

Workplace Safety and Health Guidelines

Personal Protective Equipment
for Work At Heights



Contents

1.	Introduction	03
1.1	Scope and Objectives	03
2.	Hierarchy of Control	04
3.	Personal Fall Arrest Systems	06
3.1	Definition	06
3.2	Components of a Personal Fall Arrest System	06
3.3	“A-B-C” of Personal Fall Arrest System	07
4.	Personal Protective Equipment (For Work at Heights)	09
4.1	Full Body Harness	09
4.1.1	Definition	09
4.1.2	Classification of Full Body Harnesses	09
4.1.3	Minimum Breaking Strength of Full Body Harness	12
4.1.4	Selection of Full Body Harness for Different Working Environments	12
4.1.5	Procurement, Markings and Identity Label	14
4.1.6	Lifespan of Full Body Harness	16
4.1.7	Important Points to Note when Wearing a Full Body Harness	16
4.2	Connectors	17
4.2.1	Definition	17
4.2.2	Classification of Connectors	17
4.2.3	Minimum Static Strength of Connector	19
4.2.4	Basic Rules of Using Connectors	20
4.2.5	Procurement, Markings and Identity Label	22
4.2.6	Lifespan of Connectors	22
4.3	Energy Absorbers	23
4.3.1	Definition	23
4.3.2	Types of Energy Absorbers	23
4.3.3	Static Strength of Energy Absorber	24
4.3.4	Procurement, Marking and Identity Label	24
4.3.5	Lifespan of an Energy Absorber	25
4.3.6	Bypassing of Energy Absorbers	26
4.4	Lanyards	26
4.4.1	Definition	26
4.4.2	Twin Lanyards System	27
4.4.3	Static Strength of Lanyards	29
4.4.4	Procurement, Marking and Identity Label	29
4.5	Work Positioning Belts, Travel Restraint Belts and Work Positioning Lanyards	30
4.5.1	Definition	30
4.5.2	Minimum Static Strength of Work Positioning/ Restraint Belts (and Lanyards)	31
4.5.3	Procurement, Marking and Identity Label	32

4.6	Understanding Suspension Trauma	32
4.6.1	Suspension Trauma	32
4.6.2	Management of Suspension Trauma	32
4.6.3	What should a Worker do when he Falls from Height	33
4.6.4	Suspension Trauma Strap	33
4.7	Inspection of Personal Protective Equipments	33
4.7.1	Inspection of Full Body Harness	34
4.7.2	Inspection of Connectors	36
4.7.3	Inspection of Lanyards and Energy Absorbers	37

Annex A – Sample Checklist for Full Body Harness	39
---	-----------

Annex B – Sample Checklist for Lanyard	41
---	-----------

5. References	43
----------------------	-----------

6. Acknowledgements	44
----------------------------	-----------

1. Introduction

Fall from heights (FFH) is one of the leading causes of death and injury in the workplace. It is therefore essential that measures are taken to protect workers against the risks of falling from heights.

This guide is developed to help contractors and workers who are involved in working at heights to better understand the application of personal protective equipment (PPE) such as full body harnesses, energy absorbers, connectors and lanyards.*

It is important to note that risk assessment needs to be carried out prior to any work at heights (WAH) activities. Whenever possible, WAH activities should be eliminated or substituted. Using temporary edge protection systems (such as guardrails) shall be the *first option* in designing any fall prevention systems. The use of anchorages and lifelines, with PPE shall be considered if the option of having temporary edge protection is not feasible.

1.1 Scope and Objectives

This guide is relevant for WAH activities. It contains salient points on proper usage and application of PPE to provide additional protection against fall hazards.

After reading this guide, the user should be able to:

- understand the use of a Personal Fall Arrest System (PFAS);
- understand how to select suitable PPE that conform to internationally recognised standards;
- understand the limits and constraints of PPE;
- identify different types of PPE and their applications;
- understand and manage suspension trauma; and
- identify various methods of PPE inspection.

* This publication does not promote any brand of equipment featured.

2. Hierarchy of Control

Should the task involve working at heights where there is a risk of injury from falling, the employer or principal shall implement risk control measures. The appropriate control measures selected to eliminate or reduce the risk of FFH shall be carefully assessed and implemented to ensure effectiveness.

The control of hazards and reduction of risks can be accomplished by the Workplace Safety and Health (WSH) Hierarchy of Control (see Figure 1). These controls are not usually mutually exclusive. For example, engineering controls can be implemented concurrently with administrative controls.



Figure 1: WSH Hierarchy of Control.

(1) Elimination refers to the total removal of the worker's exposure to the hazards, effectively making all the identified possible accidents, incidents and ill-health impossible. It is a permanent solution and should be attempted first, as recommended in the Hierarchy. Once the hazard is eliminated, all other controls, such as the use of fall prevention and protection system would no longer be required. Some examples include:

- Prefabricating wall frames horizontally before standing them up;
- Using precast tilt-up concrete construction instead of concrete walls constructed in situ; and
- Using paint rollers with extendable handles rather than working on ladders.

(2) Substitution involves replacing a process or product with a less hazardous process or product to mitigate the risk. For example, using mobile elevated work platforms (MEWPs) instead of ladders to reach high places.

(3) Engineering controls are physical means that reduce the likelihood of occurrence or severity of consequence of the mishap. These include structural changes to the work environment or work processes, erecting barriers to interrupt the accident transmission path between the worker and the hazard. For example, temporary edge protection systems such as guard rails can be installed at open sides to prevent persons from falling over.

(4) Administrative controls eliminate or reduce exposure to a hazard by adherence to procedures and instructions. It is a useful means to limit the frequency and duration of exposure to hazards and the number of persons involved in the task. For example, safe work procedures can be used to guide workers on the safe use of temporary work platforms.

(5) Personal protective equipment should be used only as a last resort; after all other control measures have been considered. The success of this control depends critically on the protective equipment being chosen correctly, fitted correctly, worn at all times and maintained properly.

3. Personal Fall Arrest System

3.1 Definition

PFAS is a collection and arrangement of components that work in conjunction to arrest a user in the event of a fall from height. It typically consists of an anchorage, connecting device and full body harness. The system may also include components such as a lanyard, deceleration device, lifeline or a combination of these.

3.2 Components of a Personal Fall Arrest System

In general, a complete PFAS consists of three main components — “Anchorage”, “Body Support” and “Connections”. In order to provide the desired level of protection, each of the components must be in place and properly used.

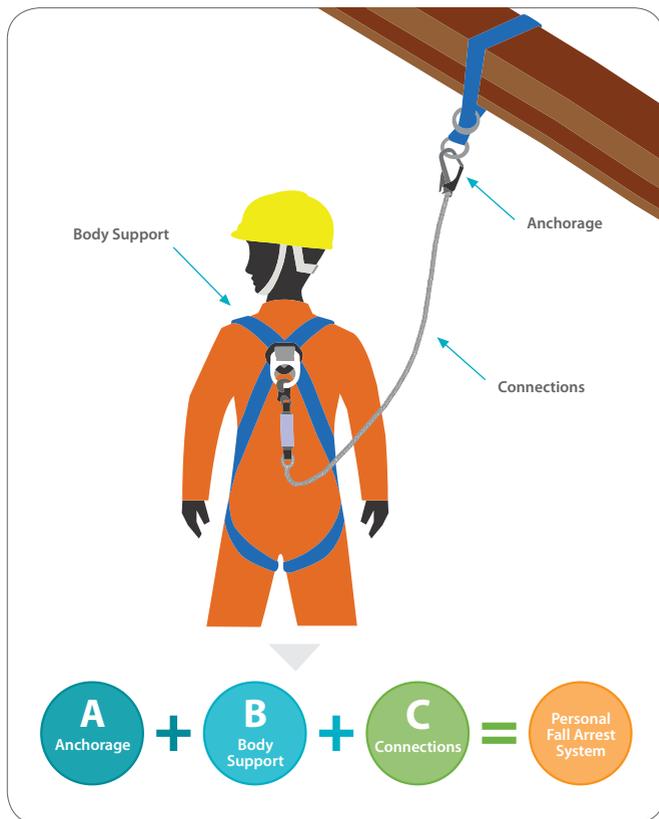


Figure 2: Three vital components of PFAS: “Anchorage”, “Body Support” and “Connections”.

