing, with which it is to be used.

12.9.3 Anchor lines are type tested together with their anchor line devices either vertically or horizontally. They are sometimes used at angles deviating from the vertical or horizontal. If an anchor line is to be used at an angle other than the vertical or horizontal, care should be taken to ensure that the anchor line device(s) that are to be used with it can operate correctly on an anchor line at that angle (for example that a fall arrester can still arrest a fall). The manufacturer should be contacted for advice, and it might be necessary to arrange for tests to be carried out.

12.9.4 For fall arrest systems, anchor lines conforming to the following standards should be used.

a) For systems based on a guided type fall arrester and a rigid vertical anchor line, an anchor line conforming to BS EN 353-1 should be used.

NOTE 1 BS EN 353-1 also specifies the guided type fall arresters to be used with rigid vertical anchor lines.

b) For systems based on a guided type fall arrester and a flexible vertical anchor line, an anchor line conforming to BS EN 353-2 should be used.

NOTE 2 BS EN 353-2 also specifies the guided type fall arresters to be used with flexible vertical anchor lines.

c) For systems based on a horizontal flexible anchor line, an anchor line conforming to BS EN 795:1996, Class C should be used.

d) For systems based on a horizontal rigid anchor line, an anchor line conforming to BS EN 795:1996, Class D should be used.

NOTE 3 BS EN 795 states that "a horizontal line is understood to be a line which deviates from the horizontal by not more than 15°".

e) Textile anchor lines used for fall arrest systems other than those given in items a) to d), should be as follows:

1) kernmantel ropes conforming to BS EN 1891:1998, type A;

2) hawser-laid polyamide ropes conforming to ISO 1140: or

3) hawser-laid polyester ropes conforming to ISO 1141.

12.9.5 It is essential that an anchor line is only used with anchor line devices which are stated by the device manufacturer to be suitable for use with that particular anchor line. In case of doubt the anchor line device manufacturer should be consulted. Components from different manufacturers should not be used together without first consulting the manufacturers for advice.

12.9.6 For work positioning systems (other than rope access systems, see **10.3**) textile anchor lines made from kernmantel ropes conforming to BS EN 1891:1998, type A are recommended. If hawser-laid ropes are used as anchor lines, those conforming to ISO 1140 for hawser-laid polyamide rope or to ISO 1141 for polyester hawser-laid rope are recommended, with due regard to their elongation characteristics.

12.9.7 For textile rope anchor lines, rope of the largest diameter which can be used with the anchor line device, and which is acceptable to the user, should be chosen. Usually, the larger the rope diameter, the greater the mass of material there is and, therefore, the greater the strength and resistance to abrasion.

12.9.8 Some flexible anchor lines are supplied with termination loops already fitted. As with lanyards (see **12.7**) termination loops on textile rope anchor lines are usually formed by splicing or sewing and those on wire rope anchor lines by means of a swage. Termination loops should be protected against wear. Anchor lines with pre-fitted terminations should incorporate thimbles in the termination loops.

12.9.9 Termination loops on textile anchor lines can also be formed by knots. Anchor lines can be obtained with the knots already tied by the manufacturer, or the knots can be tied by the user. Knots should only be tied by persons who are competent to do so. The tails of all knots should be at least 100 mm long. Knots should never be tied in anchor lines made from wire rope.

12.9.10 The strength of a rope is reduced at a knot. Examples of strength loss due to various knots tied in a 10.5 mm low stretch rope conforming to BS EN 1891:1998, type A are as follows:

— bowline knot: 26 % to 45 %;

— barrel knot: 23 % to 33 %;

— double figure-of-eight knot: 23 % to 34 %;

— double figure-of-nine knot: 16 % to 32 %;

— double figure-of-ten knot: 13 % to 27 %.

NOTE The lower and upper values relate to strength reductions due to knots that had been tied "well dressed" and "poorly dressed", respectively. This refers to the arrangement of the layers of rope in the knot and its neatness.

12.9.11 The strength of a knot depends largely on the radius of the first bend as the loaded end of the line enters the knot. A very tight bend results in a weaker knot than one with a more gradual bend. In more complex knots, several parameters can be altered within the internal geometry of the knot by tying them differently and this can also affect the strength of the knot. There can be subtle differences between one knot and another, even when tied by the same person. These are mainly due to slight twists imparted in the rope as the knot is tied. These can even be present in a well-dressed knot. This is why it is essential that knots are only tied by persons with a thorough knowledge of knots and knot tying techniques.

12.9.12 When selecting textile ropes to be used as anchor lines with knotted terminations, the static strength of the rope as stated by the manufacturer, the knots to be used, and their effect on the strength of the rope need to be taken into account. It is recommended that, as a rule of thumb, a 50 % reduction in strength due to the knot should be allowed for to give an adequate margin to cover a worst case situation.

12.9.13 A practice to be avoided is that of "choke-hitching" an anchor line through a connector (see Figure 40 view E), because this could result in incorrect loading of the connector. An anchor line should never be tied round an anchor (see Figure 40 view G), as it could come undone when subjected to a load.

12.10 Anchor line devices

Anchor line devices is a collective term for components which link the user to an anchor line and travel along the anchor line alongside the user during upward, downward or horizontal changes of position.

Anchor line devices used in personal fall protection systems are as follows:

a) length adjusters on manually adjustable lanyards for restraint systems (see **8.3**);

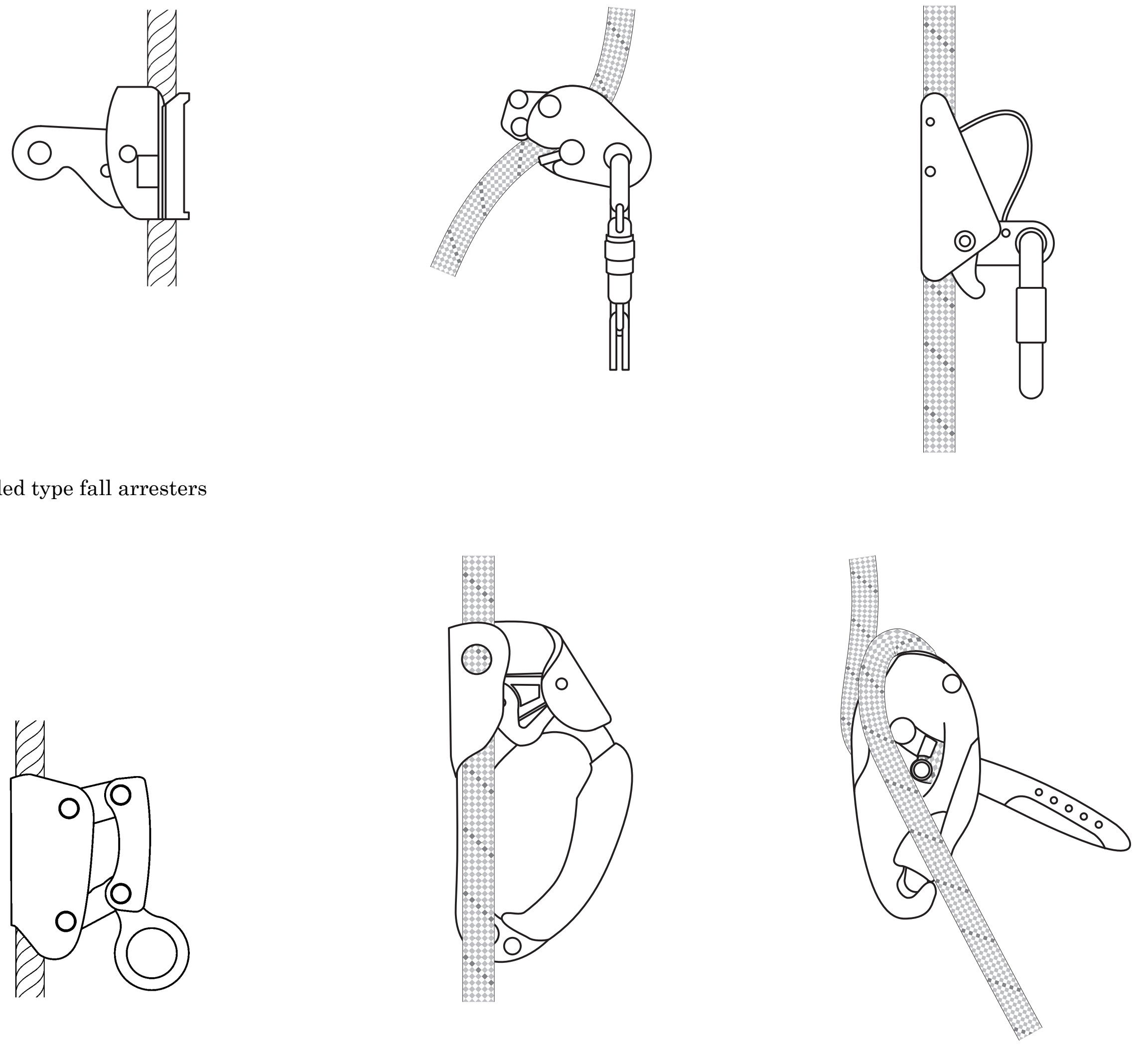
b) rope adjustment devices ("rope grabs") for work positioning systems (see **10.2.4.2**);

c) travellers for use with horizontal anchor line systems for restraint systems (see **8.2.2**) and for fall arrest systems (see **9.5**);

d) guided type fall arresters for use with vertical anchor lines for fall arrest systems (see **9.4**);

e) ascender and descender devices used for rope access systems (see **10.3** and BS 7985).

With the exception of travellers, anchor line devices are designed to lock automatically onto the anchor line when a force or load is applied. Examples of anchor line devices are illustrated in Figure 48.



a) Guided type fall arresters

b) Adjustment device for work positioning

c) Ascender device

d) Descender device

Figure 48 — Examples of anchor line devices

13 Inspection, care and maintenance of equipment

13.1 General

13.1.1 It is essential that all load-bearing equipment is given a visual and tactile inspection before each use to ensure that it is in a safe condition and operates correctly. Advice should be obtained from the manufacturer on how to do this, and this advice should be strictly followed.

13.1.2 Formal inspection procedures should be put in place by employers to ensure that personal fall protection equipment is given a detailed inspection (“thorough examination”) by a competent person before first use and at intervals not exceeding six months (or three months where the equipment is used in arduous conditions), and after circumstances liable to jeopardize safety have occurred.

13.1.3 It is essential that the person carrying out a thorough examination is sufficiently independent and impartial to allow objective decisions to be made, i.e. they have appropriate and genuine authority to discard equipment. This does not mean that competent persons necessarily have to be employed from an external company.

13.1.4 Ideally companies should be competent to conduct their own examinations. The company's insurer can normally be expected to accept this, but the company should check that this is the case. If required, the supplier or manufacturer might be able to suggest suitable people or organizations.

13.1.5 It is recommended that interim inspections of personal fall protection equipment are carried out over and above the pre-use checks and the detailed inspections, at intervals determined by the risk assessment carried out at the beginning of the job. In determining what is a suitable interval, factors such as whether items are subject to high levels of wear and tear or contamination should be considered.

13.1.6 Both the detailed inspections and the interim inspections should be recorded.

13.1.7 Procedures should also be established for maintenance of equipment and how this is to be recorded. Records listing all the items of equipment issued should be kept. These should refer to the rated load, safe working load, working load limit, minimum breaking strength, declaration of conformity, etc., as appropriate, and should be kept up to date. It could be helpful to include relevant comments noting where the equipment was used, its storage conditions, and any incidents that could affect its life (e.g. unusual loadings, use in chemical or gritty atmospheres). Such information could help to determine when to take an item out of service.

13.1.8 Any item showing any defect at any time should be withdrawn from service.

13.1.9 Information on inspection, care and maintenance of personal fall protection equipment should be obtained from the manufacturer and this should be strictly followed. The additional general advice given in **13.2** to **13.10** should also be followed. For an equipment inspection checklist see Annex C.

13.2 Lifespan

Some equipment is given a lifespan or obsolescence date by the manufacturer. Equipment that has reached such a limit, which has not already been rejected for other reasons, should be withdrawn from service and not used again, unless or until confirmed by a competent person, in writing, that it is acceptable to do so.

13.3 Textile equipment (anchor lines, lanyards, harnesses etc.)

13.3.1 It is important that components made from textile ropes and webbing are carefully checked, both before being stored and before being taken back into use, by being run through the hands to combine a visual and tactile examination. Kernmantel ropes should be examined visually to check that the sheath has not been cut and by feeling the rope for any damage to the core. Cable-laid ropes should be carefully twisted open at intervals along their length to inspect for internal damage. Harnesses and webbing should be checked for cuts, abrasions, broken stitches and undue stretching.

13.3.2 Textiles deteriorate slowly with age regardless of use. However, the most common cause of strength loss in textile equipment is through abrasion (either by grit working into the strands or by chafing against sharp or rough edges) or by other damage such as cuts. In order to minimize grit content, or simply to keep the product clean, soiled textile items should be washed in clean water (maximum temperature 40 °C) with pure soap or a mild detergent (within a pH range of 5.5 to 8.5), after which they should be thoroughly rinsed in cold, clean water. The use of a washing machine is permissible but it is recommended that the equipment be placed in a suitable bag to protect against mechanical damage. Wet equipment should be dried naturally in a warm room away from direct heat.

13.3.3 Internal abrasion can also occur without any ingress of grit, simply by the action of the fibres rubbing together when flexing during normal use. For most textile materials this is a slow process and is not significant. An exception is material made from aramid, which is very susceptible to this type of damage.

13.3.4 Any textile component with a cut should be scrapped, as should any with substantial abrasion. In webbing, the presence of a few small "plucks", i.e. loops of fibres pulled up from the surface, is not a cause for concern. However, as plucks can be susceptible to snagging and, thus, to further damage, they should be kept under observation.

13.3.5 Textile components that have been in contact with rust should be washed. Textile components with permanent, substantial rust marks should be regarded as suspect and scrapped. Tests have indicated that rust can have a weakening effect on polyamides.

13.3.6 It is essential to avoid contact with any chemical that could affect the performance of the equipment. These include all acids and strong caustic substances (e.g. vehicle battery acid, bleach, drilling chemicals and products of combustion). Chemical deterioration is often not detectable until the component starts to fall apart. The equipment should be withdrawn from service if contact does occur or is even suspected. Information on the effects of various chemicals on different textile materials used to manufacture personal fall protection equipment is given in Annex H.

13.3.7 Deterioration in textile equipment from contact with chemicals, or from mechanical damage, is often localized and not obvious, and can be missed during inspection. The safest course of action is to scrap any textile component about which there is any doubt. Proof load testing should not be carried out on textile components.

13.3.8 Textile anchor lines, lanyards or harnesses which have glazed or fused areas, could have suffered excessively high temperatures and are suspect. If the fibres appear powdery or if there are changes in colour in a dyed textile component, this can indicate contact with acids or other damaging chemicals. Swellings or distortion in a component made from textile rope can be a sign of damage to the fibres or, in kernmantel ropes, can be a sign of movement of the core relative to the sheath. Cuts, chafes, plucking and other mechanical damage weaken ropes and webbing, the degree of weakening being directly related to the severity of the damage. Loosening or excessive breaks in the yarns could indicate internal wear or cuts. Advice should be sought from the supplier or manufacturer, but if there is any doubt as to the condition of the component, it should be scrapped.

13.3.9 Most artificial fibres, with the exception of aramid, have relatively low melting points, for example, 120 °C to 135 °C for polyethylene (see Table H.2). Care should be taken to keep equipment made from textiles away from sources of heat and hot surfaces, to avoid them melting.

