National Protective Security Authority

GUIDANCE

Body Armour for Security Officers

Introduction

This document provides an introduction to body armour and is intended to guide managers in the selection, procurement and management of appropriate body armour for their civilian staff. It considers threats, body armour types, specifications, procurement, human factors considerations, durability and through life management.

Contents

Executive Summary

Owners of national infrastructure sites owe a duty of care to protect their employees from a wide range of hazards. Consideration should be given to whether they provide body armour for their staff, especially those in public-facing roles (such as security guards), who may be exposed to physical attacks.

This document provides an introduction to body armour and is intended to guide managers in the selection, procurement and management of appropriate body armour for their civilian security staff.

The current standards for body armour have been developed by the Home Office's Centre for Applied Science and Technology (HO CAST). Although they were primarily intended for use by police forces they are also appropriate for other users. The Home Office maintains a list of accredited products which have been found to meet the standards when tested at approved facilities.

Managers should discuss the likely threats and risks to their staff with their local police force. Generically the threats can be grouped as:

- A stab using a knife or spike – this may cause a deep injury that could damage vital organs.
- A slash using a knife – this may cause a long, shallow injury which is mainly a danger to major blood vessels.
  A ballistic attack using a pistol, rifle or shotgun – ballistic (gunshot) injuries are complex

The Home Office standards provide standard test procedures for each type of threat. Within each threat type several levels of severity are defined and the manager must decide which level of protection is appropriate. Body armours are usually made of ballistic and blast resistant fabrics within an outer fabric casing. In general, as protection levels increase, body armour will become heavier and stiffer and will decrease the wearer's mobility and increase the physiological load. If protection against a rifle is needed additional rigid armour plates will be needed.

Body armour only protects part of the body and is designed to protect vital organs; however it is not practical to protect the head and neck or the limbs. The manager may need to define the coverage required to match the role of the user. For instance someone in a seated role, such as a driver, will need a shorter jacket than a security guard who is largely standing up.

Generally manufacturers make two versions of a body armour, unformed and formed, which cater for different body shapes. It has been found that both types may suit individuals of either sex.

Managers will need to ensure that staff are supplied with the correct size of body armour and are trained to care for and wear it properly. There is also a need to regularly inspect body armour. A manufacturer should provide a warranty; this may vary but typically indicates a service life of 10 years.

Do you need body armour?

Body armour can be an expensive purchase, which includes not only buying the protective equipment, but also training staff in its use and the on-going care and maintenance regimes. It is important that an appropriate risk assessment is carried out to understand if body armour will be a proportional mitigation against the risks that your organisation and front line security staff may face.

Your front line civilian security staff may face the risk of an attack by bladed weapons such as knives and spikes, and/or ballistic threats including handguns, rifles, personal defence weapons

and shotguns. Body armour will provide a degree of protection, but you will also need to consider whether this additional protective security measure will impact on the security staff's mobility (due to the weight and potential restricted movement of some types of body armour) and ability to respond to other threats.

Body armour may also provide some protection against threats from improvised weapons such as screwdrivers, clubs and batons (e.g. baseball bats) or thrown items (e.g. bricks, stones and bottles). However, there are no test standards for these improvised threats.

Threats – Knives and Spikes

Knives come in many designs and may have one or two sharp cutting edges. They may produce penetrating stab or slash injuries. The knife used for stab testing is engineered to reproduce deep stabbing injuries. Similarly the knife used for slash testing is engineered to reproduce shallow, long slash injuries.

Spikes produce very deep, narrow stabbing injuries. Screwdrivers used as weapons may produce similar injuries. The spike used for testing has a circular, tapering cross-section narrowing to a sharp point.

The two types of injury are very different and the armour required to defeat them is just as different. A stab attack would be expected to penetrate to a significant depth, at one or more locations. A slash may travel a significant distance across the surface of the target, but will typically not penetrate very deeply. Studies have been conducted into the levels of vulnerability of the different bodily organs and how far below the surface of the skin these organs are typically found. These studies have informed the armour performance levels specified in test standards.