3.3 “A-B-C” of a Personal Fall Arrest System

A brief introduction to the “A-B-C” (i.e., anchorage, body support and connections) of a PFAS.

Anchorage



Anchor, anchor points/ anchorages and anchor devices

- An anchor is a fixture or place for the secure attachment of lifelines or persons (e.g., an eyebolt is a fixture and a steel beam is a place).
- An anchor point (also known as anchorage) is a part of an anchor for other equipment in a PFAS to be attached to.
- An anchor device is an element or series of elements or components of a personal PFAS, which incorporates one or several anchor points.

With reference to S5570:2011 *Personal protective equipment for protection against falls from a height – Single point anchor devices and flexible horizontal lifeline systems*, an anchor device or anchor with a minimum static strength of 12kN (2697 lb f) should be used in order to arrest a fall for a single person. Anchorages must always be located at a higher securing point; high enough for a user to avoid hitting a lower level should a fall occur.

Note: Refer to *WSH Guidelines: Anchorage, Lifelines and Temporary Edge Protection Systems* for more information on the selection, application and usage of anchorages.

Body Support



Full body harness

A full body harness is a body support device that distributes fall arrest forces across the shoulders, thighs and pelvis of its wearer.

It has a centre back fall arrest attachment for connection to the fall arrest connecting device; and may have other D-rings for use in worker positioning, fall prevention, suspension or ladder climbing.

Note that the only form of body wear acceptable for fall arrest is the full body harness.

Go to Section 4.1 for details on full body harness.

Connections



Energy absorbers and lanyard

The connection sub-system is a critical link between the body support and the anchorages or anchor devices. It can be an energy-absorbing lanyard, self-retracting lifeline (SRL), rope grab, or a retrieval system.

The means of connection will vary depending on whether the user is equipped for a personal fall arrest, work positioning or travel-restraint system.

I. Personal Fall Arrest Connection Means

The connection means for personal fall arrest is often a lanyard equipped with an energy absorbing element to limit the arresting force to 6 kN in the event of a fall.

SRLs can also be used as a connection to reduce free fall distance and energy loads from a fall.

Refer to Section 4.2 for details on connectors.

II. Work Positioning and Work/ Travel-restraint Connection Means

The means of connection for work positioning and travel restraint is often a simple lanyard (with length adjuster) made from rope, web or wire rope. These may also include specialised work positioning assemblies for rebar work, they are constructed from chain or webbing.

All work positioning devices are intended to reduce the potential for free fall; and restraint lanyards need to be specific in length to prevent the user from reaching a fall hazard zone.

Go to Section 4.5 for details on work positioning/ restraint belts and work positioning lanyards.

Figure 3: "Anchorage", "Body Support" and "Connections" of a Personal Fall Arrest System.

4. Personal Protective Equipment (For Work at Heights)

4.1 Full Body Harnesses

4.1.1 Definition

A full body harness (FBH) is a component of a body holder device that connects a user to a PFAS. It comprises components such as fittings, straps, buckles or other elements that could support the body of a user and restrain the user during and after the arrest of a fall (see Figure 4).

Some types of FBHs may incorporate other fittings that allow connection with other types of safety systems (e.g., work positioning system).

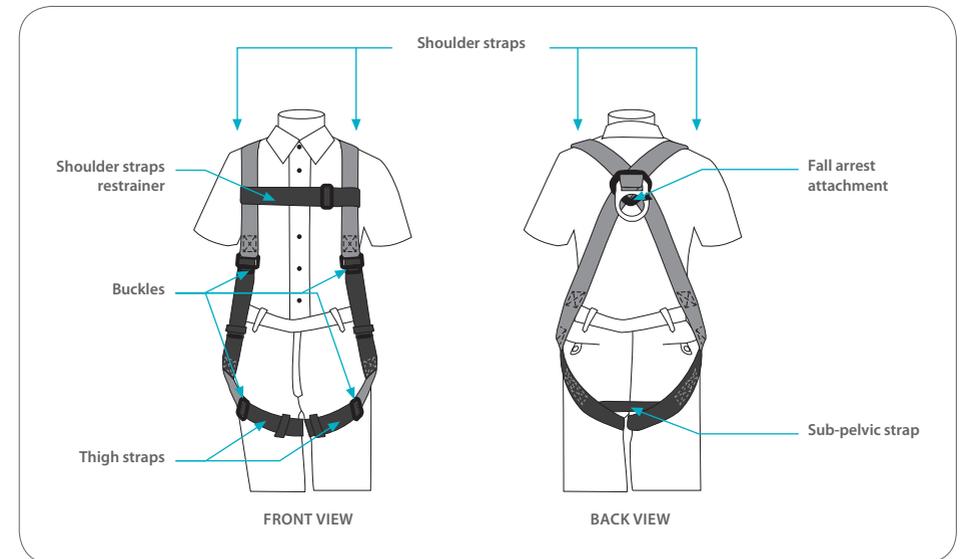


Figure 4: Basic elements of a full body harness.

4.1.2 Classification of Full Body Harnesses

There are four classes of full body harnesses. They are Class A, D, E and P (see Figure 5).

All FBHs shall, as a minimum requirement, meet the specifications in Class A. A FBH may have extra features peculiar to the operating environment as shown in Figure 5.

Class A



Fall arrest

- It shall incorporate at least one fall arrest attachment element.
- The fall arrest attachment element shall be positioned so that it lies either at the back (“dorsal” attachment D-ring) of the user (centrally between the upper shoulder blades), or centrally in front of the chest (at approximately the height of the sternum).

Class D



Controlled descent/ ascent

Class D shall meet the requirements for Class A.

- It has additional attachment elements that allow the user to connect to a controlled descent system.
- It shall have the controlled descent and ascent attachment elements incorporated so that the user can adopt an approximate seated position (whilst in suspension).

Note: Controlled descent or ascent attachment elements should only be connected to the controlled descent system, and not to the PFAS.

Class E



Confined space access

Class E shall meet the requirements for Class A.

- It has additional attachment elements that allow the user to connect to a confined space access system.
- It shall have a sliding attachment element on each shoulder strap to be used as pair, so that they enable the user to adopt a near upright position (whilst in suspension).

Note: Confined space access attachment elements are to be connected only to the confined space access system, and not to the PFAS.

Class P



Work positioning

Class P shall meet the requirements for Class A.

- It has additional attachment elements that allow the user to connect to a work positioning system.
- It shall have at least one work positioning attachment element incorporated at approximately waist level.
- If only one work positioning attachment element is provided, it shall be designed to lie in the middle of the torso.
- If work positioning attachment elements are provided (other than centrally at the front), they should be designed to be placed symmetrically in pairs and not be used separately.

Note: Work positioning attachment elements should only be connected to the work positioning system, and not to the PFAS.

Figure 5: Four classes of full body harnesses.