13.3.10 Most artificial fibres are affected by temperatures considerably below their melting point. They begin to change their character, and thus their performance, at temperatures exceeding 50 °C (referred to as the "glass transition temperature" of the material). Therefore, care should be taken to protect textile equipment made from artificial fibres against exposure to temperatures above 50 °C. (The rear parcel shelf of a car in hot weather, for example, can exceed this temperature.)

13.3.11 Textile equipment that has suffered a high shock load (impact force), or has had a load dropped on to it, should be scrapped.

13.3.12 Textile equipment should not normally be dyed, except by the manufacturer. Many dyes contain acids, or require the use of acids to fix the colour permanently to the textile, which could cause strength losses of up to 15%.

13.3.13 Textile equipment can deteriorate with age, e.g. by ultraviolet degradation due to exposure to sunlight and fluorescent light. It is very difficult to know by how much a textile component has degraded without testing to destruction. For example, usually the only visible clue to UV degradation is a fading of colour. Therefore it is advisable to set a period after which such equipment should no longer be used. The information supplied by the manufacturer for the component should be referred to when deciding on the length of this period. It is also important that a history is kept of the use of these components, which should ideally log the conditions in which they were used. The period after which the components are no longer to be used might need to be revised in the light of this history. Additional information on the effects of physical, external and chemical causes of damage to textiles made from artificial fibres is given in BS EN 1891:1998, Annex A.

13.4 Metal equipment (connectors, anchor line devices etc.)

13.4.1 Metal equipment should be handled with care as it can be damaged if dropped. Metal items such as connectors, anchor line devices, buckles on harnesses, descending and ascending devices and retractable type fall arresters require checking to ensure that they function correctly and smoothly, that bolts and rivets are tight and to look for signs of wear, cracks, deformation, corrosion or other damage. They should be kept clean and in particular the mechanisms should be kept free from dirt, which could otherwise impair their functioning. When dry, moving parts should be lubricated using a light oil or silicone grease. Lubrication should be avoided in areas that might come into contact with webbing fastening straps (for example the slide bar of a harness buckle), anchor lines, lanyards, etc. because it could affect the proper functioning of any fastening or adjusting arrangement. Any item showing any defect should be taken out of service.

13.4.2 Components made totally from metal can be cleaned by submerging in clean, hot water containing detergent or soap, for a few minutes. High-pressure steam cleaners should not be used because the temperature could exceed the recommended maximum of 100 °C. Seawater should not be used for cleaning.

After cleaning, the equipment should be thoroughly rinsed in clean, cold water and then dried naturally away from direct heat.

13.5 Protective helmets

The shells of protective helmets should be checked for cracks, deformation, heavy abrasion, scoring or other damage. The chin straps and cradles should be checked for wear, as should the security of any attachment points between different elements, such as sewn or riveted areas. Any helmet showing any defect should be taken out of service.

13.6 Disinfection of equipment

It may be considered necessary to disinfect equipment, for example after working in a sewer, although normally cleaning as described in **13.3** or **13.4** is sufficient. There are two things to consider when choosing a disinfectant: its effectiveness in combating disease and whether or not there will be any adverse effect on the equipment after one or several disinfections. Advice should be sought on these two points from the manufacturer or supplier of the equipment before carrying out any disinfection. After disinfection, the equipment should be rinsed thoroughly in clean, cold water and then dried naturally in a warm room away from direct heat.

13.7 Equipment exposed to a marine environment

Equipment that has been used in a marine environment should be cleaned by prolonged immersion in clean, cold fresh water, then dried naturally in a warm room away from direct heat and inspected before storage.

13.8 Storage

After any necessary cleaning and drying, equipment should be stored unpacked in a cool, dry, dark place in a chemically neutral environment away from excessive heat or heat sources, high humidity, sharp edges, corrosives or other possible causes of damage. Equipment should not be stored wet.

13.9 Equipment withdrawn from service

It is important that there is a quarantine procedure for ensuring that defective or suspect equipment that has been withdrawn from service does not get back into service without the inspection and approval of a competent person. Any equipment considered to be defective should be cut up or broken before being disposed of, to ensure that it cannot be retrieved and used again.

13.10 Alterations to equipment

Equipment should not be altered without the prior approval of the manufacturer or supplier because its performance might be affected.

14 Methods of work

14.1 Safe working methods

14.1.1 *General*

The Work at Height Regulations 2005 (Regulation 4) require that work at a height be properly planned, appropriately supervised and carried out in a manner which is safe. Those planning the work should review carefully the procedures to be followed in carrying out work at a height, examining how they can reduce the risks involved to an acceptable level in order to produce a safe system of work which should identify all the foreseeable risks that might arise from the work, including those to people other than their employees, and set out the steps to be taken to minimize these. It should also include reference to the standards of training, the competence of those undertaking the work, organization of work teams and rescue procedures.

NOTE Advice on rescue provision is given in Clause **11**.

14.1.2 *Site survey*

A site survey may be required to determine the means of access and egress, risks to people other than the employees and the nature of the working environment. Consideration should be given to how any rescue could be safely and efficiently carried out.

14.1.3 *Safety method statement*

From the risk assessment (see **6.1**), employers should then prepare a suitable work plan or "safety method statement". Where necessary, separate safety method statements should be prepared for each particular aspect of the job. In the safety method statement, the employer should set out the general principles and working procedures for the particular situation that are to be followed by their employees and by self-employed people contracted to work for them. This should be written in a clear and concise manner. In many cases, where types of jobs are similar, the safety method statements may be identical and may, therefore, be in the form of a general document. Where the work includes the use of tools such as welding torches, flame cutters and abrasive wheels which can constitute a potential hazard to the operative and his/her access equipment, a more detailed safety method statement needs to be prepared prior to the commencement of work. (See also **6.1.10**.)

14.1.4 *Permits to work*

In addition to the documents referred to in **14.1.1**, **14.1.2** and **14.1.3**, permits to work might be necessary (for example, from the client or contractor), particularly where there are hazards such as confined spaces or hot metal ducts or vents for steam or gases. The objective of such a permit to work system is to confirm that any hazard has been isolated before work starts and to ensure that it remains isolated while work is in progress.

14.1.5 *Documentation to be kept on site*

It is recommended that the following documentation should be kept on site:

a) an equipment log (or other suitable record) which lists all the equipment on site and which gives equipment identification numbers with cross reference to batch or individual test certificates, or certificates of conformity, and safe working load, where appropriate;

b) information about the use and care of any chemicals that may be used on site;

c) records of interim and detailed inspections;

d) a risk assessment and safety method statement including typical work details and standard practices (see **14.1.3**);

e) personal records (see **15.2.5**), or similar evidence of competence, to be carried by all persons who are undertaking work at a height.

Where the Construction (Design and Management) Regulations 1994 as amended apply, these regulations require the following to be kept on site:

1) a construction phase health and safety plan;

2) notification of the work, displayed on site (on Form F10).

14.1.6 *Emergency situations*

In working environments where site emergencies could occur at any time (nuclear, offshore, refineries, etc.), clear instructions should be given to those undertaking work at a height, by the employer or site manager, for dealing with emergency situations, should such a situation occur while they are working at a height.

14.2 Working practices

14.2.1 *Work teams*

14.2.1.1 Those working at a height should work in teams of at least two. The supervisor, together with their employer, should ensure before work commences that rescue procedures have been agreed upon that are adequate for the particular situation, and that sufficient resources are readily available to enable those procedures to be carried out should the necessity arise. When operating on a worksite with more than one discrete working area, separate supervision may be required for each of those discrete areas.

14.2.1.2 Where the work is to take place in a particularly hazardous or restricted area, such as one that could give rise to poisoning or asphyxiation, the training, abilities, experience, competence and size of the work team should be of a level that is suitable to deal with any emergency arising out of undertaking the work.

14.2.1.3 In some circumstances, the work team may require additional support members for safety reasons, for example, where there is a need to prevent the public entering an area that could be threatened by falling objects (see **14.7**), or to guard against vandals tampering with equipment.

14.2.1.4 Where work is carried out over water, suitable rescue equipment should be provided and measures adopted to arrange for prompt rescue of anyone falling into the water.

14.2.2 ***Pre-work checking and checks at the start of each day***

14.2.2.1 If a permit to work is required (see **14.1.4**), this should already have been obtained and checked. Any special precautions required should be put into effect (e.g. standby boat alerted, radio check, gas checks). At the start of each day, the work team should review the risks that could affect the safe, efficient and effective outcome of the job. This review should include referring to the risk assessment and safety method statement already prepared (see **6.1** and **14.1.3**).

14.2.2.2 The setting up of a system is recommended in which members of the work team check each other's personal fall protection equipment (known as a "buddy check") to ensure, for example, that harness fastening buckles and connectors are correctly fastened.

14.2.3 ***Work procedures***

14.2.3.1 The CHSW Regulations, Regulation 5, requires a safe place of work. Therefore, work should start from properly protected safe areas or areas made safe by the installation of temporary guarding or scaffolding. Such areas are also required to have a safe means of access.

14.2.3.2 Connection of a user to the personal fall protection system should be made in an area where there is no risk of a fall from a height.

14.2.4 ***Rest periods***

In calculating rest periods for individuals working at a height, consideration should be given to the effects of adverse climatic conditions and/or difficult or very exposed worksites, because these can affect efficiency and tiredness levels. Working in high and exposed places is likely to subject the person to factors such as wind chill or buffeting by the wind, which can have a significant effect on output, at even quite moderate wind speeds. Information regarding the effect of wind speed on available working times is given in Annex I.

14.3 Clothing and protective equipment

14.3.1 Those undertaking work at a height need to be appropriately dressed and equipped for the work situation and conditions. Attention is drawn to the Personal Protective Equipment at Work Regulations 1992 and other regulations covering equipment and health and safety of individuals working at a height as listed in **4.1**.

14.3.2 Working at a height can make it difficult for the individual to avoid exposure to harmful substances or climatic conditions. The employer needs to assess carefully what would be the most appropriate clothing to guard against such hazards. This protective clothing should be provided and appropriate measures taken to ensure that it is worn.

14.3.3 A useful guidance document on the Personal Protective Equipment at Work Regulations 1992, which includes the regulations themselves, is the HSE guidance document *Personal protective equipment at work* (HSE L25), published by the HSE. It should be noted that some equipment (e.g. ladders, lifting slings, drills, scaffolding, hoists) is subject to other regulations, such as the Provision and Use of Work Equipment Regulations 1998 (PUWER).

14.3.4 The Construction (Head Protection) Regulations 1989 require the wearing of protective helmets. It is advisable to follow these regulations even if the workplace is not a "site of construction" as defined in the regulations. Those working at a height should wear protective helmets that are suitable for the type of work being undertaken. Helmets that conform to standards for either industrial use (BS EN 397) or mountaineering (BS EN 12492) might be suitable. Users should check carefully the performance specification of industrial helmets conforming to BS EN 397 as they might not always be suitable, because some of the performance requirements considered necessary for the safety of individuals working at a height while using a personal fall protection system are:

a) not specified in BS EN 397, e.g. front, side and rear energy absorption capacity;

b) not mandatory in BS EN 397 (i.e. they are only optional), e.g. the provision of a chinstrap and fastening arrangement, low temperature performance and ventilation.

Helmets utilizing expanded polystyrene shells (common in helmets conforming to BS EN 12492) are unlikely to withstand the rigours of industrial use and, therefore, are not recommended.

Chinstraps on helmets used in work at a height should be of a design such that when the strap is properly fastened, it prevents the helmet from coming off the head. This is typically achieved by the use of "Y"-shaped straps where the two top points of the "Y" are attached to the shell of the helmet. Helmets should always be used with the chinstrap fastened. In some work situations, it might be desirable for helmets to be compatible with complementary personal protective equipment such as visors or ear defenders.

14.3.5 Individuals working at a height should wear the following:

a) protective clothing (e.g. overalls) that has no loose flaps or attachments which might be caught in any moving equipment. Pockets should be fitted with zip or touch-and-close type fastenings rather than buttons. Waterproof and/or windproof clothing should be provided for work in wet and/or windy conditions;

b) suitable footwear, which fits well, provides a good grip and gives an adequate level of protection for the task being undertaken.

14.3.6 If equipment is to be fitted to the user (e.g. a harness, see **12.6**), it is important that it is comfortable to wear and fits the wearer properly when correctly adjusted. This should be ascertained in a safe place, before work commences. It is also important that such equipment does not significantly hinder the wearer from carrying out their duties or from properly manipulating the personal fall protection equipment.

14.3.7 The following protective items might also be required. The HSE guidance document referred to in **14.3.3** gives advice on the selection, use and maintenance of most of these.

a) *Gloves*, to protect against cold weather or where the equipment or materials used might cause injury to, or have harmful effects on, the skin.

b) *Eye protection*, where debris is being cleared or material is being chipped away, or where drilling, blasting or percussion operations are being undertaken or where chemicals are being sprayed or painted which could cause irritation or damage to the eyes.

c) *Respiratory protective equipment*, where there is a risk of inhalation of harmful chemicals or dusts.

d) *Hearing protectors*, when the noise levels in the vicinity could cause a risk of hearing loss to operatives.

e) *Buoyancy or life jackets*, when working over water. These should be of a type capable of being secured to the wearer so that they cannot accidentally come loose in the event of a fall. In addition, they should not obstruct the wearer or prevent the efficient operation of the personal fall protection equipment.

f) *Protection against sunburn*, for example, by the use of a sunscreen.

14.4 Safety precautions for personal fall protection equipment

14.4.1 *General*

Precautions should be taken to ensure that the personal fall protection equipment is protected against the following:

— exposure to corrosive and other potentially damaging substances such as alkalis, acids and other corrosive chemicals and their fumes, and greases and oils (see Clause **12**);

— damage from sharp or rough edges (see **14.4.2**);

— damage by impacts from heavy items and crushing under heavy items;

— exposure to extreme climatic conditions when in transit and storage (e.g. direct sunlight, rain and temperatures below freezing point);

— exposure to direct heat and temperatures in excess of 60 °C (see Clause **13**);

— burning of any textile parts of the equipment when adjacent to welding operations, or to joining operations using hot adhesive dispensers.

14.4.2 *Avoidance of sharp edges*

Users should guard against lanyards or anchor lines passing over sharp or rough edges, which could result in the lanyard or anchor line being cut, resulting in the user going into a free fall. In a fall arrest situation, this danger is greatly increased in the event of a swing fall (see **9.5.7.2**), where the lanyard or anchor line would be pulled across the edge in a slicing action (see Figure 23b). Anchor point positions should be avoided which would give rise to the possibility of the lanyard or anchor line being pulled over an edge in the event of a fall. Where such anchor point positions cannot be avoided, a means of protecting the lanyard or anchor line should be used, e.g. cut resistant sleeving.

14.5 Use of tools and other work equipment

14.5.1 It is essential that any tools and equipment used in the work do not endanger the users' health and safety.

14.5.2 Individuals undertaking work at a height should be appropriately trained in the correct use of tools and other work equipment (see Clause **15**).

14.5.3 It is important that all tools and equipment are suitable for the work intended and compatible with the fall protection equipment. In particular, they should not present a danger to the safe operation or integrity of the fall protection equipment. Guards provided to moving parts, electrical conductors etc. should not be removed.

14.5.4 Where tools and equipment are carried by individuals working at a height, appropriate steps should be taken to prevent them being dropped or falling on to people below (see **14.7**).

14.5.5 All electrical equipment, plugs, sockets, couplers, leads, etc. should be suitable for the environment in which they are to be used.

