Home Office

Body Armour Standard (2017)

Guidance

CAST Publication number: 039/17

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Summary

This guidance document has been written to accompany the Home Office Body Armour Standard (2017), to assist police services and procurement bodies in making informed decisions in the selection of body armour and outline elements of best practice for end-users.

This document was compiled with the support of police users, the Police Federation, Police Health and Safety representatives and procurement bodies and has been written to address pertinent considerations beyond body armour testing and certification. This includes:

- **Selecting an armour:** information to substantiate and support the test methods and specifications in the Body Armour Standard, and enable police services and procurement to determine which armour type and level of protection is most suitable for their application.
- **Coverage and fit assessments:** guidance on intended use of body armour, critical coverage regions in the body and assessments of fit.
- **Maintenance and lifecycle considerations:** best practice guidelines for care and maintenance of in-service body armour to ensure armour remains fit for purpose.

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1. Introduction

This guidance document has been written to accompany the Home Office Body Armour Standard (2017), to assist police services and procurement bodies in making informed decisions in the selection of body armour and outline elements of best practice for end-users.

The Home Office Body Armour Standard (2017) provides minimum performance requirements and test methods for the assessment of body armour to protect against ballistic, knife and spike threats. This guidance document addresses pertinent considerations beyond body armour testing and certification including selecting the most appropriate armour, coverage and fit assessments, and in-service maintenance and lifecycle considerations.

This document has been compiled with the support of police users, the Police Federation, Police Health and Safety representatives and procurement bodies.

It is important to note that all body armour certified to the Home Office Body Armour Standard (2017) is considered to offer appropriate resistance to engineered threat scenarios. However, body armour is not, and can never be, 100% bullet or stab proof as there will always be a bullet or knife capable of penetrating any level of protection provided. As such, it is important that users and procurement bodies thoroughly review their threat and risk, and select the most appropriate armour for their use.

2. Selecting an armour

2.1. Threat and risk assessment

It is the responsibility of the user community to conduct timely, realistic and informed risk assessments, specific for the role of the individual officers. These risk assessments should consider the threats posed to the officers at a given time and should be reviewed regularly; both periodically and when new credible information becomes available.

In instances where, based on the risk assessment, it is not possible to be fully compliant to the standard protection levels, CAST should be contacted for advice.

2.2. Test methods and protection levels

2.2.1. Ballistic

Body armour designed for ballistic protection that has met the minimum performance requirements of the standard will offer resistance to perforation (bullet passing through armour) and behind armour effects (the degree of 'thump' experienced during the impact).

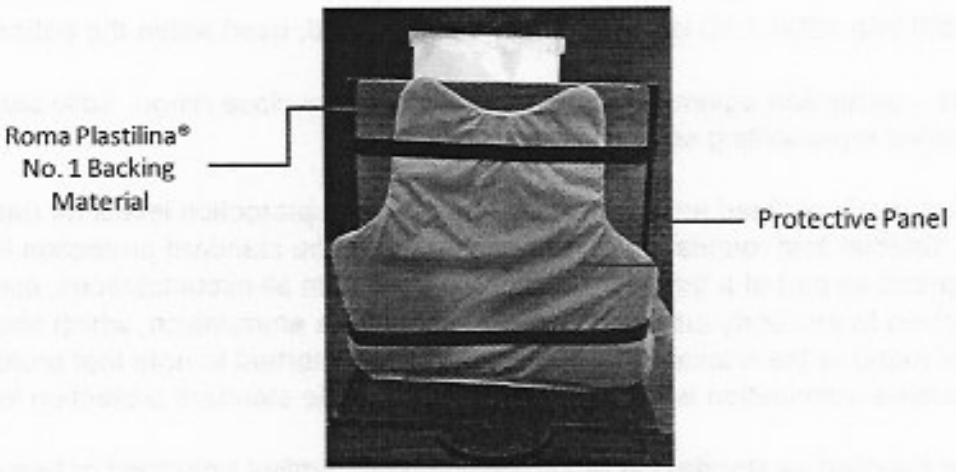


Figure 1: Photograph showing typical ballistic test configuration

Unformed armour, typically worn by male end users, is tested on flat Roma Plastilina® No. 1 modelling clay. This body armour backing material has been adopted as a consistent and measurable test medium when subject to ballistic impacts and has acted as an industry standard in the ballistics community for several decades. Shots are conducted both straight and at angles on to the body armour with perforation and back face signature (BFS) recorded as a measure of behind armour effects.