4.1.3 Minimum Breaking Strength of Full Body Harness

In accordance to *SS528: Part 1: 2006 Specification for Personal fall arrest systems. Part 1: Full body harnesses*, the minimum required static strength of a FBH is 15kN.

4.1.4 Selection of Full Body Harness for Different Working Environments

- **For Heavier Individuals**

Most FBHs are designed for the use of one person with his tools and equipment and their total mass should not exceed 100 kg. The correct FBH must be selected (with the advice from the manufacturer) to suit the individual's weight.

- **Full Body Harness for High Visibility**

Brightly coloured FBHs are recommended for work activities that requires high visibility (e.g., tunnelling).

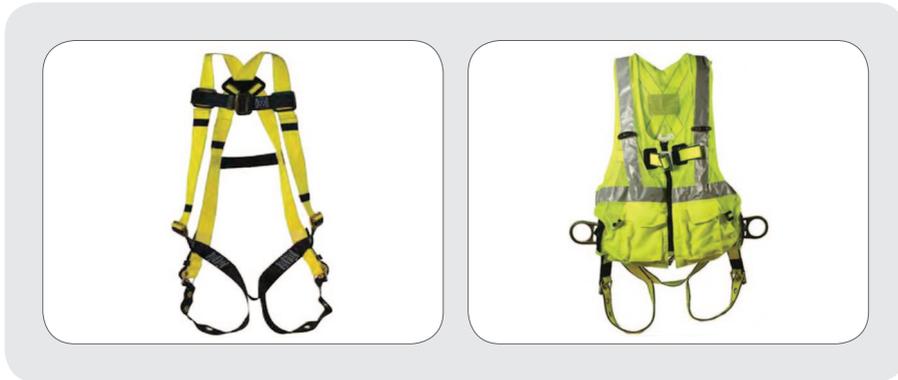


Figure 6: Types of high visibility full body harnesses.

- **Full Body Harness for Hot Works**

FBHs with char or fire-resistant grading are recommended for hot works (e.g., welding and flame cutting).



Figure 7: Full body harness for hot works.

- **Full Body Harness for Electrical Works**

FBHs with electrical resistance grading are recommended for electricians carrying out electrical work at heights.



Figure 8: Full body harness for electrical works.

- **Full Body Harness for Dirty Environment**

FBHs with special coating (e.g., polyurethane) are recommended for oily and dirty environments (e.g., oil field work, painting and tar roofing).



Figure 9: Full body harness for dirty environment.

- **Full Body Harness for Petrochemical Industry**

Anti-static FBHs are recommended for petrochemical environments to prevent the risks of electrostatic discharge igniting the explosive atmosphere.



Figure 10: Full body harness for petrochemical industry.

4.1.6 Lifespan of a Full Body Harness

FBHs can be used for a couple of years (as per manufacturer's recommendation) starting from the date they are put into use.

After the recommended period, the harness must be withdrawn from use and undergo a manufacturer's detailed inspection. The inspection can be carried out by:

- the manufacturer of the harness;
- personnel recommended by the manufacturer; or
- a company recommended by the manufacturer.

During inspection, the new admissible time of harness use till the next manufacturer's inspection will be established.

It is important to note that the harness must be withdrawn from use immediately and destroyed when it has been used to arrest a fall.

4.1.7 Important Points to Note when Wearing a Full Body Harness

A FBH must be worn properly for it to protect a worker in the event of a fall. Important points to note when wearing a FBH:

- The rear or dorsal D-ring should be located between the user's shoulder blades.
- The dorsal plate on the rear of the FBH must be in good working condition so that it can prevent the D-ring from slamming into the back of the user's head during a fall and prevent it from becoming a noose.
- The front chest strap (without the front attachment D-ring) must be fastened correctly as per the manufacturer's instructions. This will prevent the user from falling out of their harness.
- It is important for the user to select a harness with the correct D-ring orientation (i.e., select either front or rear D-ring). If the anchor point is behind a user, then the rear or dorsal D-ring would be appropriate and vice versa if the anchor point is in front of the user.
- It is critical to ensure that the FBH is correctly fitted on the user. A loose harness could lead to death or serious injuries (such as extreme testicular trauma and severe rectal damage) during a fall. However, if the harness is too tight, it can cause discomfort and limit movement.
- The best way to ensure that the body harness is of the correct fit ("snug tight") is the "two-finger test". The user inserts his middle and index fingers perpendicularly between the webbing and the body area underneath. He then tightens the buckles until the fingers can slide comfortably in and out.
- It is critical for the user to secure the FBH as the fall energy may exceed the strength of the stitching and pass through the unlocked buckle, which can cause the user to fall through the bottom of the FBH.

4.2 Connectors

4.2.1 Definition

Connectors are components that are used to link other PFAS components together, for example, a lanyard to an anchor.

Connectors that have a closure function, which provides protection against unintentional opening of the gate, should be used (e.g., by means of an automatic locking device or screw-sleeve).

There are three main components for connectors; they are "body", "gate" and "locking gear" (also known as "safety latch").

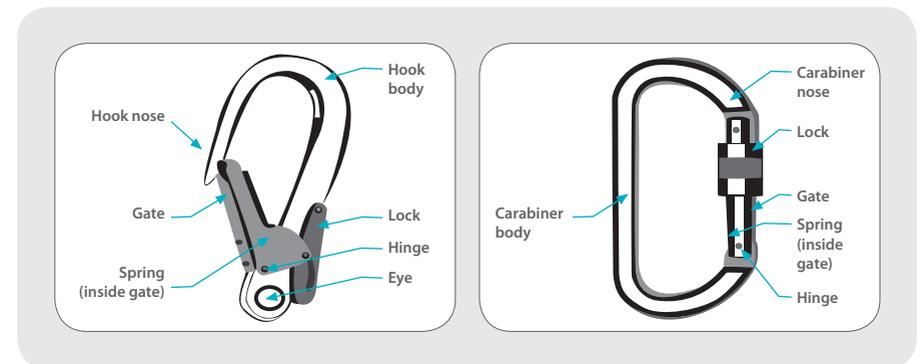
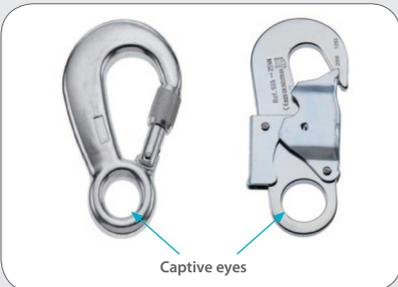


Figure 15: Components of connectors.

4.2.2 Classification of Connectors

According to BS EN 362:2004 Personal protective equipment against falls from a height. Connectors, there are five classes of connectors (see Figure 17).

Class	Connectors	Uses
Class B	<p>Basic connectors</p>	<p>Class B connectors are for general use.</p>

Class	Connectors	Uses
Class M	Multi-use connectors 	Class M connectors are for general use which may be loaded on either the major or minor axis. It is important to note the safe working load for a major and minor axis of a connector (as per manufacturer's instructions and recommendations).
Class T	Termination connectors 	Class T connectors come with a captive eye each.
Class A	Anchor connectors 	Class A connectors are connectors used for specific type of anchors.

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

Figure 16: Five classes of connectors.

4.2.3 Minimum Static Strength of Connector

The minimum required static strength of a connector is 20kN, according to *SS 528: Part 5: 2006 Specification for Personal fall arrest systems. Part 5: Connectors with self-closing and self-locking gates*; while the recommended static strength for screwlink connector is 25kN, according to *BS EN 362: 2004 Personal protective equipment against falls from a height. Connectors*.