NOTE Attention is drawn to the Electricity at Work Regulations 1989.

14.6 Communications systems

An efficient communications system should be established between all individuals working at a height and, where necessary, between them and third parties (e.g. supervisors). It is essential that this is agreed and set up before work starts and that it remains in effect for the entire time that the individuals concerned are at work.

14.7 Protection of other people

14.7.1 Precautions should be taken to prevent equipment or materials falling in such a way that they could be a danger to other people. These should be appropriate to the particular situation. Advice is given in HSE guidance document *Protecting the public — Your next move* [11].

14.7.2 When work is carried out over or near public places, the provisions of the Highways Act 1980 could apply, and advice should be obtained from the appropriate local authority.

14.8 Completion of work at the end of a shift

At the end of each shift, fall protection equipment should be secured or stored safely.

15 Aptitude, fitness and training

15.1 General

15.1.1 The modern industrial environment requires that, to work at a height safely, competently and productively, those engaged in such work have an appropriate attitude, aptitude, physical capability and training.

15.1.2 These individuals might work in remote places and/or without direct supervision. It is, therefore, especially important that they can be always relied upon to behave in a sensible and responsible manner.

15.1.3 Individuals undertaking work at a height should be physically fit and free from any disability that might prevent them from working safely at a height. Contra-indications include:

— heart disease/chest pain;
— high blood pressure;
— epilepsy, fits, blackouts;
— fear of heights/vertigo;
— giddiness/difficulty with balance;
— impaired limb function;
— uncorrected visual impairment;
— alcohol or drug dependence;
— psychiatric illness.

15.2 Training

15.2.1 All individuals undertaking work at a height should be trained to a formal programme, formalized in both time and performance, and be assessed at the end of the training programme. Training needs and the level of training should be clearly defined. This should include refresher training.

15.2.2 In addition to the use of personal fall protection equipment, training should include general and job-specific health and safety issues, the safe use of tools and other work equipment during work at a height, and the handling of materials.

15.2.3 All users of personal fall protection systems and equipment are in the learning process for some time after completing their initial training. The newly trained user should at first be under close supervision, for example by the supervisor, or by an experienced user, at the supervisor's discretion. At this stage, the person supervising should be required to check that all items of the inexperienced user's personal fall protection equipment are correctly secured before they are allowed to start work. They should not be allowed to work without close supervision until the supervisor is satisfied that the new user has achieved a suitable level of competence. This should be when they have demonstrated suitable knowledge and experience to carry out the full range of jobs that they are likely to encounter, in a safe and effective manner, and are capable of acting properly within the limits of their level of competence and in any emergency that might conceivably arise. This is particularly important for individuals who are young or who are undertaking this kind of work for the first time.

15.2.4 It is essential that individuals undertaking work at a height are competent in appropriate rescue techniques and emergency procedures, and these should form part of their initial and ongoing training. In addition to this, rescue techniques should be practised at regular intervals and before the start of any work in a situation that is unfamiliar to any of the work team (see Clause **11**).

15.2.5 Individuals who undertake work at a height should have a personal record showing the training received and describing their work experience. This is to assist employers in the verification and monitoring of the individual's experience. Employers taking on new employees should assess these records.

15.2.6 It is essential that employers maintain their employees' level of ability. This requires a re-assessment at regular defined intervals and further training where necessary. Retraining is appropriate for individuals who have had a significant break from work at a height (e.g. 6 months or more). This could be either a refresher course or a full course at the appropriate level. All refresher courses should include all the techniques covered on the initial training course.

16 Anchors

16.1 General

16.1.1 The attachment of a personal fall protection system is made to an anchor point. Anchor points may be incorporated in the structure itself or be incorporated in an anchor device, of which there are several types (see **16.1.4**).

16.1.2 Attachments can be made, for example, to:

a) a permanent feature of the building or structure intended to be for attachment of a personal fall protection system, e.g. a hole drilled in a steel beam or an eye welded to it;

b) a purpose made anchor device, e.g. an eyebolt fixed either permanently or temporarily to a building or structure;

c) a natural geological feature, e.g. a sound stone bollard on a rock face, around which a lanyard can be placed;

d) a feature of the building or structure, e.g. a girder or a structural column, around which a lanyard can be placed.

NOTE 1 In examples c) and d) the lanyard is known as an anchor sling.

NOTE 2 Anchor slings designed to go around girders or other structures are also known as girder straps. These are used to connect to girders and other structures which are too large for ordinary connectors. An example of the use of a girder strap is shown in Figure 40, view D.

16.1.3 In the examples given in **16.1.2** a) and b), the anchor point is the hole in the beam, the welded eye and the eye of the eyebolt, respectively. In the examples given in **16.1.2** c) and d), the anchor point is the point at which the ends of the anchor sling are connected together, i.e. the connector linking the two ends.

16.1.4 BS EN 795 specifies six classes of anchor device as follows:

— Class A1: anchor devices designed to be secured to vertical, horizontal and inclined surfaces, e.g. walls, columns, and lintels, for example eyebolts;

— Class A2: anchor devices designed to be secured to inclined roofs;

— Class B: transportable temporary anchor devices, e.g. a tripod over a confined space, or an anchor sling;

— Class C: anchor devices for use with horizontal flexible anchor lines;

— Class D: anchor devices for use with horizontal rigid anchor lines (e.g. rails);

— Class E: dead weight anchors for use on horizontal surfaces.

16.2 Strength and reliability of anchors

16.2.1 Anchors should be unquestionably reliable. It is essential that they have an adequate margin of strength and stability to withstand the dynamic and static forces that could be applied to them in service. A safety factor of 2.0 should be applied when calculating the required static strength of an anchor device in a personal fall protection system. Thus, for a personal fall protection system that could be called upon to arrest a fall, for single person use an anchor device with a minimum static strength of 12 kN should normally be used (see **12.2**).

16.2.2 Anchor devices (e.g. eyebolts) should conform to BS EN 795. BS EN 795:1997 specifies a minimum static strength of 10 kN for anchors for single person use. A safety factor of 2.0, as recommended in **16.2.1**, can be obtained in one of the following ways using an anchor device conforming to BS EN 795:

a) use of an anchor device with a higher static strength than the minimum specified;

NOTE Many anchor devices conforming to BS EN 795 have a static strength of 12 kN or more.

b) positioning the anchor device to limit the free fall distance;

c) including an energy absorber in the personal fall protection system, such that the impact force in the event of a fall would be limited to 5 kN. In this case, the installer or specifier should specify the equipment to be used with the anchor device.

16.2.3 If two or more users are to be connected to the same anchor, either independently or via the same anchor line, it is essential to allow for the possibility that they could fall at the same time. For two person use, the necessary minimum breaking strength of the anchor, without allowing for a safety factor, is 6 kN per person, in the direction of loading in service (see **12.2**). If more than two users are to be connected to the same anchor, because it is extremely unlikely that more than two of them will fall at the same time, the minimum breaking strength of the anchor needs to be increased by only 1 kN for each additional user. Thus, to maintain a safety factor of 2.0 the minimum static strength of an anchor for two person use should be 24 kN; for three person use it should be 26 kN; for four person use 28 kN, and so on.

16.2.4 When calculating the required strength for anchor devices, designers using limit state methods should take the appropriate minimum static strength as the design load and calculate the design resistance based on a value of γ_m chosen to suit the material from which the anchor is manufactured. Multiples of this design resistance should be applied for multi-person use. It is essential that an anchor when in place is able to withstand a static force equivalent to the relevant design resistance at least once in the direction in which the force would be applied if a fall were to be arrested. It is not recommended that the anchor be subjected to static testing with this force when in place. However, in order to ensure that the anchor is unquestionably reliable it might be necessary, where practicable, to carry out testing of anchor devices fixed in the medium in which they are to be fixed on site, e.g. concrete of a particular mix. See also BS 7883.

NOTE While, the current edition of BS EN 795 specifies a minimum static strength of 10 kN for anchors for single person use, in the revision of EN 795, which is in preparation, it is expected that a minimum static strength of 12 kN will be specified, and this value has therefore been adopted in the present standard. However, for rope access methods for industrial purposes see BS 7985:2002, **12.3.5.2**.

16.2.5 The question of proof load testing at periodic intervals is not addressed in this British Standard. If proof load testing is proposed careful consideration needs to be given to the effect on the anchor and the substrate to ensure that the subsequent integrity of the anchor and its placement is not compromised. The manufacturer of the anchor device should be consulted for advice. Advice on periodic proof loading of class A1 anchor devices conforming to BS EN 795 is given in BS 7883.

16.3 Installation of anchor devices

16.3.1 Installation of anchor devices of the types that are fixed in masonry or to roofs should only be carried out by persons competent to do so. If any doubt exists as to the structural adequacy of an anchor device, a qualified engineer should be called in to make an assessment and provide a written statement of the combinations of loads in a worst case situation that the anchor device can safely carry. Further guidance on the installation of anchor devices conforming to BS EN 795 is given in BS 7883.

16.3.2 When installing a horizontal flexible anchor line (which comes under BS EN 795 Class C, see **16.1.4**), the installer should ensure that:

— the anchor line deflection under load and the position of the anchor line supports are taken into consideration when assessing the required free space below the user in case of a fall (see **9.7**);

— the positions of the intermediate and extremity anchors, and the maximum distance between anchors, are strictly in accordance with the manufacturer's instructions.

16.3.3 Where dead weight or counter-balance anchor systems are used, particular account should be taken of cantilever and frictional effects. It is especially important to be aware that wet or icy conditions can significantly affect the frictional performance of anchor-weight systems. The frictional resistance of any anchor weight should be assured by checking that it does not move when subjected to a load of four times that which will be applied in a work positioning situation. Users should also consider the possibility of rescue, which might involve the weight of two persons.

16.3.4 Anchor slings can be made from textiles, e.g. webbing, or steel wire rope or chain. The included angle formed between the two ends of the anchor sling, where they meet at the connector (which forms the anchor point), should be as low as possible and should generally not be more than 90°. The greater the angle beyond this, the greater the loading will be (see Figure 49). The angle should never exceed 120°. Great care should be taken not to put a three way loading on the connector, unless the connector is designed to allow this (see **12.5**).

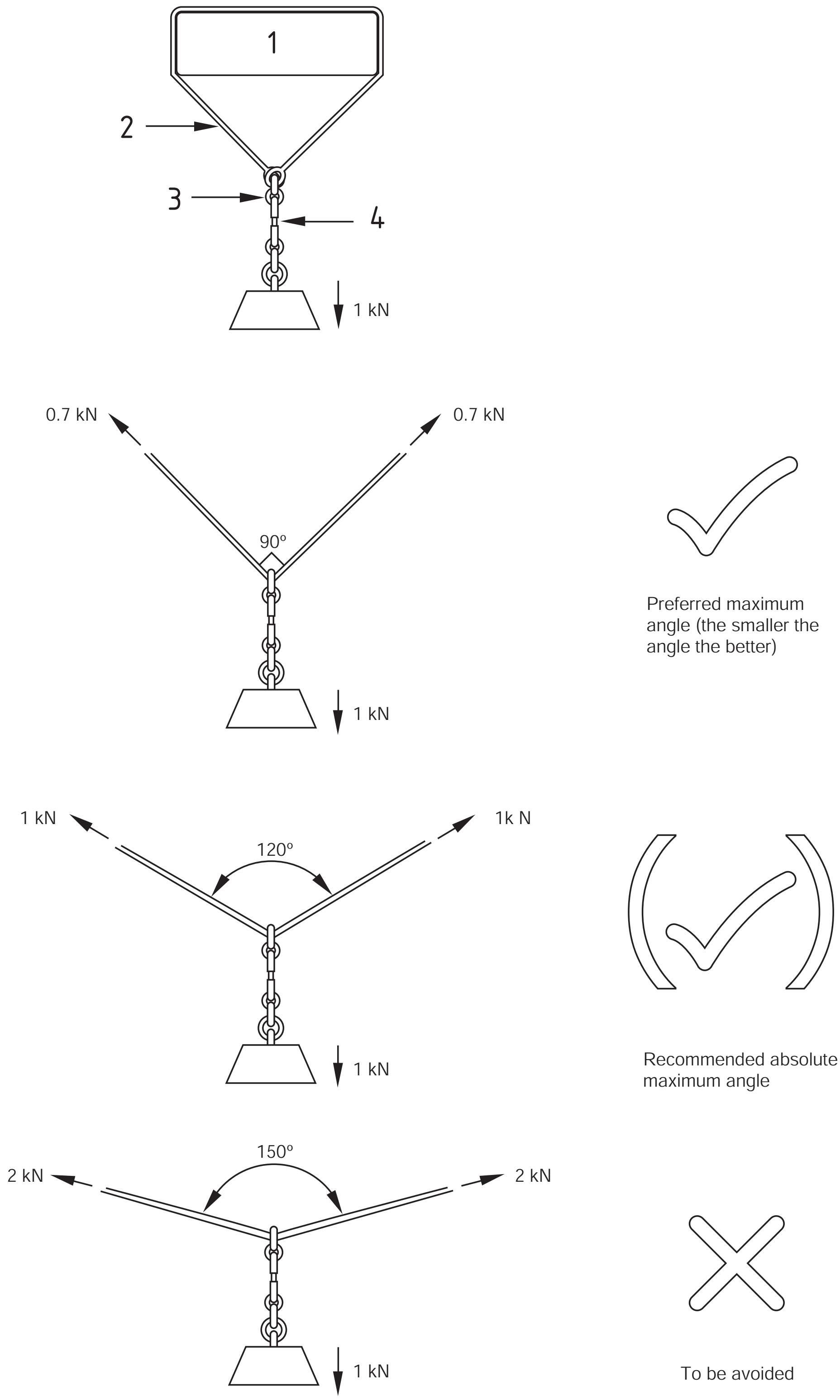
16.3.5 Anchor slings made from textiles should have a minimum breaking strength of 22 kN. The minimum strength of anchor slings made from wire rope or chain should be 15 kN. Because of the weakening effect, the looping of anchor slings or other lanyards through themselves (known as "lark's footing" or "choking") should be avoided, unless they are specifically designed to allow this, for example by provision of special loops along their length.

16.3.6 Users should be aware that neither BS EN 795, which specifies anchor devices, nor BS EN 360, which specifies retractable type fall arresters, nor BS EN 355, which specifies energy absorbers, specify tests for fall arrest systems in which:

— a full body harness is connected via a retractable type fall arrester to an anchor device using a connector;

— a full body harness is connected to an anchor device via an energy absorbing lanyard using connectors.

Users wishing to employ such a combination of components should seek confirmation from the relevant manufacturers that their products are safe to use in this way.



Key

1 Anchor	3 Anchor point
2 Anchor sling	4 Anchor line or lanyard

Figure 49 — Example of the increase in loading on an anchor line or anchor sling caused by an increase in the angle at the anchor point

16.4 Additional recommendations for anchor points for particular types of personal fall protection equipment

16.4.1 *Anchor points for restraint systems*

Anchor points for restraint systems should be strong enough and stable enough to restrain the user at the extremes of their range of movement. For single person use, it is recommended that the minimum breaking strength of the anchor point should be equivalent to at least three times the user's body mass in the direction in which the load is to be applied in service.

Where several users are to be connected to the same anchor point, the recommended minimum breaking strength is that equivalent to at least three times the combined body mass of the users, in the direction in which the load is to be applied in service.

NOTE For example, three users, each with a body mass of 100 kg, all connected to the same anchor point for restraint purposes, would require an anchor point with a minimum static breaking strength equivalent to $3 \times 100 \times 3 = 900$ kg, which would be approximately 9 kN.