Threats - Firearms

There is a large range of ballistic threats including, generically:

- **Handguns (pistols)** – these fire snub-nosed bullets at low velocity (200 to 500 m/s) which can be stopped by soft armours. Sub-machine guns fire the same ammunition at similar velocities.
- **Rifles –** these fire streamlined bullets, which have much more energy and are much more penetrating than handgun bullets, at high velocity (650 to 1000 m/s). In order to stop these bullets, rigid hard armour upgrade plates will be required in addition to soft armour. Machine guns fire the same ammunition at similar velocities.
- **Personal defence weapons –** this is a relatively new category of weapons that are being deployed by some police forces. They are high velocity weapons with smaller calibres than rifles and hence have lighter, less penetrating bullets which will penetrate soft armours but will be easily defeated by hard armour upgrade plates.
- **Shotguns –** these are fairly widely available and the cartridges usually contain a large number of spherical pellets known as a shot. At a distance these pellets will have dispersed and can readily be defeated by soft armours. However, at close range, when there is very little dispersal of the shot, the effects are much more serious and hard armour plates will be required. To replicate this situation a single large lead slug is used for test purposes. A more detailed discussion of firearms is in Factsheet 1 Firearms.

It is important to understand how these threats interact with the body, both with and without intervening body armour. In the absence of body armour, or should the body armour fail, the wearer will experience penetrating injury. With body armour which has defeated the incoming threat, there may still be the possibility of the wearer suffering injury due to a phenomenon known as behind armour blunt trauma (BABT). For more information see Factsheet 2 Injury Mechanisms and Factsheet 3 Ballistic injuries.

Body Armour Types

There are a number of different types of body armour which may be defined partly by what they are designed to defeat (the threat) which determines the materials the armour is constructed from, and partly by how they are worn and used, for example overt, covert etc. A fuller description of these types of armour can be found in Factsheet 4 Body Armour Types.

For civilian security staff the most common form of armour is worn overtly, which provides both a visual security deterrent and a layer of protective security for the security staff. Typically this consists of soft armour in a fabric carrier which is designed to defeat knives, spikes and low velocity ballistic threats. In some situations it may be necessary to add hard armour plates to defeat high velocity ballistic threats.

Soft Body Armour

Soft body armour refers to armour which is designed for the defeat of stab, slash or low velocity bullets. Due to the levels of threat for which it is designed, it is possible to use woven, uni-directional or laminated textiles in the construction of these items. Each layer of these materials is flexible; hence the term 'soft' is used. As more layers are added the flexibility will be reduced but some will remain. Generally the soft body armour is protected in a fabric casing which in turn is placed in a robust fabric carrier.

Figure 1: Overt body armour (Courtesy: Sioen)

Overt body armour is worn outside/over the normal outer layer of clothing and is therefore completely visible to any observer. It is often seen as part of a uniform, and makes a statement that the wearer is protected by an armour system. Overt body armour has the advantage that it is very easy to put on and remove.

Figure 1 shows a simple overt body armour design, which incorporates a limited amount of external pockets and attachments. Many users will often require significantly more pockets and attachments for their equipment.

Upgrade Plates

Soft body armour will not defeat high velocity bullets from rifles or machine guns. To defeat these threats the armour has to be fitted with upgrade plates. There are two different generic constructions for upgrade plates. These plates may have a facing layer of hard ceramic material backed by a more resilient composite material or may be constructed from a monolithic composite, such as Dyneema® or Spectra®. A typical upgrade plate is shown in Figure 2.

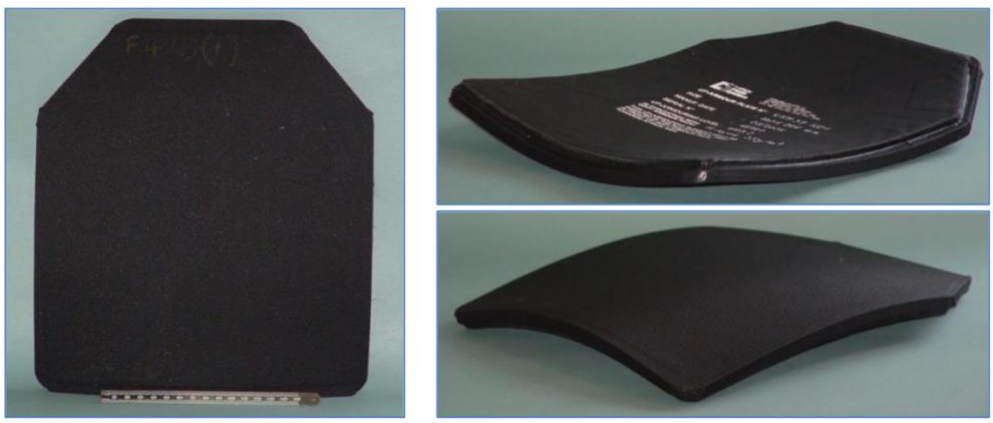

Figure 2: A typical upgrade plate

Because of their weight and rigidity, upgrade plates only cover a much smaller area of the body than soft body armour and are usually designed to protect vital organs. Plates are usually worn inserted into pockets sewn into the front and rear of the soft body armour carrier.