If an asymmetrically shaped connector is used, the static load is normally applied parallel to and close to the spine. If the load is not positioned properly, for instance when wide webbing slings or double ropes are used, the weaker, gated side of the connector will take on more load (i.e., breaking load might be less than specified).

Therefore, extreme care should be taken into account during the selection of connectors (i.e., choosing of connectors with higher static strength than the minimum specified above).

Refer to *SS 528: Part 5: 2006 Specification for Personal fall arrest systems. Part 5: Connectors with self-closing and self-locking gates* for more information on the design, construction and test methods of connectors (self-closing and self-locking gates).

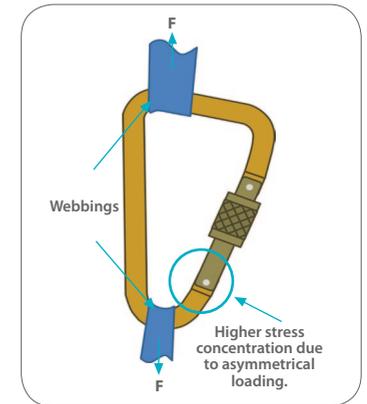


Figure 17: Difference in loading of a connector when using webbing slings (higher loading is experienced closer to the gate).

4.2.4 Basic Rules of Using Connectors

- Connectors and anchor points should be made of similar or compatible materials. For instance, when an aluminium connector is being attached to a steel anchor point, it will not be damaged by the harder surface of the anchor point.
- The design and size of a connector should be free to rotate in the anchor point (without hindrance or loosening); they should also be aligned with the direction of the dynamic load in the event of a fall.
- The connector used should have sufficient clearance to allow the gate mechanism to be fully closed and locked after the connection has being established to an anchor point.

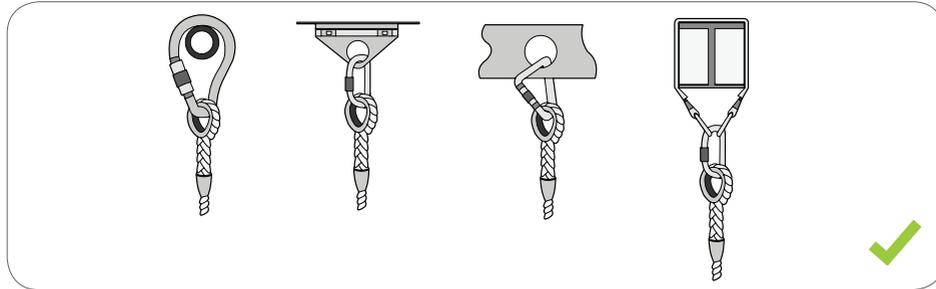


Figure 18: Examples showing the correct connectors being used with the anchor points.

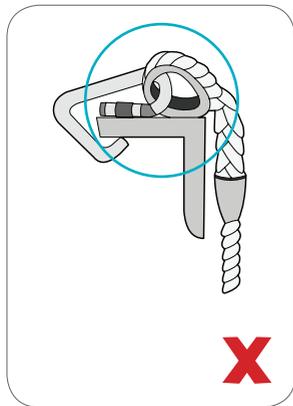


Figure 19: Example of a wrong method of using a connector. The gate mechanism of the connector cannot be closed and locked.

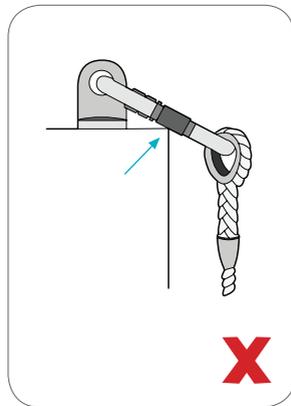


Figure 20: Example of a wrong method of connecting the connector to an anchor point. The connector is positioned such that it would not bend over the edge when a dynamic load is being applied.

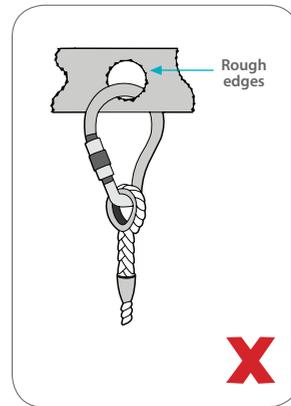


Figure 21: Example of a wrong method of connecting the connector to an anchor point with rough faces.

- A connector should never 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 20).

- A connector should not be connected to an anchor point or position that has rough edges (see Figure 21).
- The weakest point in most connectors is the gate; therefore force loading against the gate area should be avoided as this can cause “roll-out”. Roll-out is the accidental opening of the gate and the release of the connecting component from the connector caused by the pressure on the gate by a connecting device, such as an anchor, harness attachment point (metal), rope or webbing.

The safety catch or latch mechanism can be accidentally opened in two ways:

- 1) The running of the rope or webbing over the top of the gates that use a twist-action safety catch can result in the catch being rotated and unscrewed open.
- 2) The unintentional pressing of the safety catch on the double-action safety hooking against the user’s body or any structure.

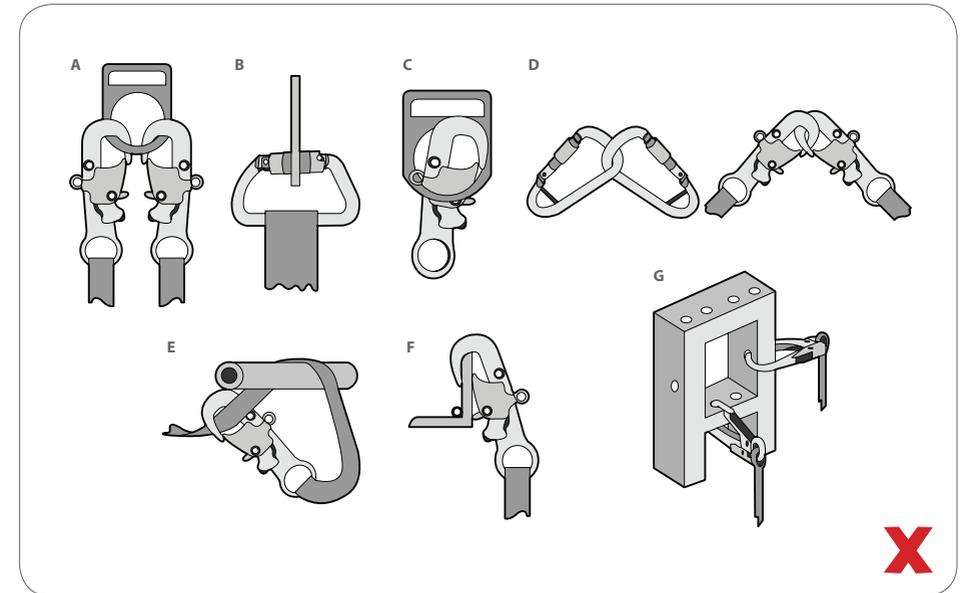


Figure 22: Examples of inappropriate connections. Snap hooks or karabiners should not be connected in the following scenarios:

- A: To a FBH’s D-ring to which another connector is attached.
- B: In such a way that would result in a direct loading on the gate.
- C: In a “false engagement” situation where the snap hook or karabiner appears to catch onto the anchor. User should check the connection visually to ensure that it is properly engaged before use.
- D: To one another.
- E: Directly to rope lanyard or webbing (unless indicated by the manufacturer).
- F and G: To any structure or object that prevents the snap hook or karabiner from proper closing and locking.