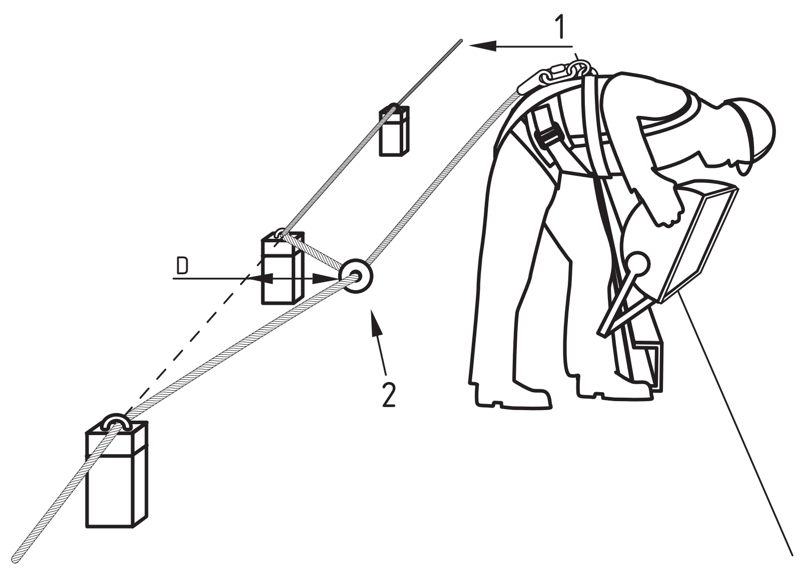
Where a horizontal anchor line is used, it should be so positioned that any deflection generated by a user pulling on it at the extreme of their range of movement does not allow a free fall to take place (see Figure 50).

16.4.2 *Anchor points for work positioning systems for technique 2*

Separate anchor points should be provided for the work positioning anchor line and for the safety back-up system (see **10.2.3.1**). The two anchor points may be interconnected by means of the work positioning anchor line and the back-up system.

16.4.3 *Anchor points for permanently and temporarily installed vertical anchor lines*

The upper anchor point should have an adequate margin of strength and stability to withstand the dynamic forces that would be applied to it in the event of a fall being arrested (see **16.2.1**).



Key

1 Horizontal flexible anchor line

2 Mobile attachment point

D Deflection of anchor line by user

Figure 50 — Example of a restraint system using a flexible horizontal anchor line, showing deflection of the anchor line by the user

16.4.4 *Anchor points for horizontal rigid and flexible anchor line systems*

Because each installation has a unique design configuration, and because fall arrest loads are applied perpendicularly to the horizontal member, loads are transmitted, magnified and shared throughout systems in a complex manner. It is essential that these factors are taken into account by a competent installer, working in accordance with the manufacturer's instructions, when determining the strength requirements for the anchor points. The general recommendation is that any anchor point within the system should have a minimum breaking strength of at least twice the load which can be applied to it in the direction of loading in service.

16.5 Intermediate support brackets for vertical and horizontal rigid anchor lines

The intermediate support brackets should have an adequate margin of strength and stability to withstand the dynamic forces that could be applied to them in the event of a fall being arrested. The magnitude and sharing of the forces between the brackets are dependent on the design of the fall arrest system. Greater margins of strength and stability should be allowed in the situation where two or more users are to be connected to the same rigid anchor line, to cater for the possibility that they might fall at the same time, because this would produce greater dynamic forces. There are other considerations, such as rescue requirements, which might also require the margins of strength and stability to be higher.

16.6 Choosing anchor point positions for fall arrest systems

16.6.1 *Choosing anchor point positions to minimize free fall distance*

NOTE The free fall distance is that distance through which the user would fall before the fall arrest system begins to arrest the fall, measured from the user's position prior to the fall.

Where possible, an overhead anchor point should be used. Should a fall occur, this position minimizes the free fall distance, and therefore minimizes the fall arrest distance and the potential for injury. An anchor point below the user's head level should only be considered as a second choice, and only in circumstances in which its use can be justified. Use of an anchor point at foot level is not recommended and should be avoided wherever possible because this position allows the greatest free fall distance and therefore the risks of injury are increased (see **9.1.3.1** and Figure 9).

Most retractable type fall arresters require an anchor point directly above the user (see **9.3.7.3**).

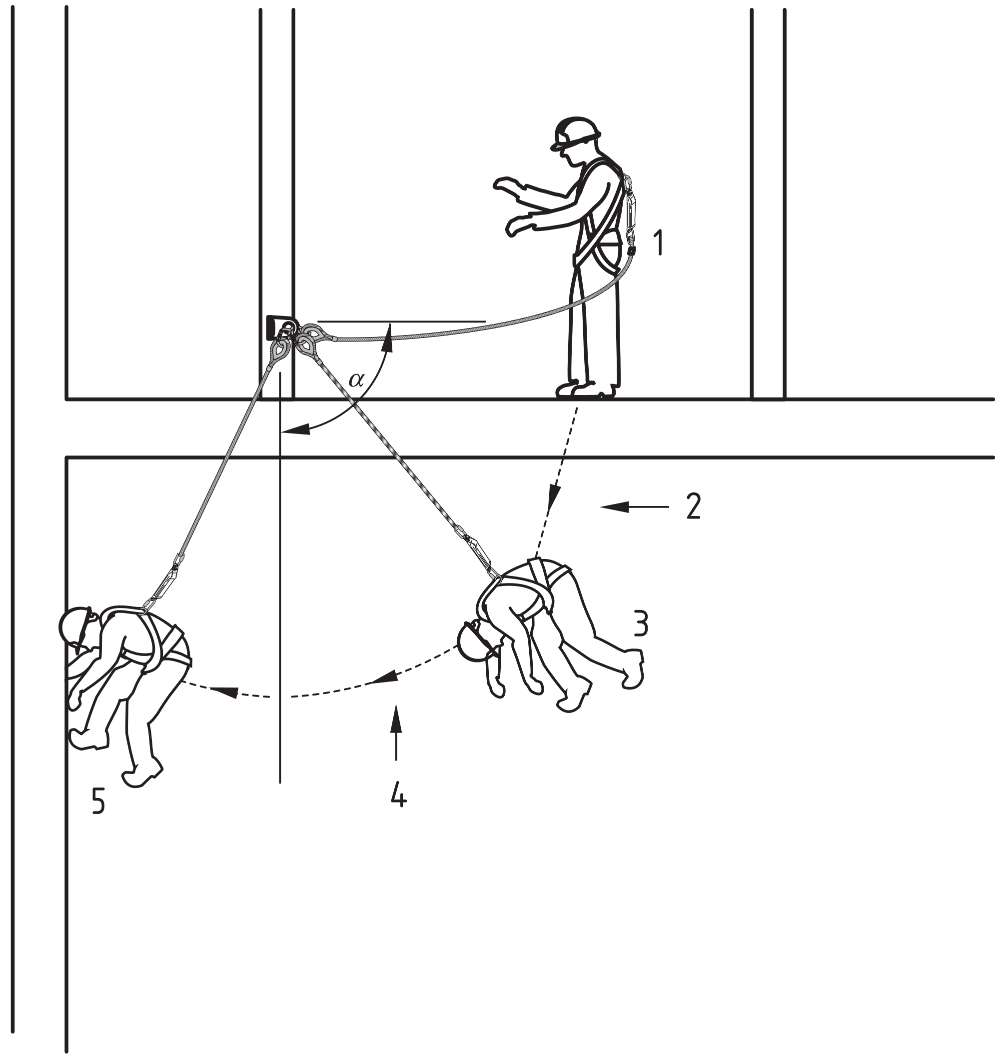
For guidance on requirements for free space below the user of a fall arrest system see **9.7** and Annex F.

16.6.2 *Choosing anchor point positions to minimize swing falls*

NOTE A swing (or "pendulum") fall is a fall in which at the point of fall arrest the vertical trajectory of the user is diverted into a swing or pendular trajectory with significant horizontal velocity.

In order to minimize the size of swing falls, an anchor point position should be used which keeps the angle α (as shown in Figure 51 and Figure 52) as small as possible. This is especially important in areas where the proximity of surrounding structures could present a collision risk. Most manufacturers of retractable type fall arresters give an upper limit on the angle α when the system is in use of 30º to 40º. If the user needs to move horizontally along the structure, then a second anchor point should be used which is more vertically above the intended work area, or a horizontal rigid anchor line should be used, permitting the point of attachment to move with the user (see **9.5**).

These principles also apply to temporarily installed vertical anchor lines.



Key

1 Position of user before fall

2 Free fall trajectory

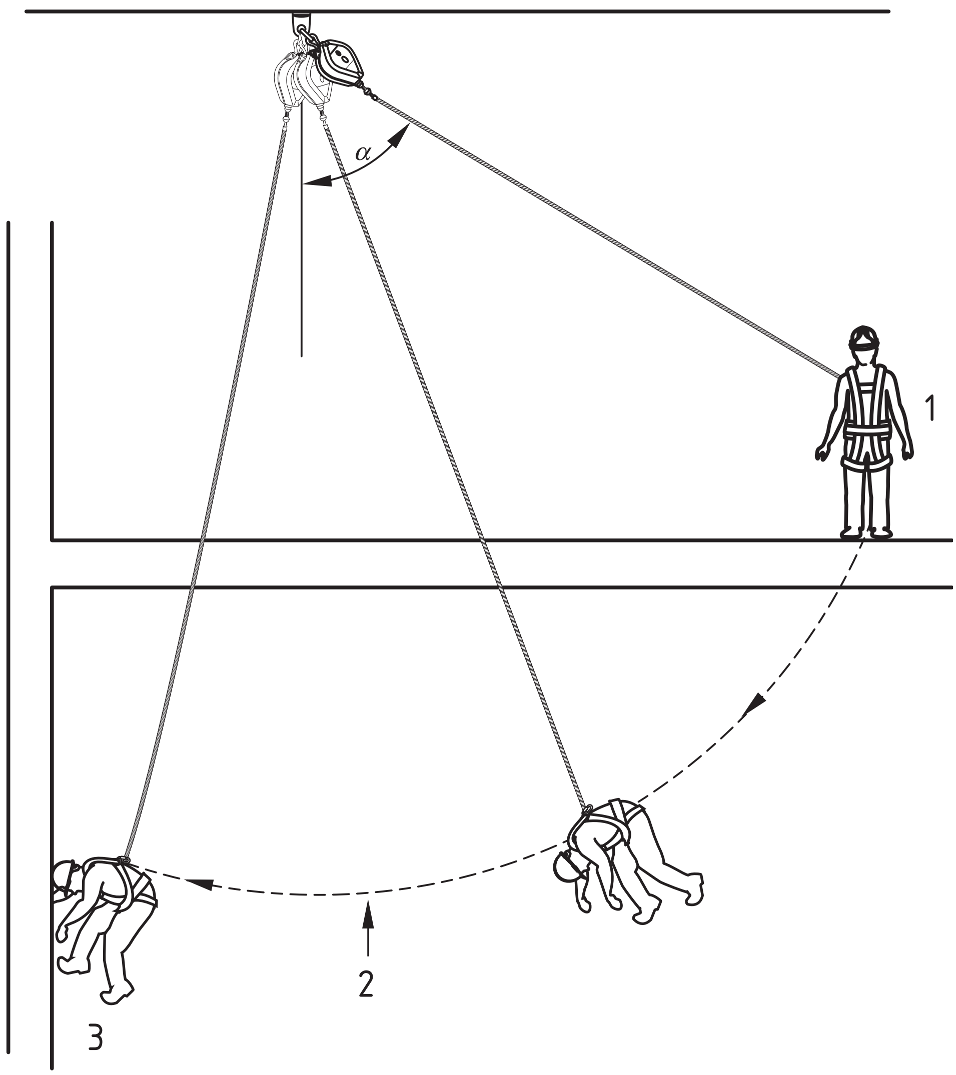
3 User at end of free fall

4 Swing fall trajectory

5 User collides with structure

α Angle between the energy absorbing lanyard and the vertical

Figure 51 — Danger of a swing fall when using an energy absorbing lanyard



Key

1 Position of user before fall

2 Swing fall trajectory

3 User collides with structure

α Angle between the retractable lanyard and the vertical

Figure 52 — Danger of a swing fall when using a retractable type fall arrester

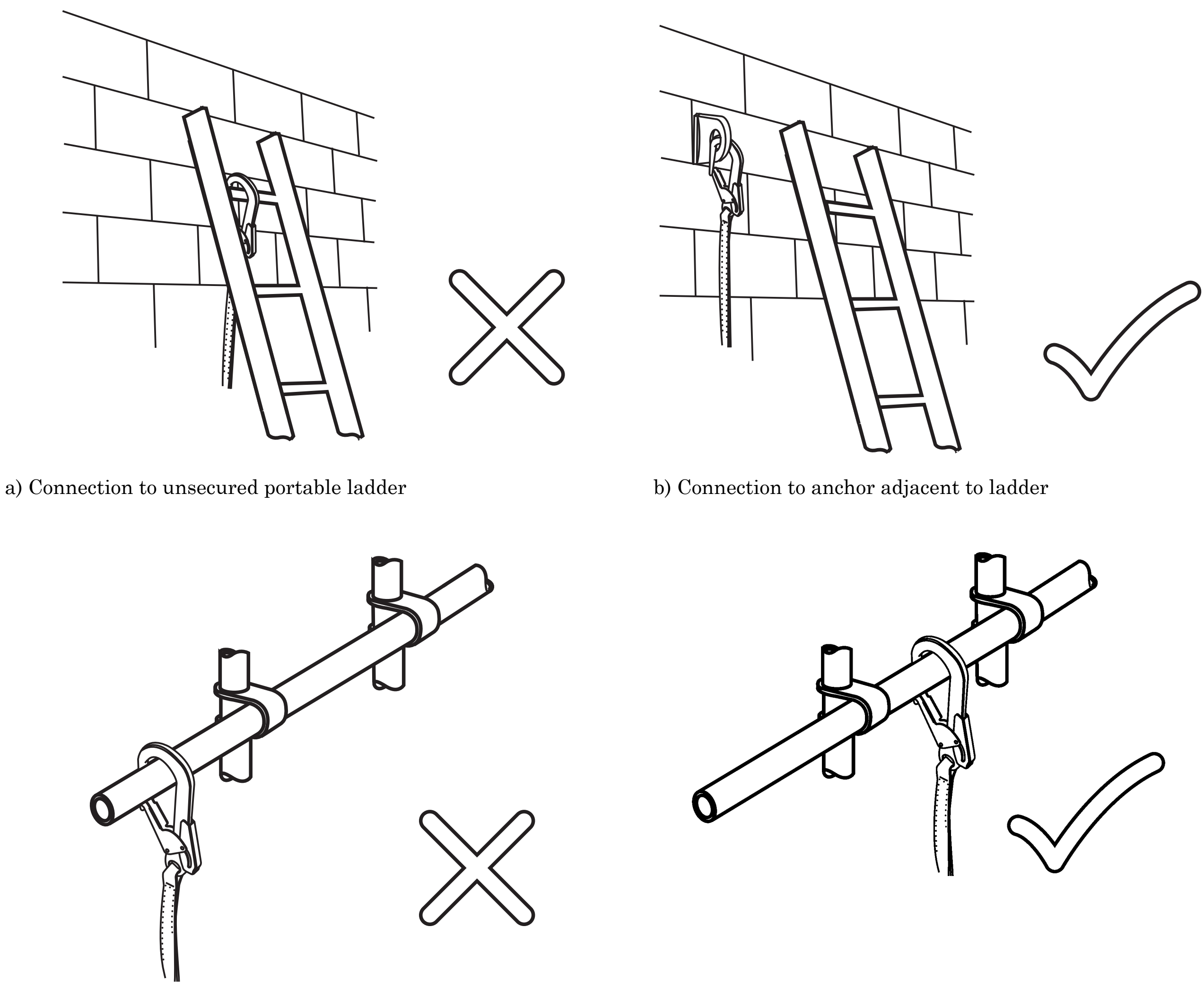
16.6.3 *Avoiding potentially dangerous anchor positions*

16.6.3.1 *Portable ladders*

Personal fall protection systems should not be connected to portable ladders that are leaned against a structure for the purpose of access (see Figure 53a), as a fall can lead to both the ladder and the user falling to the ground. The personal fall protection system should be connected to an anchor adjacent to the ladder (see Figure 53b). A connection to a portable ladder should only be made if the top of the ladder is adequately secured and the system has been tested connected to such a ladder.