Formed armour, typically worn by female end users, is tested on shaped Plastiline® 40 backing materials. This is formed into small and large shaped female torsos that are anthropometrically correct. These are used to provide a better representation of the fit of the armour on an end user and subsequent ballistic performance on a more realistic shaped form.

Plates are tested on anthropometric mid-sized shaped male front and rear torso backing materials using Roma Plastilina® No. 1 modelling clay and are assessed for perforation and BFS. These backing materials improve consistency between tests and, as with formed armour testing, enable assessment on a more realistic form.

Each ballistic protection level is designed to be representative of different operational scenarios. They do not purport to be exhaustive of the range of potential threats which may be faced but provide a good level of protection for most scenarios. Protection levels should be carefully considered during procurement to ensure realistic threats are covered. If there is a specific threat that is not covered here, it may be added as a special round[1].

- **HO1** – protection against handgun ammunition fired from short barrelled firearms.
  - 9 × 19 mm Full Metal Jacket (FMJ) ammunition is the most widely used handgun ammunition in the world.
  - 9 × 19 mm Jacketed Hollow Point (JHP) ammunition is widely used police handgun ammunition.
- **HO2** – protection against 9 mm handgun ammunition (as used in HO1) fired at greater velocity from long barrelled firearms (e.g. MP5).
- **HO3** – protection against 'soft core' ammunition fired from rifles.
  - 7.62 × 51 mm NATO ball ammunition is a representative 'soft core' rifle round.
  - 7.62 × 39 mm surrogate ammunition is a standardised, consistent replica of widely-used automatic rifle ammunition.
- **HO4** – protection against harder core, heavier mass ammunition fired from rifles.
  - .308 Win 480A TAC is a high mass copper round, used within the police community.
- **SG1** – protection against shotgun rounds fired from close range. Solid slug rounds adopted representing severe shotgun threat.

The standard levels outlined are considered the minimum protection levels for each tier of protection. 'Special' test rounds are an enhancement on the standard protection levels and may be required as part of a threat and risk assessment. In all circumstances, consideration should be given to test body armour against current police ammunition, which should be added as a special round to the relevant protection level. It is important to note that protection against 5.56 mm carbine ammunition is not assessed as one of the standard protection levels.

If plates are supplied as standalone protection (without certified unformed or formed soft armour backing), consideration should be given to test against the HO2 handgun protection level and in service police ammunition.

2.2.2. Stab

Body armour designed to offer stab protection, that has met the minimum performance requirements of the standard, will offer resistance against knife or spike penetration from a set of pre-defined impact levels. Figure 2 shows a typical stab test configuration.

[1] Consideration must be given to the firing velocities. If unsure, please contact CAST for advice.