4.2.5 Procurement, Markings and Identity Label

All connectors used as PPE should be acquired through reliable sources or suppliers. They must be well-constructed and manufactured in conformance to relevant recognised international standards (such as ISO, BS EN, ANSI, and SS). They must also come with a COC.

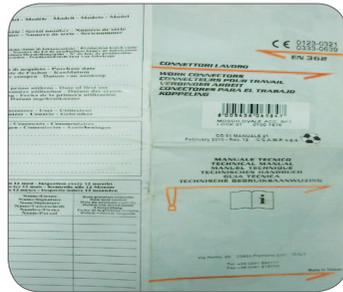


Figure 23: Example of a manufacturer's certificate for a connector.

All connectors shall be clearly marked, permanently labelled or come with identity label with, at least, the following information:

- manufacturer or supplier's name, trademark (or any other means of identifications);
- number showing compliance to SS 528 (or ISO 10333);
- manufacturer's product identification information (e.g., batch number or serial number for traceability purposes);
- year of manufacture; and
- minimum breaking strength of 20kN or more.



Figure 24: Example of a karabiner's marking and identity label.

4.2.6 Lifespan of Connectors

Connectors such as a snap hook can be used for a couple of years as per manufacturer's recommendation. After the recommended period, they must be withdrawn from use and undergo a manufacturer's detailed inspection.

The inspection can be carried out by:

- manufacturer of the harness;
- personnel recommended by the manufacturer; or
- a company recommended by the manufacturer.

During inspection, the new admissible time of connectors' use till the next inspection will be established.

It is important to note that the connector must be withdrawn from use immediately and destroyed when it has been used to arrest a fall (unless stated as otherwise per manufacturer's manual).

4.3 Energy Absorbers

4.3.1 Definition

An energy absorber is a component which limits the arresting forces applied to the PFAS, anchor device and user by dissipating the kinetic energy generated during a fall.

When a sharp downward force (i.e., a fall) happens, the energy absorber deploys itself and absorbs the energy generated; decelerating the user over a short distance and thus reducing the impact force to the user.

It should be noted that an energy absorber can be activated partially. With reference to *BS 8437: 2005 – Code of practice for selection, use and maintenance of personal fall protection systems and equipment for use in the workplace*, this could happen if it is being subjected to a force above 2kN without a fall occurrence. To avoid this scenario, the user should not put their weight suddenly on any component including the energy absorber.

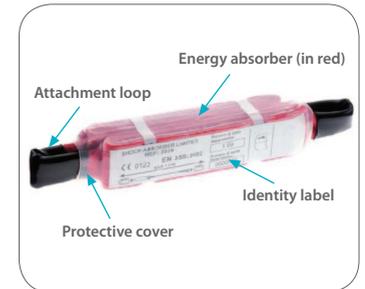


Figure 25: Main components of an energy absorber.

All energy absorbers shall have protective coverings to shield them against external contaminants, adverse climate, sharp objects, and so on.

4.3.2 Types of Energy Absorbers

There are two types of energy absorbers as specified by *SS 528: Part 2: 2006 Specification for Personal fall arrest systems. Part 2: Lanyards and energy absorbers*.

Type 1	The potential free-fall distance can be limited to a maximum of 1.8 m.	If a fall takes place, the arresting force is limited to a maximum of 4.0kN
Type 2	The potential free-fall distance can be limited to a maximum of 4.0 m.	If a fall takes place, the arresting force is limited to a maximum of 6.0kN

Table 1: Two types of energy absorbers.

4.3.3 Static Strength of Energy Absorber

A fully deployed energy absorber shall be able to withstand a force of 22kN (for Type 1) and 15kN (for Type 2) without rupturing or being torn.

4.3.4 Procurement, Markings and Identity Label

All energy absorbers (with or without lanyard) used as PPE should be acquired through reliable sources or suppliers. They must be well-constructed and manufactured in conformance to relevant recognised international standards (such as ISO, BS EN, ANSI and SS). They must also come with a COC (see Figure 26).

All energy absorbers shall be clearly marked, permanently labelled (by any method that will not damage the materials) or come with identity label with the following information (see Figures 27 and 28):

- name, trademark, manufacturer's identification or supplier who is responsible for acting on behalf of the manufacturer of the product (for claiming compliance to certain standards);
- standard's number (e.g., ISO 10333-1);
- manufacturer's serial number or other markings for traceability purposes;
- manufacturer's model number and type of full body harness the energy absorber is designed to be used with;
- year of manufacture of the product;
- manufacturer's warning instructions to be followed;
- minimum clearance for safe fall arrest (as measured from the anchor);
- maximum free-fall distance that the energy absorber can give the user an appropriate degree of protection upon activation; and
- details which classify the energy absorber according to its relevant type and any consequent restrictions upon safe use are explained appropriately.

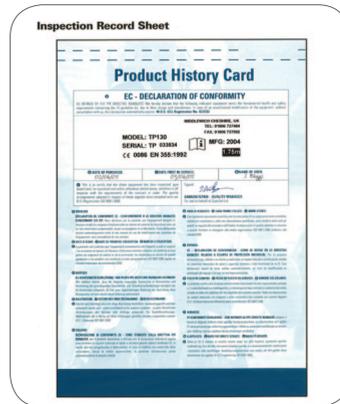


Figure 26: Example of a manufacturer's certificate for an energy absorber with lanyard.



Figure 27: Example of an energy absorber's identity label showing the date of manufacture, serial number, standard of conformance, material, and so on.



Figure 28: Example of an energy absorber's identity label (opposite side) showing the free fall distance, arresting force and a diagram displaying the safety distance upon activation of the energy absorber.

4.3.5 Lifespan of an Energy Absorber

An energy absorber (with or without a lanyard) can be used for a couple of years (as per manufacturer's recommendation), starting from the date of they are put into use.

After the recommended period or when it has been used to arrest a fall, the energy absorber must be withdrawn from use and destroyed.



Figure 29: Example of an unsafe practice where an activated energy absorber is being tied up and reused.

4.3.6 Bypassing of Energy Absorbers

Energy absorbers shall be used with care in all instances and in accordance to the manufacturer's instructions. It shall not be removed from the designated area of the FBH. It is also important to ensure that no "bypassing" occurs due to improper connection of the energy absorber to the lanyards.

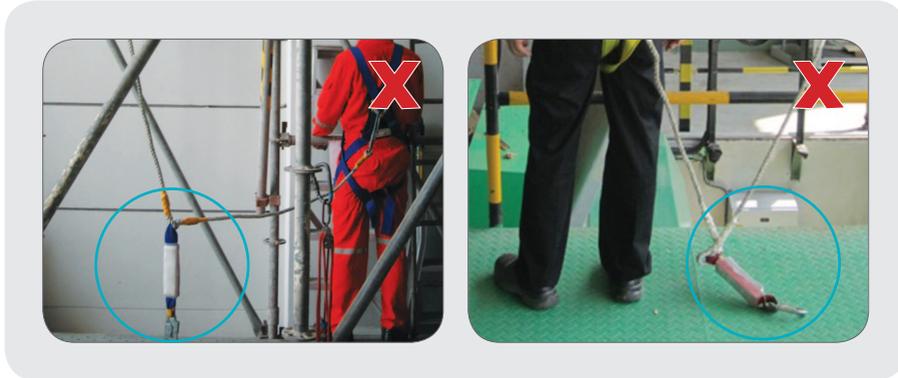


Figure 30: Examples of unsafe practices where an energy absorber are fitted incorrectly or "bypassed". These energy absorber will not be deployed correctly in the event of a fall.

4.4 Lanyards

4.4.1 Definition

A lanyard is a finished length of flexible material, which is often used in conjunction with an energy absorber (see Figure 31).