16.6.3.2 *Beams and cantilevers*

Personal fall protection systems should not be connected to open ended beams or cantilevers (see Figure 53c), as an initial fall arrest can cause the connection to slip off the open end of the beam or cantilever, resulting in the user falling to the ground. Connections to beams and cantilevers should only be made between supports (see Figure 53d).



a) Connection to unsecured portable ladder

b) Connection to anchor adjacent to ladder

c) Connection to open ended beam

d) Connection to beam between supports

Figure 53 — Examples of correct anchor positions and of incorrect (potentially dangerous) anchor positions

Annex A (informative) Basic principles of protection against falls from a height

A.1 There are two essential elements in the protection of persons against falls from a height. The first element is the primary support and the second element is the fall protection system. A detailed explanation of how this applies in practice is given in **A.2** to **A.7**.

A.2 In the case of a person working on an upper floor of an office block, for example, the primary support is the floor and the fall protection system is the walls surrounding that floor which prevent the person reaching zones where the risk of a fall from a height exists, i.e. the edge of the floor.

A.3 When that person goes from one floor to another by means of the stairs, the primary support is the stair treads. The fall protection system is the balustrade and handrail at the side of the stairs, which prevents a fall off the side of the stairs into the stairwell. In the case of a staircase, identification of the hazard presented by the stairs and assessment of the risk of a fall from a height, are carried out at the building design stage, and the risk is minimized by the design of the stairs, e.g. the angle at which the staircase is placed, the rise and depth of the steps, the distance between landings, the type of balustrade and the height of the handrail.

A.4 In the case of a person working on a flat roof, the primary support is the roof. The fall protection system might be a barrier around the edge of the roof. In the absence of a barrier the person would need to be equipped with a personal fall protection system, in this case a restraint system. Again, the fall protection system (the barrier or the restraint system) prevents the person from reaching zones where the risk of a fall from a height exists, i.e. the edge of the roof.

A.5 If the roof that the person is working on is at an angle, and that angle and the amount of grip is such that the person will slip down the roof if not supported, a work positioning system including an independent safety back-up system is essential. The work positioning lanyard or the anchor line constitutes the primary support and the back-up safety system provides the second element, i.e. fall protection.

A.6 Suspended platforms and scaffolding platforms can also be classified as work positioning systems. In this case the primary support is the platform. The fall protection system would be the guard rail around the platform. Additional fall protection could be provided by a personal fall protection system for each person working on the platform, for example, by a restraint system or by a fall arrest system.

A.7 If a person is working on a structure in such a situation that if they lose controlled physical contact with the structure they will fall, the primary support is the structure itself. In this situation, fall protection has to be provided by a fall arrest system.

Annex B (informative) Harness comfort and adjustability test

B.1 General

This annex gives a test procedure for assessing the comfort of a harness when worn by the intended user while suspended, as they might be during normal work activity or following a fall. The adjustability of the harness when worn by the intended user is also assessed. The test is suitable for belts with sub-pelvic support, sit harnesses and full body harnesses. It should not be used for belts without sub-pelvic support or for chest harnesses.

B.2 Safety precautions

B.2.1 Part of the test procedure involves the user being suspended clear of the ground while wearing the harness. The test should be carried out in a safe place, with at least one other person present, preferably someone who is appropriately qualified in first aid for dealing with emergencies involving persons working at a height. The test should be arranged so that when the user is suspended, there is only a small clearance between the user's feet and the ground, e.g. 100 mm. A means of support should be provided, e.g. a wooden box, of a height slightly greater than the clearance between the user's feet and the ground so that if the user finds the harness too painful, or experiences any other discomfort, they can immediately put their feet on it to support their weight.

B.2.2 If the user experiences any unacceptable pain at any time during the test procedure, the test should be stopped immediately. The test should also be stopped immediately if the user experiences any of the following:

— faintness or dizziness;

— breathlessness;

— sweating or hot flushes;

— nausea;

— loss or greying of vision;

— an increase in pulse rate.

NOTE In the extremely unlikely event of any of these symptoms occurring, the user should be removed from suspension immediately and sat on the floor with their knees raised and their back against a wall or other raised support until the symptom(s) disappear. Gentle tensing and relaxing of the leg muscles while in this position, e.g. by raising the toes while keeping the heels on the ground, can help. If the symptoms persist for more than a few minutes, the user should be gradually moved into a more substantially horizontal position over a period of 20 min to 40 min and their transfer to hospital arranged as quickly as possible. Medical personnel should be advised that orthostatic shock is suspected.

B.2.3 The test involves testing in turn each of the attachment points on the harness that is intended to be used in practice. The test of each attachment point should have a maximum duration of 4 min, and the user should have a break of at least 5 min between tests. While in suspension the user should move their legs regularly to maintain circulation, and during the breaks they should exercise their legs, for example by walking about.

B.3 Procedure

B.3.1 The procedure detailed in **B.3.2** to **B.3.7** should be carried out for each of the harness attachment points designated by the manufacturer that are intended to be used by the user. If the harness has side waist attachment points these should always be tested in pairs (see **12.6.4**). The user should be directly supervised throughout the procedure.

B.3.2 The user should don the harness in accordance with the manufacturer's instructions and adjust it to ensure a snug fit.

B.3.3 A lanyard and a connector suitable for fall arrest purposes should be used. One end of the lanyard should be attached to the attachment point, or points, under test using the connector. The other end of the lanyard should be attached to an anchor that is sufficiently strong to support the user's mass with a safety factor of at least 10. This anchor should be positioned such that the user can be suspended with their feet just clear of the ground. One way to do this is to raise the user by means of a winch.

B.3.4 The duration of the test should be timed with a stop-watch. Subject to the safety precautions given in **B.2**, after a minimum of 3 min 45 s and a maximum of 4 min the test should be stopped and the user lowered to the ground.

B.3.5 One minute after the start of the test, the harness should be checked to determine whether it is still properly adjusted to fit the user snugly. After the first minute, adjustment of the harness while the user is in suspension may be made at any time during the test. If necessary, the test may be temporarily stopped and the harness readjusted in accordance with the manufacturer's instructions. The time taken to adjust the harness while the user is not in suspension should be added to the suspension time given in **B.3.4**.

B.3.6 During the test, while the user's feet are off the ground, the harness should be examined to determine whether:

a) any metal fitting is in contact with the groin, the inside of the thighs, the armpits or the small of the back;

b) any part of the harness is exerting direct pressure on the genitals, head or neck.

In addition, the user should note whether they experience any of the following:

1) any loss of feeling (numbness) or tingling ("pins and needles") in any part of the body;

2) any restriction of normal breathing.

In addition to the safety precautions detailed in **B.2**, if the harness is in contact or causing pressure as detailed in item a) or b), or if the user experiences any of the symptoms listed in items 1) and 2) the test should be stopped immediately.

B.3.7 During the test, while their feet are clear of the ground, the user should carry out the following movements to determine whether the harness allows adequate freedom of movement:

a) hold the left foot with the right hand, then release;

b) hold the right foot with the left hand, then release;

c) hold both hands together at full stretch above the head, then release;

d) hold both hands together behind the waist and then release.

B.3.8 After the suspension test is completed, and with the user standing on the ground, the amount of adjustment in each adjustment element of the harness, e.g. the length of strap ends, including any length required for locking the adjusters, should be checked to ensure there is sufficient adjustment to allow for less or additional clothing to be worn for the expected conditions of work, for example, in hot or cold weather.

B.4 Evaluation of results

The harness can be judged as suitable if all the following conditions are met.

a) It was not necessary to stop the test for any of the reasons given in **B.2** or **B.3.6**.

b) The user was able to carry out the movements listed in **B.3.7** a) to d) with relative ease.

c) The harness was considered to be sufficiently adjustable for the user in the expected conditions of work, when assessed in accordance with **B.3.8**.

Annex C (informative) Equipment inspection checklist

An equipment inspection checklist is given in Table C.1.

Table C.1 — Equipment inspection checklist

Component	Inspection procedure
All textile equipment	*General checking procedure for all textile equipment* ☐ Have you read the information supplied by the manufacturer? ☐ Is the product within the manufacturer's recommended lifespan? Visual — Check for: ☐ Excessive wear to any part ☐ Abrasion, particularly to load-bearing parts ☐ Furry webbing or rope (this indicates abrasion) ☐ Stitching cut, broken or abraded ☐ Cuts, particularly to load-bearing parts ☐ Dirty webbing or rope (dirt accelerates abrasion, both externally and internally) Visual and tactile — Check for: ☐ Damage by chemicals. Powdery surface ☐ and/or discolouration ☐ and/or hardened areas ☐ (these often signify chemical contamination) ☐ Damage by heat, e.g. glazed areas Action: ☐ Product beyond recommended lifespan: remove from service ☐ Excessive wear to any part: remove from service ☐ Abrasion: a small amount is permissible. Remove from service if excessive ☐ Cuts: remove from service ☐ Dirty: clean according to manufacturer's instructions ☐ Chemical contamination: remove from service ☐ Heat damage: remove from service ☐ Stitching cut, broken or abraded: remove from service If in doubt on any point, remove from service

Table C.1 — Equipment inspection checklist (*continued*)

Component	Inspection procedure

Harnesses	*Checks in addition to the general checking procedure for all textile equipment*
	
	Visual and tactile — Check:
	☐ Inside and outside any textile attachment point loops for all the features listed under the general checking procedure
	☐ Fastening and adjustment buckles for:
	    ☐ correct assembly
	    ☐ correct functioning
	    ☐ excessive wear
	    ☐ corrosion
	    ☐ cracks
	    ☐ other damage
	☐ Other safety critical metal or plastics components for:
	    ☐ correct functioning
	    ☐ corrosion
	    ☐ cracks
	    ☐ other damage
	
	Action:
	☐ Textile attachment point loops: treat in accordance with general checking procedure
	☐ Fastening and adjustment buckles, other safety critical metal or plastics components:
	    ☐ Excessive wear: remove from service
	    ☐ Corrosion: remove from service
	    ☐ Cracks: remove from service
	    ☐ Other damage: remove from service
	    ☐ Incorrect functioning: remove from service
	
	If in doubt on any point, remove from service

Table C.1 — Equipment inspection checklist (*continued*)

Component	Inspection procedure
Lanyards and energy absorbers	*Checks in addition to general checking procedure for all textile equipment* Visual and tactile — Check: ☐ Inside and outside any attachment point loops for all the features listed under the general checking procedure ☐ All knots for security ☐ That knot overlaps are sufficient ☐ That the energy absorber has not begun to deploy, e.g. tear webbing beginning to tear Action: ☐ Attachment point loops: treat in accordance with general checking procedure ☐ Knots: if in doubt, remove from service. Knots may be retied by a competent person. Tension knot with body weight and ensure that there is sufficient overlap (minimum 100 mm). If the knots in a lanyard appear to be very tight, either retie the knots or replace the lanyard. ☐ Energy absorber begun to deploy: remove from service If in doubt on any point, remove from service
Textile anchor lines	*Checks in addition to the general checking procedure for all textile equipment* Visual — Check: ☐ Ends of rope for excessive wear Visual and tactile — Check for: ☐ Internal damage. On cable-laid ropes, open up the lay and inspect as above. On kernmantel ropes, feel for unusually soft or hard areas, on sheath and core. (This signifies damage.) Particularly check ends of ropes ☐ All knots for security ☐ That knot overlaps are sufficient Action: ☐ Excessive internal grit: clean according to manufacturer's instructions. If it is not possible to remove the grit, inspect the rope for damage by abrasion more frequently than normal ☐ Unusually soft or hard areas: remove from service. (Sometimes, the damage is only local, so damaged areas can be cut out.) ☐ Knots: if in doubt, remove from service. Knots may be retied by a competent person. Tension knot with body weight and ensure that there is sufficient overlap (minimum 100 mm). If the knots in an anchor line appear to be very tight, either retie the knots or replace the anchor line If in doubt on any point, remove from service

Table C.1 — Equipment inspection checklist (*continued*)

Component	Inspection procedure
Metal components	*Checking procedures for metal components*
Anchor lines made from metal (flexible and rigid); lanyards made from steel wire	☐ Have you read the information supplied by the manufacturer? Visual — Check for: ☐ Build up of foreign matter, e.g. grit, grease, paint ☐ Wear, particularly at termination and intermediate anchors ☐ Deformation of rail or steel wire rope e.g. twisting or kinking or broken strands of wire ☐ Cuts ☐ Cracks ☐ Heavy marking or scoring ☐ Burring ☐ Corrosion ☐ Contamination by chemicals, e.g. pitting, flaking of aluminium products (usually due to salt water) Visual and tactile — Check that: ☐ Any moving parts function correctly ☐ Threaded assemblies are fully tightened and correctly secured ☐ There is no deformation of any parts Action: ☐ Remove any foreign matter ☐ Some wear is permissible: refer to manufacturer's information ☐ Deformation or broken strands: remove from service ☐ Cuts, heavy burring, marking or scoring: remove from service ☐ Cracks: remove from service ☐ Contamination by chemicals: remove from service ☐ Incorrect functioning: remove from service until corrected ☐ Threaded assemblies not properly tightened: remove from service until corrected If in doubt on any point, remove from service

Table C.1 — Equipment inspection checklist (*continued*)

Component	Inspection procedure
Anchor line devices	☐ Have you read the information supplied by the manufacturer? Visual — Check for: ☐ Build up of foreign matter, e.g. grit, grease, paint ☐ Wear, particularly on bobbins, cam teeth or face, rope channel ☐ Deformation ☐ Cuts ☐ Cracks ☐ Heavy marking or scoring ☐ Burring ☐ Corrosion ☐ Contamination by chemicals, e.g. pitting, flaking of aluminium products (usually due to salt water) Visual and tactile — Check that: ☐ Moving parts function correctly, e.g. bobbins, cams, springs, locking devices, handles ☐ Hinge pins are in good condition ☐ Threaded assemblies are fully tightened and correctly secured ☐ There is no deformation of any parts Action: ☐ Remove any foreign matter ☐ Wear: some wear is permissible; refer to manufacturer's information ☐ Moving parts: if any do not function correctly, remove from service ☐ Hinge pins not in good condition: remove from service ☐ Deformation: remove from service ☐ Cuts, heavy burring, marking or scoring: remove from service ☐ Cracks: remove from service ☐ Contamination by chemicals: remove from service ☐ Incorrect functioning: remove from service ☐ Threaded assemblies not properly tightened: remove from service If in doubt on any point, remove from service

Table C.1 — Equipment inspection checklist (*continued*)