Body Armour Specifications

A body armour specification is different to either a test method or test standard, as it refers to a specific user requirement for a particular body armour. Sometimes a body armour specification will include a test regime which is not found in one of the official published test methods or standards. It may specify such elements as size range, materials of manufacture, test regime, climatic restrictions, integration with other clothing or equipment, maximum weight and maximum thickness. A body armour specification may be referred to by other terms such as system requirement or user requirement document. A body armour specification would normally be used by organisations which are purchasing a large number of items, as its preparation is not a quick or trivial task.

Test Methods and Standards

There are a number of different test methods and standards for items of body armour available. A test method is a document which describes how the body armour is to be tested, whereas a test standard describes levels of performance which must be met to pass the armour for service. Test methods and standards will be designed to be relevant to the specified user community, and they may, or may not, be suitable for transference to other user communities.

It should be noted that body armour accredited to the Home Office standards is considered to offer appropriate resistance to engineered threat scenarios. However body armour is not, and can never be 100% bullet, stab or slash proof as there will always be a bullet or knife capable of defeating any level of protection provided.

Consequently, it is important that security managers and procurement bodies thoroughly review their threats and select the most appropriate armour for their staff.

Stab and Slash-Resistant Body Armour

Stab-resistant body armour provides protection against knives and/or spikes. There have been three main stab-resistant body armour constructions used to date. The earliest type consisted of a number of interlocking metallic plates. This construction is heavy and fairly rigid to wear, although there was limited flexibility between the interlocking plates. The next type consisted of a fine steel chain-mail and woven textile combination Again this construction is quite heavy, but produces the most flexible solution. Finally a number of layers of laminated ballistic fabric can be used. This will probably provide the lowest weight of armour, but will be less flexible than chain mail versions.

The 2018 Home Office standard [3] covers testing of slash resistant materials. This test consists of a ‘Stanley®’ blade mounted in a drop tower. The blade is mounted in a Slash Missile, in such a manner as to cause the slash motion to be at 20 to the armour sample (which is mounted on the Force Table). If the measured damage is within specified limits the fabric tested is considered to be compliant with the standard. It provides for two levels of slash resistance, SR1 and SR2. SR1 is the lower level and should be used for less vulnerable areas e.g. the hands and arms. SR2 should be used for high risk areas such as the neck and groin.

Slash-Resistant Body Armour

Slash-resistant body armour can consist of a relatively light-weight armour system of perhaps only a couple of layers of fabric.

In the UK, the test standard for stab-resistant body armour is specified in the HO CAST standard of 2017 [1]. This should be read in conjunction with the HO CAST Body Armour Standard (2017) - Guidance [2]. The HO CAST 2017 standard includes both knife and spike resistance. The test is based upon a standardised knife blade or spike being dropped onto body armour under gravity. The standard provides two increasing levels of tests for knife resistance, KR1 and KR2 which permit limited penetration of the blade, and two levels for spike resistance, S1 and S2 which permit no penetration of a spike.

Bullet-Resistant Body Armour

Soft textile-based body armour, in the form of a waistcoat, is used to defeat low velocity bullets. Low velocity bullet-resistant body armour may be combined with components which add in stab protection (the testing of which has been discussed previously), thus making it multi-purpose armour. Bullet-resistant body armour will not necessarily defeat a knife or a spike. To defeat high- velocity bullets, rigid upgrade plates will be inserted in pockets in the outer carrier of a soft armour system. A pair of upgrade plates are used, one at the front and one at the rear, to provide protection for the areas covered. These plates may be monolithic composite, or ceramic-faced and composite- backed.

The 2017 Home Office standard for ballistic-resistant body armour [1], provides a number of different levels for both low and high velocity bullet-resistant body armour. Within Table 8 of the standard there are four increasing threat levels with the prescript HO: HO1, HO2, HO3 and HO4. HO1 and HO2 are handguns whilst HO3 and HO4 are rifles. There is one level with the prescript SG: SG1 for shotguns. There is also a level defined as ‘Special’ which can be any round specified by the user. Three examples of possible ‘Special’ ammunition types are given in Table 9 of the standard.