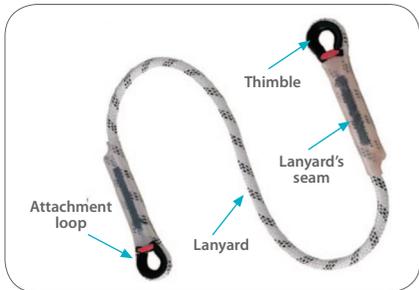


Figure 31: Components of a lanyard.

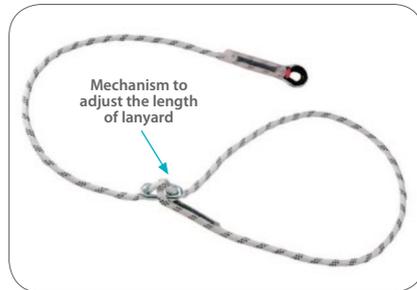


Figure 32: Example of an adjustable lanyard.

An adjustable lanyard incorporates a designed mechanism that allows the shortening and lengthening of its length (see Figure 32).

An energy-absorbing lanyard (also known as "shock-absorbing lanyard") is a type of lanyard with an integrated energy absorber (see Figure 33).

An energy-absorbing lanyard of a correct length may be used for travel restraint purposes provided that it will not be subjected to a force that could deploy the integrated energy-absorbing material.

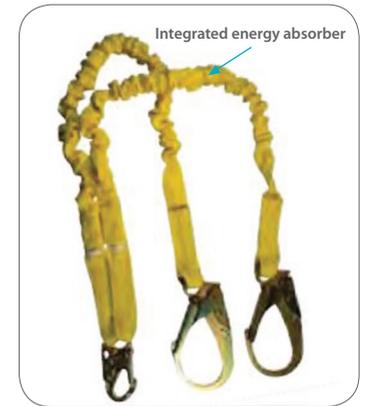


Figure 33: Example of an energy-absorbing lanyard.

4.4.2 Twin Lanyards System

A twin lanyards system (also known as "Y-shaped" or "twin-tailed" lanyards) incorporates two lanyards with a single energy absorber (see Figure 34).

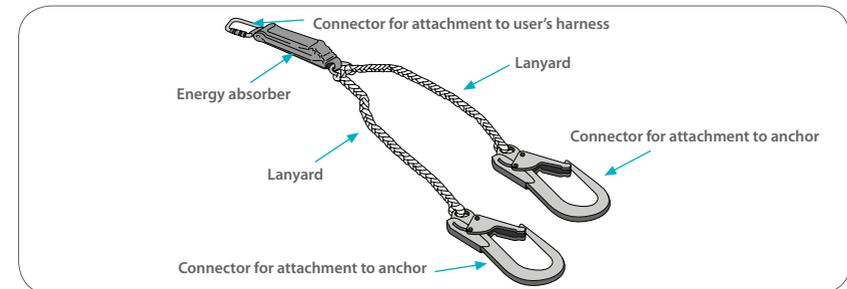


Figure 34: Example of a twin lanyards system.

Twin lanyards are used for 100% tie-off (i.e., second lanyard must be connected to the next anchor point or lifeline before the connection to the previous anchor point is disengaged).

It is important to note that lanyard tails (i.e., connector for attachment to anchor) shall not be attached to any part of the FBH as this could cause the energy absorber to fail in the event of a fall. This is known as "short-circuiting" or "back clipping" (see Figure 35).

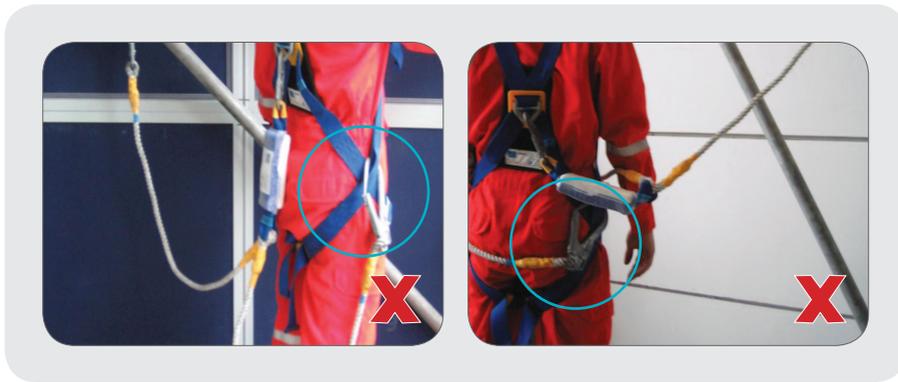


Figure 35: Examples of “back clipping” of twin lanyards.

The use of lanyard retainers attached to the FBH is recommended for:

- safe attachment of unused (or dangling) lanyards to prevent tripping hazards posed to the user during movements; and
- preventing “back clipping” as the lanyard retainers are designed to break off during a fall without damaging the FBH.



Figure 36: Lanyard retainer (left) and lanyard retainer attached to a FBH.

4.4.3 Static Strength of Lanyards

Lanyards (including their terminations and with or without adjustment device) shall be able to sustain a force (see Table 2) without rupturing and being torn.

Different Types of Lanyards	Maximum Force (kN)
Fibre rope based lanyard	22
Webbing based lanyards	22
Chain based lanyards	15
Wire rope based lanyards	15

Table 2: Static strength of different types of lanyards.

4.4.4 Procurement, Markings and Identity Label

All lanyards used as part of PPE should be acquired through reliable sources or suppliers. These energy absorbers shall be of good construction and manufactured in conformance to international standards (such as ISO, BS EN, ANSI, SS, etc).

All lanyards shall be clearly marked, permanently labelled (by any method will not damage the materials) or come with identity label with the following information:

- name, trademark, manufacturer’s identification or supplier who is responsible for acting on behalf of the manufacturer of the product (for claiming compliance to certain standards);
- standard’s number (e.g., ISO 10333-1);
- manufacturer’s serial or batch number or other markings for tracing purposes;
- type of fibre used as the material construction;
- year of manufacture of the product; and
- manufacturer’s warning instructions to be heeded.



Figure 37: Example of a lanyard with an identity label.

4.5 Work Positioning Belts, Travel Restraint Belts and Work Positioning Lanyards

4.5.1 Definition

A work positioning belt is used as a form of body support (which encircles the user's waist) that works in tension to prevent a worker from falling.

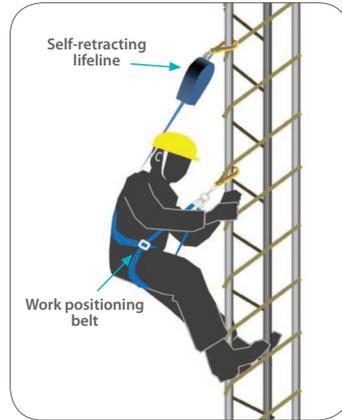


Figure 38: Example of a work positioning system (with an SRL used as a fall arrest system).

A travel restraint belt is a form of body support (which encircles the user's waist) that prevents the user from reaching zones where the risk of a FFH exists.

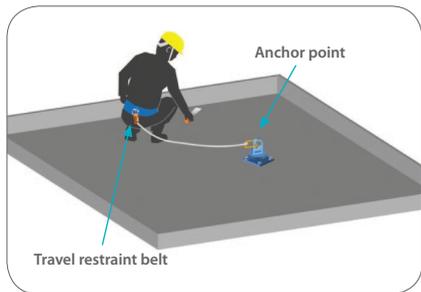


Figure 39: Example of a travel restraint system.