Component	Inspection procedure
Connectors	☐ Have you read the information supplied by the manufacturer? Visual — Check for: ☐ Build up of foreign matter, e.g. grit, grease, paint ☐ Wear, particularly where the rope or webbing normally lies ☐ Deformation ☐ Cuts ☐ Cracks ☐ Heavy marking or scoring ☐ Burring ☐ Corrosion ☐ Contamination by chemicals, e.g. pitting, flaking of aluminium products (usually due to salt water) Visual and tactile — Check that: ☐ Moving parts function correctly, e.g. keeper locates in body correctly, spring returns keeper correctly, keeper locking mechanism operates correctly (screw gate, twist-lock), any threaded parts run correctly ☐ Hinge pin is in good condition ☐ Catch pin is not bent ☐ There is no deformation of any parts Action: ☐ Remove any foreign matter ☐ Wear: Some wear is permissible; refer to manufacturer's information ☐ Moving parts: if any do not function correctly, remove from service ☐ Hinge pin not in good condition: remove from service ☐ Catch pin bent: remove from service ☐ Deformation: remove from service ☐ Cuts, heavy burring, marking or scoring: remove from service ☐ Cracks: remove from service ☐ Contamination by chemicals: remove from service ☐ Incorrect functioning: remove from service ☐ Threaded assemblies not properly tightened: remove from service If in doubt on any point, remove from service

Table C.1 — Equipment inspection checklist (*continued*)

Component	Inspection procedure
Retractable type fall arresters	*Checks in addition to general checking procedure for all textile equipment* ☐ Have you read the information supplied by the manufacturer? Visual — Check for: ☐ Build up of foreign matter, e.g. grit, grease, paint, on the retractable anchor line ☐ Any damage to the retractable anchor line, e.g. abrasion, cuts, chemical damage ☐ Damage to the casing ☐ Excessive wear to any part Visual and tactile — Check that: ☐ The extension and retraction of the anchor line from, and back into, the casing functions correctly ☐ The locking mechanism functions correctly Action: ☐ Remove any foreign matter ☐ Damage of any sort to anchor line: remove from service ☐ Deformation: remove from service ☐ Cuts, heavy burring, marking or scoring: remove from service ☐ Cracks: remove from service ☐ Contamination by chemicals: remove from service ☐ Moving parts: if any do not function correctly, remove from service If in doubt on any point, remove from service
Helmets	☐ Have you read the information supplied by the manufacturer? ☐ Is the helmet within the manufacturer's recommended lifespan? Visual and tactile Check for: ☐ Cracks, deformation or other damage to the shell ☐ Damage to the cradle/chinstrap assembly ☐ Excessive wear to any part Check that: ☐ Chin strap (if fitted) adjusts easily Action: ☐ Helmet beyond recommended lifespan: remove from service ☐ Any cracks, deformation or other damage, including scoring or cuts to the shell: remove from service ☐ Damage to the cradle/chinstrap assembly: remove from service ☐ Chin strap, if fitted, does not adjust easily: remove from service If in doubt on any point, remove from service

Annex D (informative)
Suspension trauma

D.1 Suspension trauma is a condition in which a person suspended in a harness can experience pallor, cold sweats, nausea, ringing in the ears, blurred vision, dizziness, feeling faint, loss of consciousness and eventually death. The condition appears mainly to affect persons who are suspended in a harness without moving, for example, when unconscious.

D.2 Muscular action in moving the limbs normally assists the return against gravity of blood in the veins back to the heart. If the legs are completely immobile, these "muscle pumps" do not operate and an excess of blood accumulates in the veins, which are capable of considerable expansion and, therefore, have considerable capacity. The excess of blood in the veins is known as venous pooling. Pressure from the harness straps on veins and arteries could also be a contributory factor to this retention of blood in the venous system, which reduces the circulating blood volume available to the heart. Thus, the circulatory system is disturbed. This can lead to a critical reduction of blood to the brain and the symptoms described above. Other organs critically dependent on a good blood supply, such as the kidneys, can also suffer serious damage, with fatal consequences.

D.3 The movement of a person with venous pooling (e.g. in a rescue) into a horizontal position can cause a massive flow of venous blood to the heart, which cannot cope, and this can cause potentially fatal cardiac abnormalities.

D.4 In several clinical trials where the test subjects were told not to move, most experienced many of the symptoms of suspension trauma, some including loss of consciousness, in just a few minutes. Others managed for longer before reporting symptoms.

D.5 Further information on suspension trauma is given in the HSE publication *Harness suspension: review and evaluation of existing information* [12].

Annex E (informative)
Advantages and disadvantages of differently positioned attachment points for fall arrest equipment on a full body harness

E.1 General

The designated fall arrest attachment points on a full body harness are as follows (see **9.1.2.2**):

— a rear (dorsal) attachment point, which is arranged to lie centrally between the shoulder blades when the full body harness is worn;

— a front (sternal) attachment point, which is arranged to lie centrally at the bottom of the breastbone when the full body harness is worn.

The advantages and disadvantages of these two attachment points are given in **E.2** and **E.3**. This information is based on HSE document *Harness suspension: review and evaluation of existing information* [12].

E.2 Rear attachment point

E.2.1 *While the user is working*

E.2.1.1 *Advantages*

The advantage of a rear attachment point is that the lanyard is out of the way at the back of the user and so will cause minimum interference with the work being carried out.

E.2.1.2 *Disadvantages*

Disadvantages of a rear attachment point are as follows.

a) It is not possible for the user to see the attachment point and it is difficult to for the user get to the connector to check that it is connected safely to the harness and lanyard.

b) It is more difficult than with a front attachment point for the user to adjust the lanyard to the optimum length, i.e. with no or little slack.

E.2.2 *In the event of a fall*

E.2.2.1 *Advantages*

A rear attachment point has the following advantages in the event of a feet-first fall.

a) There is minimum backward whiplash effect on the user as the fall is arrested. The user's head is pushed forward and is stopped by the chin hitting the chest, which is better than it being pushed back so that the neck goes into hyperextension.

b) There is minimum swing.

c) Provided that the harness is correctly adjusted, the lanyard and connector are unlikely to catch the user's head, either at the front or the back.

E.2.2.2 *Disadvantages*

A rear attachment point has the following disadvantages.

a) There is a large swing in a head-first fall.

b) There is the possibility, in both a feet-first and a head-first fall, of the user hitting the front of their head against the structure.

c) If the harness is not correctly adjusted, the connecting D-ring and connector can pull up during the fall arrest phase and impact forcefully against the back of the user's head.

d) In a head-first fall, the lanyard and connectors can catch the back of the user's head.

e) In a head-first fall, depending on the orientation of the user's body at the time of arrest of the fall, there can be substantial hyperextension of the neck (whiplash).

E.2.3 ***If the user is held in suspension following a fall***

E.2.3.1 *Advantages*

If the user is suspended from a rear attachment point their head is held forwards, which has the advantage that if the user is unconscious they will not swallow their tongue.

E.2.3.2 *Disadvantages*

A rear attachment point has the following disadvantages.

a) The user's airway could be blocked by the effect of the effect of the head lolling forward onto the chest.

b) The user is held at a steep angle (usually almost vertical). Usually, the geometry of the harness is such that this causes the leg-loops or thigh straps to concentrate pressure on the inside thigh and/or the groin area, which can result in considerable discomfort. It can also cause restriction of the blood vessels in the legs which, together with the steep angle and the user's lack of ability to move, encourages venous pooling which can lead to the onset of suspension trauma. (A less steep angle of suspension could reduce the potential for these problems to arise.)

c) It is difficult, while the user is in suspension, to attach a foot-loop to the attachment point to aid comfort.

E.2.4 ***Rescue***

E.2.4.1 *Advantages*

Following a fall the user is held at a steep angle (usually almost vertical), which has the following advantages.

a) A vertical rescue from a confined space is easy to carry out.

b) A vertical rescue using a winch is easy to carry out.

c) It is easy for a rescuer to carry out the recovery of a casualty in descent.

E.2.4.2 *Disadvantages*

A rear attachment point has the following disadvantages.

a) It is very difficult for the user to carry out a self-rescue if they are hanging free (i.e. away from the structure) because it is difficult to begin a swing in order to reach the structure.

b) It is difficult, if not impossible, for the user to reach the lanyard in order to attach self-rescue devices.

E.3 Front attachment point

E.3.1 ***While the user is working***

E.3.1.1 *Advantages*

Advantages of a front attachment point are as follows.

a) It is easy for the user to adjust the lanyard to the optimum length, i.e. with no or little slack.

b) It is easy for the user to check that connections to the harness and the lanyard are correct.

E.3.1.2 *Disadvantages*

A disadvantage of a front attachment point is that the lanyard can sometimes get in the way of the work being carried out.

E.3.2 ***In the event of a fall***

E.3.2.1 *Advantages*

A front attachment point has the following advantages.

a) In a head-first fall, as the fall is arrested the initial movement of the user's head is likely to be forwards so that the chin hits the chest, thus minimizing any whiplash effect. In the next "bounce" in the fall the head moves backwards but this is less serious as it occurs with less force than the initial movement.

b) There is the possibility of the user being able to grab the lanyard at the initiation of a fall, or during the fall, thus reducing rotation of the body and so reducing the likelihood of whiplash.

E.3.2.2 *Disadvantages*

A front attachment point has the following disadvantages.

a) In a feet-first fall there will always be a head-back swing with the possibility of the user hitting the back of their head against the structure.

b) After a head-back swing there is a powerful swing in the opposite direction, which could cause the user to suffer a frontal impact against the structure.

c) In a feet-first fall there is likely to be some hyperextension of the user's neck (whiplash).

d) The lanyard and connector could impact forcefully against the front of the user's head during the fall arrest phase, particularly if the harness has not been adjusted correctly.

E.3.3 ***If the user is held in suspension following a fall***

E.3.3.1 *Advantages*

A front attachment point has the following advantages.

a) Suspension from a front attachment point is usually more comfortable than suspension from a rear attachment point. Usually, the geometry of the harness means that there is less pressure on the inside thigh and/or groin area than with a rear attachment point.

b) It is easy to attach a foot-loop to the attachment point to aid comfort.

E.3.3.2 *Disadvantages*

A front attachment point has the following disadvantages.

a) If the user is unconscious their head could fall back allowing the tongue to block the airway.

b) Although the angle of suspension is usually less steep than that with a rear attachment point, i.e. the user is suspended in a less vertical position, if the user is injured or unconscious there is still a great risk of suspension trauma. (An even less steep angle of suspension could reduce the potential for this problem to arise.)

E.3.4 ***Rescue***

E.3.4.1 *Advantages*

A front attachment point has the following advantages.

a) It is good for self-rescue because:

1) it is easy for the user to start a swing towards the structure;

2) it is easy for the user to attach self-rescue components to the lanyard, e.g. a foot loop or an ascender.

b) It is easy for the user to be connected to a rescuer and for the rescuer or a first aider to attend to them.

c) It is easy to carry out a snatch (single person) rescue.

E.3.4.2 *Disadvantages*

A front attachment point has the disadvantage that a vertical rescue from a confined space is less easy than with a rear attachment point because the position in which the user is held is not so close to the vertical.

Annex F (informative) Examples of the calculation of minimum free space requirements for different fall arrest systems

WARNING. The distances given in this annex are for illustration only. They should not under any circumstances be used in the setting up of an actual fall arrest system. The manufacturer's instructions for the particular equipment to be used should always be consulted.

F.1 System based on an energy absorbing lanyard

Table F.1 gives an example of the calculation of the minimum free space requirements when a fall arrest system based on an energy absorbing lanyard of 2.0 m, or of 1.5 m, overall length is to be used in the situations shown in Figure 32 (see **9.7.2**). The anchor point and ground level have been used as the datum points. This example illustrates the limitations of using a fall arrest system based on an energy absorbing lanyard in terms of the relatively large amount of free space required, and also the need to place the anchor point overhead wherever possible to give a shorter free fall distance and thus a smaller free space requirement.

NOTE Where an energy absorbing lanyard is used, the free fall distance is the distance the user travels from the onset of the fall to the point at which the energy absorbing lanyard begins to arrest the fall. The greater the free fall distance the more the energy absorber has to extend to absorb the energy of the fall and hence the greater the free space requirement.

Table F.1 — Example of calculation of minimum free space requirements for a fall arrest system based on an energy absorbing lanyard

Distance	Description	Measurement m					
		Anchor point above user[a] [see Figure 32a)]		**Anchor point at shoulder level** [see Figure 32b)]		**Anchor point at foot level** [see Figure 32c)]	
		2 m lanyard	**1.5 m lanyard**	**2 m lanyard**	**1.5 m lanyard**	**2 m lanyard**	**1.5 m lanyard**
A	Length of lanyard + Length of extended energy absorber	2.0 + 0.25	1.5 + 0.2	2.0 + 0.75	1.5 + 0.5	2.0 + 1.75	1.5 + 1.25
B	Harness stretch distance + Distance between the connection point of the lanyard on the harness and the user's feet	2.0	2.0	2.0	2.0	2.0	2.0
C	Safety clearance	1.0	1.0	1.0	1.0	1.0	1.0
A + B + C	Minimum free space requirement	5.25	4.7	5.75	5.0	6.75	5.75

[a] Anchor point above user but still with sufficient slack in the lanyard to allow the user to bend down in order to reach work areas at walkway level.

F.2 System based on a retractable type fall arrester

Table F.2 gives an example of the calculation of the minimum free space requirement when a fall arrest system based on a retractable type fall arrester is to be used in the situation shown in Figure 33 (see **9.7.3**). The walkway and ground level have been used as the datum points.

NOTE With a retractable type fall arrester the free fall distance is much less than with an energy absorbing lanyard.

Table F.2 — Example of calculation of minimum free space requirement for a fall arrest system based on a retractable type fall arrester

Distance (see Figure 33)	Description	Measurement m
A	Free fall distance + Brake operation distance + Harness stretch distance	1.5
B	Safety clearance	1.0
A + B	Minimum free space requirement	2.5

F.3 Systems based on a vertical anchor line (rigid or flexible)

Table F.3 gives an example of the calculation of the minimum free space requirements when one of the fall arrest systems based on a vertical anchor line, as shown in Figure 34, is to be used (see **9.7.4**). In the case of the rigid anchor line (see Figure 34a) the ladder rung on which the user is standing and ground level have been used as datum points. In the case of the flexible anchor line (see Figure 34b) the walkway and ground level have been used as datum points.

Table F.3 — Example of calculation of minimum free space requirements for fall arrest systems based on a vertical anchor line

Distance	Description	Measurement m	
		Rigid anchor line [see Figure 34a)]	**Flexible anchor line** [see Figure 34b)]
A	Free fall distance + Fall arrester operation distance + Length of extended energy absorber (if included in system) + Anchor line extension distance[a] + Harness extension distance	1.5	2.5
B	Safety clearance	1.0	1.0
A + B	Minimum free space requirement	2.5	3.5

[a] Applies only to the system with a flexible anchor line.

F.4 System based on a horizontal anchor line and an energy absorbing lanyard

WARNING. The calculation of the free space requirement when arresting a fall by the use of a flexible horizontal anchor line is extremely complex and takes account of numerous factors. This calculation should only be undertaken by system manufacturers, or by competent persons authorized to use software issued by the manufacturer. Software issued by one manufacturer should never be used to perform calculations for another manufacturer's system.

Table F.4 gives examples of the calculation of the minimum free space requirements when a fall arrest system based on a horizontal anchor line at shoulder height and an energy absorbing lanyard of 2.0 m overall length is to be used by a single user in the situations shown in Figure 31 (see **9.7.5**). The anchor line level and ground level have been used as the datum points.