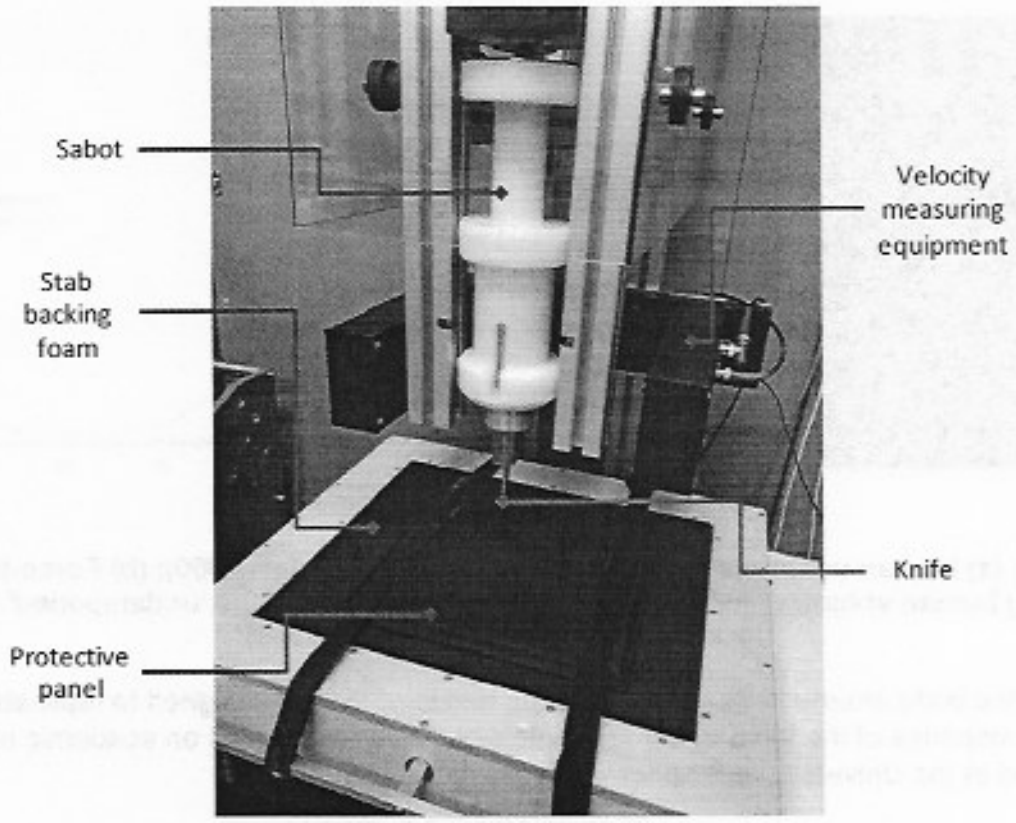


Figure 2: Photograph showing typical stab test configuration

All knife testing adopts a standard engineered test blade, derived from police seizures and academic research into the influence of knife characteristics on penetration. This knife is designed to be optimised for stabbing and as such is dissimilar to common knives that may be faced (e.g. kitchen knives, hunting knives) which are designed for cutting rather than stabbing. The production of this test blade is highly controlled with tight engineering tolerances such that there is minimal variance between standard tests.

Spike testing is conducted with a non-edged weapon of a tapering cylindrical geometry resolving to a point at the impact tip. This was introduced primarily to address modified weapons of concern in prison services. This test spike is similarly engineered with tight production tolerances. Images of the engineered test knife and spike are shown in Figure 3.

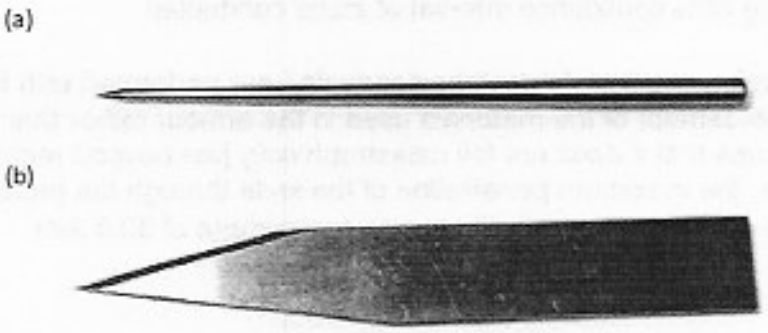


Figure 3 - (a) Test Spike; (b) Test Knife

Stab testing is conducted using a gravity-driven falling guided missile, known as a sabot, which is raised to a series of pre-determined heights to achieve necessary impact energies. Within the sabot are two foam damper discs, which when compressed on impact provide a secondary release of energy, more realistic to a human stab. This was based on instrumented human volunteer stab tests conducted by academics and is shown in Figure 4.