Figure 40: Example of a work positioning cum travel restraint belt.



Figure 41: Example of an unsafe practice showing extension of a travel restraint length with incorrect usage of a twin lanyards system.



Figure 42: Example of a work positioning lanyard.

A work positioning lanyard is a component that links up the work positioning or work restraint belts to an anchorage (see Figure 42).

It is important to take note that the work positioning and travel restraint belts (with lanyard) shall not be used for any form of fall arrest purposes.

4.5.2 Minimum Static Strength of Work Positioning/ Restraint Belts (and Lanyards)

In accordance to *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*, work positioning or restraint belts and work positioning lanyards shall be able to withstand the static strength listed in Table 3.

Different Types of Lanyards	Maximum Force (kN)
Work positioning/ restraint belt	15
Work positioning/ restraint belt (integrated with work positioning lanyard)	15
Work positioning lanyard	15

Table 3: Static strength for different types of lanyards.

4.5.3 Procurement, Markings and Identity Label

All work positioning or restraint belts and lanyards like any other PPE should be acquired through reliable sources or suppliers. They must be well-constructed and manufactured in conformance to relevant recognised international standards (such as ISO, BS EN, ANSI and SS). All work positioning or restraint belts (with lanyards) shall come with a COC.

They shall be clearly marked, permanently labelled (by any suitable method that will not damage the materials) or come with identity label with the following information:

- name, type and size of device;
- trademark, manufacturer's identification or supplier who is responsible for acting on behalf of the manufacturer of the product (for claiming compliance to certain standards);
- manufacturer's batch number and device serial number;
- year of manufacture of the product;
- material of construction (e.g., polyamide);
- information stating the intended purpose of each attachment components or elements; and
- manufacturer's instructions, warning or caution.

4.6 Understanding Suspension Trauma

4.6.1 Suspension Trauma

"Suspension trauma" is a condition in which a worker (in his FBH) remains suspended at height after a fall. Suspension in a harness may cause blood to pool in the veins of the legs; this can result in the worker becoming unconscious. If the worker is not promptly rescued, serious injury or death can occur.

Some warning signs of suspension trauma include:

- faintness;
- breathlessness;
- sweating;
- paleness;
- hot flushes;
- increasing pulse rate and blood pressure; and
- unconsciousness.

4.6.2 Management of Suspension Trauma

The best way to manage suspension trauma is to prevent situations where workers can end up being suspended. In cases where such situations cannot be avoided, it is vital that the hazard is recognised and addressed immediately as it can be life-threatening.

It is critical that a well-trained rescue team is available to respond to such a situation when a worker has fallen and is suspended in the air. The suspended worker needs to be rescued as soon as reasonably practicable (in less than 10 minutes) to prevent possible fatality or major injury.

4.6.3 What should a Worker do when he Falls from Height

If this happens and the worker is suspended in his FBH, he should:

- Stay calm;
- Try to make contact with fellow workers so that rescue can be arranged;
- Try to maintain blood circulation by moving his feet and toes. If possible, he should place his feet onto a solid surface so as to take one's weight off the harness; and
- Deploy the suspension trauma strap.

4.6.4 Suspension Trauma Strap

A suspension trauma strap is an additional safety accessory attached to the FBH. It helps to reduce the effects of suspension trauma after a fall occurs by providing a step for fallen workers to use (see Figure 43). The suspension trauma strap is useful provided that the suspended worker is in a conscious state.

Most suspension trauma straps allow a worker who is suspended in air to "stand up" in their harness to help relieve the pressure experienced in the lower limbs. This will help the blood to circulate in the upper body and reduce the effects of suspension trauma.



Figure 43: Example of a deployment of a suspension trauma strap.

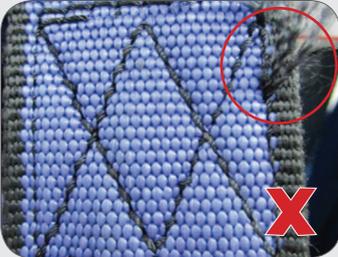
It is important to note that the suspended worker needs to be rescued as soon as possible even with the activated suspension trauma strap.

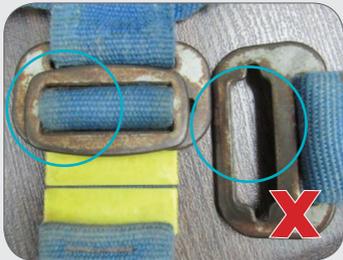
4.7 Inspection of Personal Protective Equipment

- All PPE shall be inspected before every use.
- Regular inspection by a competent person should be performed at least once every 12 months as per manufacturer's instructions. For use in extreme environments (e.g., near hot works), more frequent inspections are required.
- Inspection procedures and records should be documented and filed in a location where they are readily available to the users or authoritative inspection. A sample checklist is shown in Annex A.
- It is important to follow all specific instructions or recommendations for inspection that are provided with the equipment at the time of purchase. These instructions must be stored in a location accessible to users. If required by the manufacturer, the equipment shall be returned to the manufacturer for inspection, repair or recertification.
- All equipment must be scrapped if the stress indicator or warning system has been activated.
- If the PPE has been used to arrest a fall, remove all components of the system from service and dispose them according to manufacturer's recommendation.

4.7.1 Inspection of Full Body Harness

Parts	Methods
Webbing	<p data-bbox="360 229 981 309">Hold the webbing with both hands and bend it into an inverted "U" shape. Due to surface tension, major cuts and damaged fibres will be revealed.</p>  <p data-bbox="360 612 658 655">Cracks will reveal due to surface tension.</p> <p data-bbox="360 687 909 740">Repeat this step for the entire length and both sides of webbing.</p> <ul data-bbox="360 751 981 804" style="list-style-type: none"> • Look out for frayed edges, broken fibres, pulled stitches, cuts, burns and signs of ultraviolet (UV) and chemical damage.  <p data-bbox="360 1107 524 1129">Cuts on webbing.</p>  <p data-bbox="360 1436 546 1458">Frayed on webbing.</p>

Parts	Methods
Webbing	 <p data-bbox="1514 446 1800 469">Damaged stitches on webbing.</p>  <p data-bbox="1514 774 1778 826">1. Discolouration due to UV. 2. New Full Body Harness.</p>  <p data-bbox="1514 1128 1800 1181">Chemical damage due to paint marking on webbing.</p>  <p data-bbox="1514 1474 1778 1497">Webbing damaged by burns.</p>

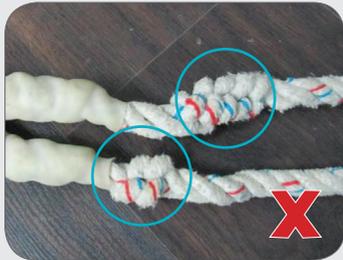
Parts	Methods
D-rings or back pad	<ul style="list-style-type: none"> Inspect the D-rings for distortion, cracks, breaks, severe corrosion, and rough or sharp edges. Check the D-ring's back pad for signs of damage.
Buckle attachment	<ul style="list-style-type: none"> Inspect for any unusual wear, frayed or cut fibres, broken stitching of the buckle or D-ring attachments
Quick-connect buckles	<ul style="list-style-type: none"> Inspect the mating buckle for distortion. Check the outer and centre bars and ensure that they are straight and aligned. Inspect corners and attachment points at the center bar. Inspect and remove any debris that may hinder the engagement of the buckles Inspect for severe corrosion and pitting.  <p>Severe corrosion.</p>

4.7.2 Inspection of Connectors

Parts	Methods
Karabiner and snaphook, and so on.	<ul style="list-style-type: none"> Inspect closely for any cracks, corrosion or pitted surfaces and distortions in the hook and eye.  <p>Badly corroded snap hook.</p>

Parts	Methods
Karabiner and snaphook, and so on.	<ul style="list-style-type: none"> Check that the safety latch seats within its cavity without any "sticking" or binding effect (i.e., not being jammed within). It should also not be distorted or obstructed. Check that the latch spring is not distorted and should exert sufficient force to firmly close the latch.