Table F.4 — Example of calculation of minimum free space requirements for fall arrest systems based on a horizontal anchor line and an energy absorbing lanyard

Distance	Description	Measurement m		
		Single span horizontal anchor line, 10 m span [see Figure 31b)]	**Multi-span horizontal anchor line, 3 m span** [see Figure 31c)]	**Horizontal rail, fixed at intervals** [see Figure 31a)]
A	Length of lanyard + Length of extended energy absorber + "V"-deflection of anchor line[a]	4.5	3.0	2.75
B	Harness stretch distance + Distance between the connection point of the lanyard on the harness and the user's feet	2.0	2.0	2.0
C	Safety clearance	1.0	1.0	1.0
A + B + C	Minimum free space requirement	7.5	6.0	5.75

[a] Applies only to the systems with a flexible anchor line shown in Figure 31b) and Figure 31c).

Annex G (informative)
Typical methods of work in a partially supported position using a work positioning system

G.1 Technique 1

G.1.1 *Precautions prior to commencing work*

G.1.1.1 Before work commences, the work positioning lanyard should be checked to ensure that the maximum rated load is not exceeded, i.e. that the maximum rated load of the lanyard exceeds the sum of user's body weight plus clothing and all tools and equipment that are to be carried.

G.1.1.2 The support structure around which the work positioning lanyard is to be passed should be checked to ensure that it is unquestionably reliable, i.e. strong enough and stable enough to support the user.

G.1.1.3 The user should ensure that they are familiar with the manufacturer's instructions for adjusting the work positioning lanyard and for connecting the work positioning lanyard to their harness, in particular that they know the correct alignment for the particular type of connectors that they are using (see **G.1.2.3**).

G.1.1.4 The user should don their harness in accordance with the manufacturer's instructions and should take care to ensure that it is correctly adjusted.

G.1.1.5 During ascent, descent and movement between positions of work, the work positioning lanyard should be carried in such a way that it does not get in the way of the user, e.g. by connecting the lanyard by both connectors to one side attachment point on the user's harness.

G.1.1.6 On arriving at the work position the user should connect first to the safety back-up personal fall protection system.

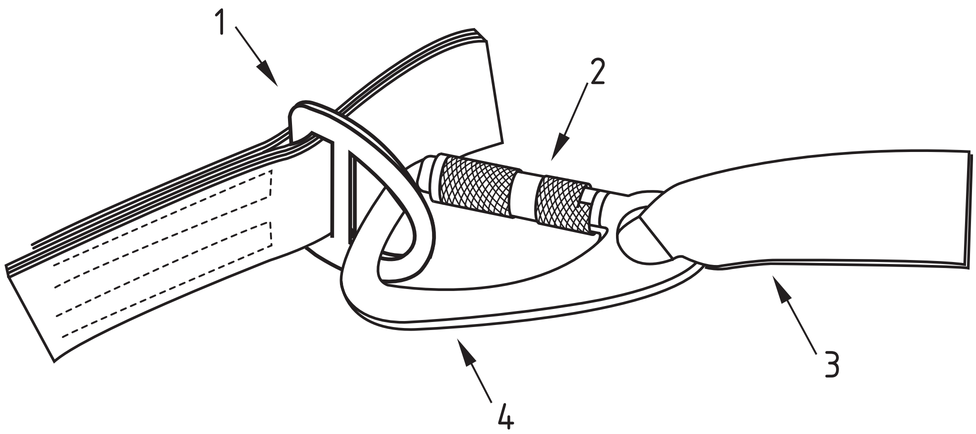
G.1.2 *Passing the work positioning lanyard around the support structure and attaching it to the user's harness*

G.1.2.1 Once the user is connected to the safety back-up system the work positioning lanyard should be passed around the supporting structure and secured and adjusted in accordance with the manufacturer's instructions. Passing the lanyard over abrupt or sharp edges should be avoided wherever possible. Work positioning lanyards made from webbing should be positioned so that they sit flat on the supporting structure and, if necessary, should be untwisted to allow this. Adjustment buckles should be pointing outwards.

G.1.2.2 If at all possible the work positioning lanyard should always be passed around the supporting structure in such a way that it cannot slip downwards, e.g. by passing it above a cross-member or other projection. When this is not possible, the lanyard should be passed around the supporting structure a number of times, to give additional grip.

G.1.2.3 The work positioning lanyard should then be attached to the user's harness. The user should take care to ensure that the gate mechanism of each connector is fully closed and secured and that the connector is aligned correctly in the harness attachment point. In some designs of connectors the gate mechanism should be away from the body, in others nearer the body. An example of the correct alignment for one type of connector is shown in Figure G.1. Failure to ensure that the connectors are aligned correctly creates a risk of inadvertent disengagement of the connector during work (known as "roll-out") (see **12.5**).

G.1.2.4 The point at which the work positioning lanyard passes around the support structure should be positioned so that it is at least above the waist of the user. The lanyard should be adjusted to the shortest length possible without compromising comfort or ease of work. This is to ensure that if the user loses their foothold, any swing fall into the structure is minimized, and therefore the potential for injury is reduced. (See Figure G.2.) Care should be taken when adjusting the work positioning lanyard to ensure that this is done in a controlled manner. Otherwise there is a risk that the entire lanyard could pass through the adjustment device until the stop is reached, and the resulting large loop would be likely to lead to instability and a fall.



Key

1 Harness side waist attachment point

2 Gate

3 Work positioning lanyard

4 Connector

Figure G.1 — Example of correct alignment of connector in side waist attachment point on user's harness

G.1.2.5 The safety back-up personal fall protection system should be adjusted so that there is a minimum amount of slack in it. This is essential in order to ensure that should the user suffer a fall, the safety back-up fall protection system arrests the fall before the user is subjected to any force from the work positioning system.

G.1.2.6 The user should then slowly lean back into their harness, until the tension in the work positioning lanyard supports the user's weight (see Figure 35).

G.1.3 ***Preparing to move to another position***

After work at a particular position is completed, the user should assume a safe standing position, with the safety back-up personal fall protection system still connected to the support structure. The work positioning lanyard can then be removed from the support structure.

G.2 Technique 2

G.2.1 ***Precautions prior to commencing work***

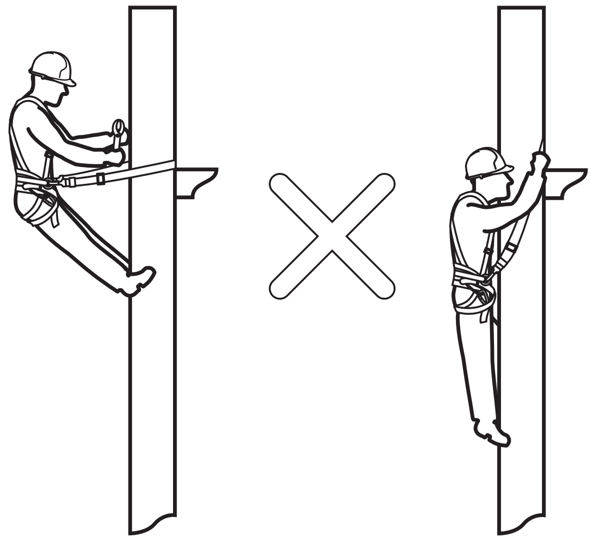
G.2.1.1 Before work commences, the anchor line should be checked to ensure that the maximum rated load is not exceeded, i.e. that the maximum rated load of the anchor line exceeds the sum of user's body weight plus clothing and all tools and equipment that are to be carried.

G.2.1.2 The anchor to which the anchor line is to be connected should be checked to ensure that it is unquestionably reliable, i.e. strong enough and stable enough to support the user.

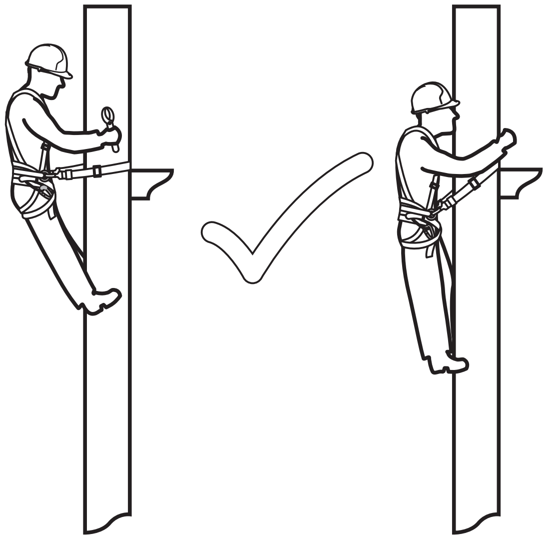
G.2.1.3 The user should ensure that they are familiar with the manufacturer's instructions for adjusting the anchor line and for connecting the anchor line to the anchor and to their harness, in particular that they know the correct alignment for the particular type of connectors that they are using (see **G.1.2.3**).

G.2.1.4 The user should don their harness in accordance with the manufacturer's instructions and should take care to ensure that it is correctly adjusted.

G.2.1.5 During ascent, descent and movement between positions of work, the anchor line should be carried in such a way that it does not get in the way of the user, e.g. by keeping it to one side or stowing it in a suitable bag.



a) Lanyard too long. User suffers large swing fall into structure



b) Lanyard correct length. User suffers small swing fall into structure

NOTE Safety back-up personal fall protection system not shown for clarity.

Figure G.2 — Potential swing falls into structure while using work positioning technique 1, assuming that the work positioning lanyard does not slide down the structure

G.2.1.6 On arriving at the working surface the user should connect first to the safety back-up personal fall protection system.

G.2.2 ***Connecting the anchor line to the anchor and attaching it to the user's harness***

G.2.2.1 Once the user is attached to the safety back-up system the anchor line should be connected to the anchor and attached to the user's harness, and secured and adjusted in accordance with the manufacturer's instructions. Passing the anchor line over abrupt or sharp edges should be avoided. Anchor lines should be protected at all times from abrasion or other causes of damage (e.g. hot or sharp surfaces). Where necessary, additional protection for the anchor line should be used, e.g. a canvas rope protector.

G.2.2.2 The user should take care to ensure that the connections at the attachment points on the harness and the anchor line have been made correctly by ensuring that the gate mechanism of each connector is fully closed and secured and that the connector is aligned correctly in the attachment point. Failure to ensure that the connectors have been aligned correctly creates a risk of inadvertent disengagement of the connector during work (see **G.1.2.3**).

G.2.2.3 Before the user moves to the work position, the anchor line should be completely pulled through the adjustment device so that there is no slack as the user descends down the working surface, for example a roof.

G.2.2.4 Once the work position is reached, the anchor line should be adjusted to the shortest length possible, to eliminate slack, without compromising comfort or ease of work, and kept as nearly as possible perpendicular to the anchor. This is essential to ensure that should the user lose their foothold, any swing fall across the structure is minimized, thus reducing the potential for injury.

G.2.2.5 The user should then slowly lean back into their harness until the tension in the anchor line supports the user's weight.

G.2.3 ***Moving up and down the working surface by varying the anchor line length***

G.2.3.1 The anchor line should be kept under tension, otherwise slack might form which could lead to a fall.

G.2.3.2 The adjustment device should be operated in such a way that the length of the anchor line is only altered by a small amount at a time. During adjustment, tension should be maintained in the anchor line so that it continues to support the user.

Annex H (informative) Properties of some of the artificial fibres used in the manufacture of personal fall protection equipment

H.1 The resistance to chemicals of some of the artificial fibres used in the manufacture of personal fall protection equipment is given in Table H.1 and other properties are given in Table H.2. This information has been compiled from manufacturer's data. However, it should be noted that several variants of most of these fibres exist and new variants are being continuously developed.

H.2 It is essential to consult the manufacturer regarding the properties of specific products and their resistance to contaminants.

Table H.1 — Resistance to chemicals of some of the artificial fibres used in the manufacture of personal fall protection equipment

Chemical	Polyamide[a]		Polyester[a]		Polypropylene[b]		High tenacity polypropylene		High performance polyethylene	Aramid		
	20 °C	60 °C	20 °C	60 °C	4 days 20 °C	21 h 70 °C	4 days 20 °C	21 h 70 °C	6 months[d]	21 °C[c]	60 °C[c]	6 months 20 °C
Acetic acid 10 %	L	L	N	N	N	L	—	—	N	N	N	—
50 %	L	C	N	N	N	L	—	—	N	L (1 000 h)	L	—
80 %	C	C	N	N	N	L	—	—	N	N	L	—
100 %	C	D	L	C	L	L	—	—	N	N (24 h)	L	—
Acetic acid (glacial)	—	—	—	—	—	—	N	N	N	—	—	N
Acetone	N	N	L	C	N	L	—	—	N	N	N	—
Ammonia gas	—	—	L	C	N	N	—	—	N	—	—	—
Ammonia solution 10 %	L	L	C	C	N	N	—	—	N	N	N	L
25 %	C	C	C	C	N	N	—	—	N	N	N	—
100 %	C	C	C	C	N	N	—	—	N	N	L	—
Aniline	L	L	—	—	N	N	—	—	N	—	—	—
Aqua regia	D	D	C	C	C	C	—	—	D	—	—	—
Aviation fuel (115/145 octane)	N	N	N	N	L	C	—	—	N	N	N	—
Aviation fuel (turbine fuel)	N	N	N	N	L	D	—	—	N	N	N	—
Benzene	N	N	N	L	—	C	C	—	N	N	N	—
Brine (saturated)	N	L	N	L	N	N	—	—	N	L	C	—
Bromine gas	—	—	L	C	C	D	—	—	L	—	—	—
Calcium hypochlorite 20 %	D	D	L	L	L	L	—	—	L	—	—	—
Carbon dioxide gas	L	L	N	N	N	N	—	—	N	—	—	—
Carbon tetrachloride	N	N	N	N	C	C	—	—	N	N	N	—
Castor oil	N	N	N	L	N	N	—	—	N	—	—	—
Chlorine gas	D	D	—	—	D	D	—	—	C	—	—	—

N: Negligible effect; L: Limited effect; C: Considerable effect; D: Dissolves or decomposes.

[a] Duration of test not known.
[b] Other than high tenacity polypropylene.
[c] Values in parentheses are test durations. For other chemicals duration of test not known.
[d] Test temperature not known. It was probably 20 °C.

Table H.1 — Resistance to chemicals of some of the artificial fibres used in the manufacture of personal fall protection equipment (*continued*)

Chemical	Polyamide[a]		Polyester[a]		Polypropylene[b]		High tenacity polypropylene		High performance polyethylene	Aramid		
	20 °C	60 °C	20 °C	60 °C	4 days 20 °C	21 h 70 °C	4 days 20 °C	21 h 70 °C	6 months[d]	21 °C[c]	60 °C[c]	6 months 20 °C
Chlorine water	N	L	N	N	N	L	—	—	C	—	—	—
Chloroform	L	L	L	L	C	D	—	—	N	L	C	—
Chromic acid 1 %	D	D	L	C	L	L	—	—	C	—	—	—
10 %	—	—	—	—	—	L	—	—	—	C (1 000 h)	—	—
50 %	D	D	C	C	L	L	—	—	D	—	—	—
80 %	D	D	C	C	—	—	—	—	D	—	—	—
Dibutyl phthalate	N	—	N	—	N	L	—	—	N	—	—	—
Diethyl ether	N	—	N	—	L	—	—	—	N	—	—	—
Ethylene glycol	N	—	N	—	N	N	—	—	N	—	—	—
Freon	N	—	N	—	N	—	—	—	N	N	N (500 h)	—
Formic acid 40 %	—	—	—	—	—	—	—	—	—	L (10 000 h)	—	—
75 %	—	—	N	L	—	—	N	—	N	N (100 h)	—	—
Glycerine	N	N	N	N	N	N	—	—	N	—	—	—
Hydrochloric acid 2 %	L	C	L	L	N	N	—	—	N	L	C	C
10 %	C	C	L	L	N	N	—	—	N	C (100 h)	D	—
30 %	D	D	L	C	N	N	—	—	N	D	D	—
(concentrated) 38 %	D	D	C	C	N	L	—	—	N	D	D	—
Hydrofluoric acid 2 %	D	D	N	L	N	N	—	—	L	N	L	—
10 %	D	D	D	D	N	N	—	—	N	N (100 h)	C	—
20 %	D	D	D	D	N	N	—	—	N	D	D	—

N: Negligible effect; L: Limited effect; C: Considerable effect; D: Dissolves or decomposes.