For all of these tests an internal firing test range is required. The test standard covers two main test requirements. Firstly there is a proof test for the ballistic resistance of the armour. Secondly there is a back-face signature measurement; this is used to assess the deformation which may cause behind armour blunt trauma.

Procurement of body armour

The first stage of procurement is for the security manager to determine their requirements for body armour. The following aspects need to be considered:

- the threat type and level to be protected against – stab, slash, handgun, rifle
- the type of body armour carrier – overt, covert, fully concealed
- any required pockets and attachments
- colour of carrier
- maximum weight of the body armour
- warranty period

Large organisations which procure body armour will probably have some type of approved suppliers system. If the HO CAST Body Armour Test Standards are used to specify the armour,

then there is an approved items list published on the Police Protective Equipment website: http://ped-cast.homeoffice.gov.uk/index.php/search/search_equipment/n

Carrier Options and Designs

When deciding which body armour to purchase the carrier options are often as important as the protection offered by the item. Organisations may have specific requirements for how their body armour interacts with other items of clothing and equipment. Also the body armour carrier may be required to provide load carriage. If purchasing individual or low numbers of items, the choice of carrier will probably need to be made from a selection of Commercial off the Shelf (COTS) items. However, if a larger number of items is being purchased, then the buyer should be able to request modifications to carrier designs or ask for bespoke designs to meet their exact requirements. In theory the carrier should be a cheaper component than the body armour components, and hence more than one carrier option may be possible for the same body armour filler.

Purchasing Process

The purchase process will be determined by what process is available to the procuring organisation. If a number of items are being procured by an organisation and a tendering process is appropriate, the procurer can have greater influence over the manufacturer and also negotiate better value for money. For individuals who are purchasing only for themselves, they will normally only be able to purchase COTS items and have little influence on cost or design.

Assessment of the Body Armour

In order to determine that the body armour being purchased meets the user's requirements, a full assessment needs to be completed. This is usually split into design and performance aspects.

Carrier Type, Comfort and Fit

The available body armour items need to be assessed to ensure that they meet the design requirements.

- Is the carrier the correct type – overt, covert?
- Does the carrier have suitable pockets and attachments?
- Is the body armour of a comfortable design?
- Is the sizing correct for the individual user(s)?
- Does the price represent good value for money?
- Is the weight of the body armour acceptable?
- Is the weight of the body armour distributed well over the body?
- Is the bulk of the body armour acceptable for the intended role?
- Is the carrier available in a suitable colour?

Test Methods and Standards

Whichever threat regime has been determined as relevant by the user, the most probable test standard to be used would be the HO CAST 2017 series (or HO CAST 2018 Slash Resistant Materials). For more information see Factsheet 5 Test Procedures. General questions to ask should include:

- Is the potential body armour approved by HO CAST?
- Is the body armour approved to the relevant threat levels?
- Is any further testing required?

Human Factors

Physiological Load

Any body armour system will add some level of physiological load to the wearer. This includes the weight, bulk, lack of flexibility and heat burden caused by the armour. Each of these will also affect the comfort of the item.

- **Weight** – Most users view the weight of the armour as the most important factor. However, it is less the actual weight but more about how that weight is distributed over the body. The weight of the armour may be acting on the shoulders, around the waist (on the hips) or a combination of the two. The weight and its effective distribution affect for how long a user can operate in the armour.
- **Bulk** – The bulk of the body armour may be more of a burden than the weight. Whereas the weight tends to dictate how long it is possible to wear the body armour, the bulk affects the wearer's ability to conduct the tasks that they are required to do. The bulk of the armour restricts normal movement and also restricts access in buildings, vehicles etc.
- **Flexibility** – Another characteristic of the body armour which restricts movement of the wearer is the flexibility. This flexibility relates mainly to the armour material itself, and some armour materials are more flexible than others. For example, woven armour materials will be more flexible than unidirectional or laminated armour materials. For armour systems with a greater area of coverage it may be possible to improve the flexibility of the system, using methods of joining different components.
- **Heat Burden** – Any body armour will consist of a number of layers of material. It has been demonstrated that the number of layers that are required to provide protection from the threat will prevent the transmission of heat or moisture away from the body. Also the heat burden can be related to the weight of the armour. Heavy armour will cause the wearer to use more energy and hence produce more heat than a lighter one. The heat burden can be partially managed by passive and active cooling systems.
- **Fit** – It is essential that a user is issued with body armour which is the correct size for them. The two main measurements of the body armour which affect the fit are the chest circumference and the length. It is quite possible to get body armour which is the correct chest measurement, but which is the wrong length. If the armour is too short, it will not provide the necessary coverage to the vital organs. If the armour is too long it will make it difficult and uncomfortable to wear, especially when the wearer is sitting down, for example, when driving.
- **Comfort** – The comfort of body armour is not easy to measure and can only really be evaluated by users when they are wearing the armour and carrying out their work. The comfort of the armour will be a result of the combination of the characteristics described above: weight, bulk, flexibility, heat burden and fit.