4.7.3 Inspection of Lanyards and Energy Absorbers

Parts	Methods
Thimbles	<ul style="list-style-type: none"> Check that the thimble is seated firmly in the eye of the splice. Check that the splice has no loose or cut strands. Check that the edges of the thimble are free of sharp edges, distortions or cracks.
Rope lanyard	<ul style="list-style-type: none"> Inspect the rope lanyard by rotating it from end-to-end for any signs of fluff, worn, broken or cut fibres. Check that the rope lanyard is not being tied as knots. Check for signs of noticeable change from the rope's original diameter; this indicates weakened areas from extreme loads.  <p>Damaged lanyards</p>
Webbing lanyard	<ul style="list-style-type: none"> Check for any cuts and breaks by bending the webbing slightly and observing each side of the webbed lanyard. Check for any breaks in stitching. Check and inspect signs of swelling, discoloration, cuts, cracks or charring; these are signs of chemical or heat damage.

Parts	Methods
Energy-absorbing lanyard	<ul style="list-style-type: none"> Examine this type of lanyard using the same method described for webbing lanyard (see above). It is important to check for signs of deployment of the indicator or warning flag. If activated sign is shown, the energy-absorbing lanyard must be discarded.
Wire rope lanyard	<ul style="list-style-type: none"> Inspect the wire rope lanyard by rotating it. Check for cuts, kinked, frayed areas or unusual wear patterns on the wire. Broken strands will be separated from the body of the lanyard.
Energy absorbers	<ul style="list-style-type: none"> The outer protective pack should be examined for signs of holes, cuts or tears.  <p>Cuts on energy absorber.</p> <ul style="list-style-type: none"> Check the stitching on the areas where the pack is sewn or attached to D-rings, belts or lanyards for loose strands, rips and deterioration. Check for signs of activated energy absorber.  <p>1. Energy absorber after being activated. 2. New and inactivated Energy absorber.</p>

Annex A – Sample Checklist for Full Body Harness

Inspection Checklist for Full Body Harness				
Model no.:		Inspector:		
Serial no.:		Inspection date:		
Date made:		Removal/Disposal date:		
No.	Description	Qty.	Overall Assessment	Comments
Fabric Parts				
Webbing (Straps)				
1	Shoulder			
2	Shoulder strap retainer			
3	Shoulder ring strap			
4	Thigh			
5	Sub-pelvic			
6	Tool belt support			
Stitching				
7	Shoulder ring strap			
8	Shoulder strap tip			
9	Shoulder strap retainer			
10	Shoulder strap reinforcement			
11	Buckle			
12	Thigh strap			
13	Thigh strap edges			
14	Sub-pelvic strap			

Metallic Parts				
D-Rings/ Oval Rings				
15	Back			
16	Hip			
17	Chest			
18	Shoulder			
Buckles/ Adjusters/ Grommets				
19	Adjuster, torso sizing			
20	Buckle, tongue			
21	Buckle, friction			
22	Grommets, thigh strap			
Plastic Parts				
23	Back D-ring locator			
24	Strap collar			
25	Labels			
26	Tool belt support clips			

Annex B – Sample Checklist for Lanyard

Inspection Checklist for Lanyard				
Model no.:		Inspector:		
Serial no.:		Inspection date:		
Date made:		Removal/Disposal date:		
No.	Description	Qty.	Overall Assessment	Comments
Fabric Parts				
Webbing (straps)				
1	Lanyard leg(s)			
Stitching				
2	Lanyard leg (one fixed)			
2	Lanyard leg (one adjacent)			
2	Lanyard legs (twin)			
Brake				
3	Webbing, loop(s)			
4	Stitching, strap loops			
5	Stitching, cover			
6	Binding tape			
7	Cover			
Fiber Rope				
8	Lanyard leg			
9	Splices			

Metallic Parts				
10	Lanyard leg (wire rope)			
11	Snaphooks, one leg			
11	Snaphooks, twin legs			
11	Snaphook			
12	Karabiner			
13	Adjuster			
14	Swaged fitting			
15	Thimble			
16	Hog ring			
Plastic Parts				
17	Labels			
18	Thimble			
19	Vinyl coating, wire rope			

5. References

- Workplace Safety and Health Act
- Workplace Safety and Health Act (Construction) Regulations
- Workplace Safety and Health Act (Scaffold) Regulations
- Workplace Safety and Health Act (Risk Management) Regulations
- Code of Practice for Working Safely at Height
- Code of Practice for WSH Risk Management
- SS 528 Part 1: 2006 – Personal fall arrest systems – Full body harness
- SS 528 Part 2: 2006 – Personal fall arrest systems – Lanyards and energy absorbers
- SS 528 Part 5: 2006 – Personal fall arrest systems – Connectors with self-closing and self-locking gates
- BS EN 795: 1997 Protection against falls from a height. Anchor devices. Requirements and testing
- BS EN 1492-1: 2000 + A1:2008 Textile slings. Safety. Flat woven webbing slings made of man-made fibres for general purpose use
- BS EN 1891: 1998 Personal protective equipment for the prevention of falls from a height. Low stretch kernmantel ropes
- BS 7883: 2005 Code of practice for the design, selection, installation, use and maintenance of anchor devices conforming to BS EN 795
- BS 7985: 2009 Code of practice for the use of rope access methods for industrial purposes
- BS 8437: 2005 Code of practice for selection, use and maintenance of personal fall protection systems and equipment for use in the workplace
- ISO 1140 :2004 Fibre ropes - Polyamide - 3-, 4-, 8- and 12 - strand ropes
- ISO 1141 :2004 Fibre ropes - Polyester - 3-, 4-, 8- and 12 - strand ropes
- ISO 10333-4: 2002 Personal fall arrest systems - Part 4: Vertical rails and vertical lifelines incorporating a sliding-type fall arrester
- ISO 14567: 1999 Personal protective equipment for protection against falls from a height - Single-point anchor devices
- ISO 22159: 2007 Personal equipment for protection against falls - Descending devices
- ISO 22846-1: 2003 Personal equipment for protection against falls - Rope access systems - Part 1: Fundamental principles for a system of work

6. Acknowledgements

We would like to thank Asretec Pte. Ltd., Capital Safety Group Asia Pte. Ltd., Caterpillar Asia Pte. Ltd., Honeywell Safety Products, QMT Industrial & Safety Pte. Ltd. and 3M Technologies (Singapore) Pte. Ltd. for their contribution to this publication.

Published in November 2012 by the Workplace Safety and Health Council in collaboration with the Ministry of Manpower.

All rights reserved. This publication may not be reproduced or transmitted in any form or by any means, in whole or in part, without prior written permission. The information provided in this publication is accurate as at time of printing. All cases shared in this publication are meant for learning purposes only. The learning points for each case are not exhaustive and should not be taken to encapsulate all the responsibilities and obligations of the user of this publication under the law. The Workplace Safety and Health Council does not accept any liability or responsibility to any party for losses or damage arising from following this publication.

This publication is available on the
Workplace Safety and Health Council
Website: www.wshc.sg
Email: contact@wshc.sg