[a] Duration of test not known.
[b] Other than high tenacity polypropylene.
[c] Values in parentheses are test durations. For other chemicals duration of test not known.
[d] Test temperature not known. It was probably 20 °C.

Table H.1 — Resistance to chemicals of some of the artificial fibres used in the manufacture of personal fall protection equipment (*continued*)

Chemical	Polyamide[a]		Polyester[a]		Polypropylene[b]		High tenacity polypropylene		High performance polyethylene	Aramid		
	20 °C	60 °C	20 °C	60 °C	4 days 20 °C	21 h 70 °C	4 days 20 °C	21 h 70 °C	6 months[d]	21 °C[c]	60 °C[c]	6 months 20 °C
Hydrogen peroxide 1 %	C	D	N	N	N	N	—	—	L	—	—	—
3 %	D	D	L	C	N	L	—	—	L	—	—	—
10 %	D	D	L	C	N	L	—	—	—	—	—	—
30 %	D	D	L	C	N	C	—	—	—	—	—	—
12 part	—	—	—	—	—	—	L	—	—	—	—	—
Hydrogen sulphide	N	L	L	L	N	N	—	—	—	—	—	—
Kerosene	—	—	—	—	L	D	—	—	N	N	N (500 h)	N
Lactic acid 20 %	L	C	N	N	N	N	—	—	N	—	—	—
Lanolin	N	N	N	N	N	N	—	—	N	—	—	—
Lubricating oil	N	N	N	N	N	L	—	—	N	—	—	—
Meat juices	N	N	N	N	N	N	—	—	N	—	—	—
Methanol	N	L	N	N	N	N	—	—	N	L	L	—
Methyl ethyl ketone	N	—	N	—	N	C	—	—	N	N	N	—
Motor oil	N	N	N	N	L	D	—	—	N	N	N (10 h)	—
Naphthalene	N	—	N	L	N	N	—	—	N	N	N	—
Nitric acid 10 %	D	D	N	L	N	L	—	—	N	C (100 h)	C	C
50 %	D	D	L	C	C	D	—	—	N	D	D	—
70 %	D	D	C	D	—	D	L	—	C	C (24 h)	D	—
fuming	D	D	D	D	D	D	—	—	D	—	—	—
Nitrobenzene	C	D	D	D	L	—	—	—	N	—	—	—
Petrol	—	—	—	—	—	—	—	—	N	—	—	N
Perchloroethylene	N	N	N	N	—	—	C	—	N	N	N (10 h)	N

N: Negligible effect; L: Limited effect; C: Considerable effect; D: Dissolves or decomposes.

[a] Duration of test not known.
[b] Other than high tenacity polypropylene.
[c] Values in parentheses are test durations. For other chemicals duration of test not known.
[d] Test temperature not known. It was probably 20 °C.

Table H.1 — Resistance to chemicals of some of the artificial fibres used in the manufacture of personal fall protection equipment (*continued*)

Chemical	Polyamide[a]		Polyester[a]		Polypropylene[b]		High tenacity polypropylene		High performance polyethylene	Aramid		
	20 °C	60 °C	20 °C	60 °C	4 days 20 °C	21 h 70 °C	4 days 20 °C	21 h 70 °C	6 months[d]	21 °C[c]	60 °C[c]	6 months 20 °C
Phosphoric acid 25 %	D	D	L	C	N	—	—	—	N	N	N	—
50 %	D	D	C	D	N	—	—	—	N	L	L	—
Phenol 5 %	C	D	L	C	C	—	—	—	—	N	—	—
Phenol based disinfectant	—	—	—	—	N	L	—	—	—	—	—	—
Potassium hydrate 40 %	—	—	—	—	—	—	N	N	—	—	—	—
Sea water	—	—	—	—	—	—	—	—	N	—	—	N
Silicone oil	N	N	N	N	N	N	—	—	N	—	—	—
Sodium hydrate 40 %	—	—	—	—	—	—	N	N	—	—	—	—
Sodium hydroxide 10 %	N	N	L	C	N	N	—	—	L	L	C	C
50 %	L	C	D	D	N	N	—	—	—	—	—	—
Sodium hypochlorite (0.25 % Cl)	—	—	N	N	—	—	—	N	L	—	—	—
(5 % Cl)	—	—	N	N	—	—	L	—	—	D (1 000 h)	—	—
Sulfuric acid 2 %	L	L	L	C	N	N	—	—	N	N (1 000 h)	L	—
10 %	C	D	L	C	N	N	—	—	N	L (1 000 h)	C	—
50 %	C	D	L	C	N	L	—	—	L	D	D	—
90 %	D	D	D	D	N	—	—	N	C	D	D	—
Sulfur dioxide	D	D	L	C	N	N	—	—	—	—	—	—
Tallow	N	N	N	N	N	N	—	—	—	—	—	—
Toluene	N	N	N	N	—	C	N	—	N	N	N	L

N: Negligible effect; L: Limited effect; C: Considerable effect; D: Dissolves or decomposes.

[a] Duration of test not known.
[b] Other than high tenacity polypropylene.
[c] Values in parentheses are test durations. For other chemicals duration of test not known.
[d] Test temperature not known. It was probably 20 °C.

Table H.1 — Resistance to chemicals of some of the artificial fibres used in the manufacture of personal fall protection equipment (*continued*)

Chemical	Polyamide[a]		Polyester[a]		Polypropylene[b]		High tenacity polypropylene		High performance polyethylene	Aramid		
	20 °C	60 °C	20 °C	60 °C	4 days 20 °C	21 h 70 °C	4 days 20 °C	21 h 70 °C	6 months[d]	21 °C[c]	60 °C[c]	6 months 20 °C
Transformer oil	N	N	N	N	N	C	—	—	N	N	N	—
Trichloroethylene	N	N	N	N	—	C	C	—	N	N	N	—
Turpentine	N	N	N	N	C	C	—	—	N	—	—	—
Urine	N	L	N	N	N	N	—	—	—	—	—	—
White spirit	N	N	N	N	C	C	—	—	N	N	L	—
Xylene	N	N	N	N	C	C	—	—	N	—	—	—

N: Negligible effect; L: Limited effect; C: Considerable effect; D: Dissolves or decomposes.

[a] Duration of test not known.
[b] Other than high tenacity polypropylene.
[c] Values in parentheses are test durations. For other chemicals duration of test not known.
[d] Test temperature not known. It was probably 20 °C.

Table H.2 — Other properties of some of the artificial fibres used in the manufacture of personal fall protection equipment

Property	Polyamide		Polyester	High tenacity polypropylene	High performance polypropylene	Aramid
	Type 6	Type 66				
Melting point (°C)	195 to 230	235 to 260	230 to 260	165 to 170	145 to 155	Chars at 350[a]
Effect of low temperature (−40 °C)	Nil	Nil	Nil	Nil	Nil	Nil
Abrasion resistance	Very good	Very good	Very good	Fair	Good	Poor
Flexion durability	Very good	Very good	Very good	Good	Good	Very poor
Moisture regain (%)[c]	4.5	4.5	0.4	0.05	<0.05	—
Loss of strength when wet (%)	10 to 20	10 to 20	Nil	Nil	—	Nil
Resistance to UV	Poor	Good	Good	Good[b]	Good	Poor
Density (g/cm^3)	1.12	1.14	1.38	0.91	0.97	1.45
Tensile strength (GPa)	—	0.9	1.1	0.6	2.7	2.7
Tenacity (N/tex)	0.7	0.8	0.8	0.6 to 0.7	2.65	1.9
Tenacity (g/den)	8	9	9	7.0 to 7.5	30	22
Elongation at break (%)	20	20	13	18	3.5	1.9 to 4.0
Comments	—	—	—	Floats on water	Floats on water	Fire resistant

[a] Aramids do not melt but they decompose at 427 °C to 482 °C
[b] Good with inhibitor, poor without
[c] Increase in mass of fibres through absorption of atmospheric moisture

Annex I (informative) The effect of wind speed and working height on available working times

The information given in Table I.1 is based on work presented in the Toronto University Wind Study Report on the Hong Kong and Shanghai Bank headquarters and in a survey of factors affecting working periods at various heights in windy and inclement conditions.

Table I.1 is intended only to be an example, as the actual height where work is being done and the temperature of the surrounding air have a major effect on available working time.

The values in Table I.1 give an indication of what might be a reasonable length of shift at different wind speeds when the work situation, a platform in this case, is unprotected and an indication of the benefits that might be obtained from the use of containment netting or containment sheeting as a protection.

Table I.1 — Available working time in an 8 h shift at different wind speeds

Wind speed	Available working time		
	Unprotected	With containment netting	With containment sheeting
m/s	h	h	h
2	8	8	8
5	5	7	8
7	4	6	7
9	3	5	6
11	2	4	5
14	1.5	3	4
28	0.5[a]	0.5[a]	0.5 [a,b]

[a] Emergency work only.
[b] Sheeting could be in danger of blowing away.

Other sources of information on recommended working practices in relation to wind speed include the following:

— BS 5975:1996, **6.3.1.3.1**, in relation to falsework, refers to a "...maximum wind speed during which working operations can take place..." of Beaufort Scale 6 (or, a design wind speed, v_s, of 18 m/s);

— Construction Industry Research and Information Association (CIRIA) Special Publication 131 *Crane Stability on Site* [13] Chapter 1.4 gives a "...typical maximum in-service wind speed..." for a tower crane of 20 m/s (45 mph);

— Prefabricated Access Suppliers' and Manufacturers Association (PASMA) *Operator's Code of Practice* [14] states "...if the wind speed should exceed 17 mph you should cease to work upon the tower…".

Bibliography

Standards publications

BS 4275:1997, *Guide to implementing an effective respiratory protective device programme.*

BS 5975:1996, *Code of practice for falsework.*

BS 7028:1999, *Eye protection for industrial and other uses — Guidance on selection, use and maintenance.*

BS 7883:1997, *Code of practice for application and use of anchor devices conforming to BS EN 795.*

BS EN 136:1998, *Respiratory protective devices — Full face masks — Requirements, testing, marking.*

BS EN 140:1999, *Respiratory protective devices — Half masks and quarter masks — Requirements, testing, marking.*

BS EN 143:2000, *Respiratory protective devices — Particle filters — Requirements, testing, marking.*

BS EN 149:2001, *Respiratory protective devices — Filtering half masks to protect against particles — Requirements, testing, marking.*

BS EN 166:2002, *Personal eye protection — Specifications.*

BS EN 341, *Personal protective equipment against falls from a height — Descender devices for rescue.*

BS EN 352 (all parts), *Hearing protectors.*

BS EN 364:1993, *Personal protective equipment against falls from a height — Test methods.*

BS EN 365:2004, *Personal protective equipment against falls from a height — General requirements for instructions for use, maintenance, periodic examination, repair, marking and packaging.*

BS EN 374-1:2003, *Protective gloves against chemicals and micro-organisms — Part 1: Terminology and performance requirements.*

BS EN 388:2003, *Protective gloves against mechanical risks.*

BS EN 397:1995, *Specification for industrial safety helmets.*

BS EN 407:1994, *Protective gloves against thermal risks (heat and/or fire).*

BS EN 420:2003, *Protective gloves — General requirements and test methods.*

BS EN 458:1994, *Hearing protectors — Recommendations for selection, use, care and maintenance — Guidance document.*

BS EN 1496:1996, *Personal fall protection equipment — Rescue lifting devices.*

BS EN 12275:1998, *Mountaineering equipment — Connectors — Safety requirements and test methods.*

BS EN 12277:1998, *Mountaineering equipment — Harnesses — Safety requirements and test methods.*

BS EN 12492:2000, *Mountaineering equipment — Helmets for mountaineers — Safety requirements and test methods.*

BS EN 14387:2004, *Respiratory protective devices — Gas filter(s) and combined filter(s) — Requirements, testing, marking.*

BS EN ISO 9001:2000, *Quality management systems — Requirements.*

PD 6484:1979, *Commentary on corrosion at bimetallic contacts and its alleviation.*

PD 6636:1998, *Personal protective equipment — Lifejackets and buoyancy aids — Guide for selection and use.*

Other publications

[1] HEALTH AND SAFETY EXECUTIVE. *Five steps to risk assessment.*

[2] HEALTH AND SAFETY EXECUTIVE. *Health and safety in construction.* (HS(G)150), HSE Books, 1996.

[3] HEALTH AND SAFETY EXECUTIVE. *Health and safety in roof work.* (HS(G)33) HSE Books, 1998.

[4] HEALTH AND SAFETY EXECUTIVE. *Inspecting fall arrest equipment made from webbing or rope.* INDG 367. HSE Books, 2002.

[5] EUROPEAN COMMUNITIES 89/686/EEC Council Directive on the approximation of the laws of the member states relating to personal protective equipment, and amendments. Luxembourg: Office for the Official Publications of the European Communities, 1989.

[6] DEPARTMENT OF TRADE AND INDUSTRY. *Personal Protective Equipment: Guidance notes on UK Regulations*.

[7] ADVISORY COMMITTEE FOR ROOF WORK. *Test for fragility of roofing assemblie*s. ACR(M)001:2000[3)].

[8] HEALTH AND SAFETY EXECUTIVE. *Assessment of factors that influence the tensile strength of safety harness and lanyard webbings*. HSL/2002/16[4)].

[9] HEALTH AND SAFETY EXECUTIVE. *Assessment of factors that influence the tensile strength of safety harness and lanyard webbings. Supplementary information*. HSL/2002/17[3)].

[10] HEALTH AND SAFETY EXECUTIVE. *Issues surrounding the failure of an energy absorbing lanyard*. SIR59.

[11] HEALTH AND SAFETY EXECUTIVE. *Protecting the public — Your next move* (HS(G)151) 1997.

[12] HEALTH AND SAFETY EXECUTIVE. *Harness suspension: review and evaluation of existing information*. CRR 451. HSE Books 2002.

[13] CONSTRUCTION INDUSTRY RESEARCH AND INFORMATION ASSOCIATION (CIRIA) Special Publication 131 *Crane Stability on Site*.

[14] PREFABRICATED ACCESS SUPPLIERS' AND MANUFACTURERS' ASSOCIATION. *Operator's code of practice*. 9th Edition, 2003[5)].

[3)] Available from the National Federation of Roofing Contractors, 24 Weymouth Street, London WG1 7LX. Tel: 0207 436 0387, Fax: 0207 637 5215, or on www.roofworkadvice.info.

[4)] Available on www.hse.gov.uk/research/hsl/engineer.htm

[5)] Available from The Secretary, PASMA, PO Box 1828, West Mersea, Essex, CO5 8HY. www.pasma.co.uk *blank*

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