The Home Office CAST Body Armour Standard (2017) Guidance, Section 3.2.4 [2] includes a section on Comfort and Fit which states 'body armour should be fastened firmly against the body when in use such that the protective panels are held over the intended region. Body armour should be adjustable to accommodate a modest change in size of the user.'

It also states that: 'In all cases, fitting of body armour shall be conducted in accordance with the manufacturer's measurements. It is important to note that it is the responsibility of the end user to ensure their armour fits them; this may be under the supervision of trained personnel within their organisation or in conjunction with the manufacturers. It is recommended that representatives of the manufacturers are sought to assist with this process.'

Armour Coverage

The decision regarding the area of coverage of the supplied armour should be a balance between the protection of the most vulnerable organs of the torso (thorax and abdomen) and the physiological burden inflicted by the armour. However, in practice there are other factors which heavily influence the area of coverage. These include the ability to shoulder a weapon, to attach other equipment and its interaction with clothing or other protection components etc.

HO CAST Body Armour Standard (2017) Guidance [2] describes in detail the requirements for Coverage in Sections 3.2.1 Critical Organs, 3.2.2 Anthropometric Landmarks and 3.2.3 Guidelines. These provide further detail on the material above and are an important source.

Male and Female Armour

For obvious reasons, the shaping of male and female armours is different. However the terms ‘male’ and ‘female’ are being used less commonly. Instead, the terms being introduced are ‘formed’ and ‘unformed’ body armour. It is possible that a male user of body armour may have more of a requirement for formed armour than some female users.

Load Carriage

Some users of body armour require it to do more than just protect them from hostile threats. They may have other items of equipment to which they need ready access in order to enable them to do their jobs. Therefore there may be a requirement to incorporate some level of load carriage on the outer carrier of the body armour. This is really only an option for overt body armour and may consist of some simple pockets but could also include detachable pockets. The detachable pockets may use a type of MOLLE (Modular Lightweight Load-carrying Equipment) system for easy attachment.

Durability

Warranty

Body armour manufacturers will provide a warranty with newly supplied body armour and it is important that a purchaser understands what the warranty covers. This may be the performance of the product or merely that the materials will not deteriorate. This warranty is usually based upon that supplied by the manufacturer of the base ballistic fibre or yarn.

Expected Life

The expected life of body armour is generally based on the warranty provided by the manufacturer and most users would be reluctant to use body armour beyond its expiry date. This is because body armour cannot be tested easily to confirm that it still works without the use of destructive testing. Some users with large quantities of body armour may have systems in place to conduct some process of extended life analysis (ELA) which involves taking random samples from a particular batch and testing them to destruction. For users with only small numbers of body armour, this process would not be economically viable.

For soft body armour the expected life of the item is determined by the manufacturing process. The body armour is made of different materials each of which will have an expected life. The processing of some of these materials also reduces their life. For example, the process of weaving textile fibres can cause damage to the fibres and this can lower their performance slightly. Upgrade plates will last a long time, as long as the ceramic has not been cracked by

impact with the floor or other items, and as long as the composite backing is still properly attached to the strike-face.

Body armour is usually a fairly durable product, but there are certain conditions which can affect its performance:

- **Temperature** – As with other items, the materials used in body armour will perform best when maintained within a specific temperature range. Fortunately this temperature range for most of the materials used in body armour is wide and greater than that which could be endured by the user. The only consideration would be to make sure that the armour is not stored in hot climates in enclosed spaces under glass, where the elevated temperatures could cause some degradation of some textile fibres.
- **Humidity / Water** – Soft armour materials will usually be contained within a completely waterproof casing, or alternatively the fibres will be water-repellent treated. Some armour materials are susceptible to water and humidity. These materials will lose some of their ballistic performance when wet, but will usually regain that performance once they have dried out. It is however, important not to allow the armour to retain trapped water or moisture. Should the armour become wet or be fully immersed in water for any reason, then it should be hung up to dry in a warm environment. Care should be taken to avoid getting oil, solvents or other chemicals on the body armour. They may degrade the outer carrier but are unlikely to affect the soft armour unless sufficient contaminant is present to penetrate the inner casing of the soft armour
- **Ultra-Violet (UV) Light** – Soft armour should not be affected by UV light unless the protective envelope is split, therefore, periodically the carrier should be inspected for obvious splits. Certain armour materials are affected by exposure to UV light. These armour materials are the para-aramids, such as Kevlar® and Twaron®. When exposed to UV light the outer layers will be permanently damaged, and their performance will be reduced. As a body armour pack is constructed of many layers, the overall reduction in performance is not very significant, but could mean that the armour may not pass a test, if retested.
- **Impact Damage to Ceramic-Faced Plates** – Often upgrade plates will be labelled with statements such as ‘Handle with Care’ which may seem strange for an item which can defeat a high velocity rifle bullet. The ceramic strike-face of the plate is a very hard material, much harder than most bullets. However, it is also a brittle material and its fracture toughness may not be limited and therefore it could be susceptible to cracking if impacted or dropped on a hard floor. Such cracks will reduce the structural integrity of the strike-face, and it is possible that the armour could fail if subsequently impacted with a high velocity bullet. For users of large numbers of upgrade plates, there may be some non-destructive test regime in place to check the condition of the upgrade plates at regular intervals. These methods may be based upon ultrasonic or digital radiography methods. For individual users, a simple acoustic ‘tap’ test may be useful.

Through-Life Management

Through-life management should cover the full life of the body armour from procurement through to disposal and needs to consider a number of factors:

- Identification of item upon receipt
- Issue to the correct personnel upon initial receipt
- Storage when not being worn
- Care, maintenance and inspection
- Disposal at the end of its life
- Plans for replacement

Issue

Body armour may be a personal issue or it may be issued as required from a pool of items. For a personal issue, the body armour supplied to the wearer should be the correct size for that individual (assuming they were correctly measured, had originally supplied their correct measurements, or hadn't changed their size since being measured for the armour). For body armour items issued from a pool, it is difficult for the wearer to be confident that the armour they are wearing is the correct size from them. Every effort should be made to ensure that the supply includes sufficient body armour of the correct mix of sizes for the expected pool of users. However it should be noted that the largest and smallest armours in an available size range are rarely required.

Identification

All body armour should have a unique identification number allowing it to be fully traceable back to its manufacture batch and date. The number should also be able to state exactly what the performance level of the armour is, and in accordance with which standard.

Storage

Whilst there are no major factors to consider with the storage of body armour, it is worthwhile bearing the following in mind. If possible, and if being stored for a long period of time, the soft body armour would be best stored lying flat on a shelf. If this is not possible and it needs to be stored upright, it should be hung from a substantial clothes hanger. Upgrade plates should be stored lying flat. If armour is left in the back of a car for any length of time, then care should be taken in high temperatures. In hot climates the armour should not be left under glass, if at all possible.

HO CAST Body Armour Standard (2017) Guidance [2] Section 4.5 also discusses Storage

Maintenance and Inspection

The care and maintenance of the body armour should be managed in accordance with the manufacturer's instructions. Even though body armour may be expected to be nearly indestructible, some components do require extra care for a long life. The only regular maintenance required for most items of body armour is cleaning. The manufacturer of the body armour should supply cleaning instructions and these should be strictly followed in order to prolong the life of the armour.

The armour pack should be regularly removed from its carrier and the condition of its protective envelope checked. The armour pack should be replaced if there are any cuts or splits in the protective envelope. The condition of the carrier is less critical and its replacement is more likely to be determined for cosmetic reasons or because of worn out attachments and fasteners.

Maintenance and inspection is also outlined in Section 4.2 of HO CAST Body Armour Standard (2017) Guidance [2].

Disposal

Disposal of body armour that is no longer required should be managed to minimise any environmental damage. There are now a number of companies who will dispose of body armour and recycle some of the components. For example, Kevlar® and Twaron® woven textile can be finely chopped and used in such applications as brake linings and thermal insulation. Some

components however are not recyclable and land-fill is the only option. Disposal sales of used body armour should be discouraged; as there could be legal implications for the seller should the armour be re-used and tested in an attack.

References

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