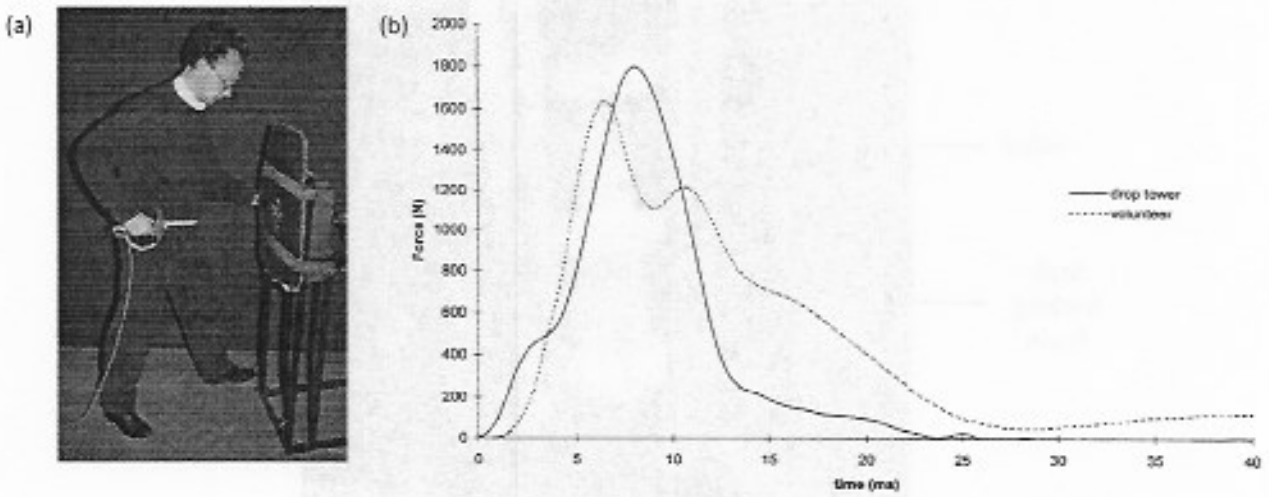


Figure 4: (a) Human volunteer stab force experiments (Horsfall, 2000); (b) Force-time traces showing human volunteer force profile and a concentrated mass 'undampened' stab from a drop tower (Chadwick *et al.*, 1999)

Beneath the body armour in all stab tests are a series of foams, designed to replicate the dynamic response of the torso under knife impacts. These are based on academic research conducted at the University of Strathclyde (Nicol *et al.*, 1999).

Measurements of knife penetration are made based on the depth of knife penetration into the foam backing material. This foam has a similar, but harsher, response to knife penetration than biological skin tissue in that it will cut more easily and hence provide a more conservative test method. The maximum permissible depth of penetration is 9.0 mm, which has been derived based on imaging studies by Connor *et al.* (1998) and Bleetman & Dyer (2003) relating to the proximity of major organs to the skin surface.

Knife protection levels were set based on an academic study of human volunteers, measuring the velocity and effective mass involved in stabs from a range of personnel (Horsfall *et al.*, 1999). The 'E1' test energies specified at each protection level are based on this study.

- KR1 – the base knife protection level with an impact energy (24 joules) representing the 85% confidence interval of stabs conducted.
- KR2 – the enhanced knife protection level with an impact energy (33 joules) representing 90% confidence interval of stabs conducted.

At each energy level, a quarter of the stabs conducted are performed with 50% greater energy (E2). This is an assessment of the materials used in the armour rather than the protection it provides, and ensures that it does not fail catastrophically just beyond required test energies (E1). In these tests, the maximum penetration of the knife through the protective panel is 20.0 mm, with one penetration permissible up to a maximum of 30.0 mm.

2.3. Reading a certificate

Document Number C17:00000

Home Office

Confirmation of Accreditation

This document confirms that the product detailed below has met the minimum requirements of the Body Armour Standard 012/17 and has been accredited by the Home Office.

Manufacturer's name	
Manufacturer's address	
Model number	*Unique body armour identifier*
Protection level(s)	*The protection level(s) which the armour has been tested against.*
Size range (smallest-largest)	*The size range which has been assessed in certification testing.*
Available as	*Form in which the armour is supplied (e.g. Male and Female, 2 piece)*
Areal density (kg/m^2)	*Value indicating the mass per square metre of the armour*
Additional testing	*Indicates whether the armour has passed wet or extreme temperature testing.*
Original test house reference	*Unique reference assigned by the test house relating to the certification test report*
Current PQT test reference	*Unique reference assigned by the test house relating to the production quality testing (PQT) test report*
Issue date	*Date at which the most recent certificate (certification or PQT) was issued*
Expiry date	*Date at which the most recent certificate (certification or PQT) expires and requires re-testing*

This compliance document is issued on the basis of adherence to publication 012/17 Section 9.

This document has been issued by the Centre for Applied Science and Technology, part of the Home Office, and as such is a OFFICAL document. This document may be withdrawn by the Home Office if the manufacturer fails to comply with the terms of the applicable Home Office Publication.

The contents of this document will be available in the public domain via the Protective Equipment Database website: http://ped-cast.homeoffice.gov.uk

2.4. Ergonomic assessments

Prior to any procurement of body armour, a comprehensive set of user trials should be conducted to assess the usability of different potential solutions. Such an assessment should assess the fit and comfort of armour and address the following considerations:

- Users (i.e. age, gender, stature, size, role).
- Assessment period (e.g. length of time, in service trials).
- Scenarios (i.e. operational environments in which armour worn).
- Compatibility with other kit/equipment (e.g. public order PPE).
- Feedback (e.g. questionnaire, interview).

3. Coverage and fit assessments

3.1. Intended use

Body armour must be used in the configuration it has been tested in. All body armour certified to the Home Office Body Armour Standard (2017) will be labelled and clearly indicate the orientation that the armour must be worn. Body armour must always be worn in the orientation indicated on the label, otherwise it may not afford the intended level of protection. This is illustrated in the example label by the statement 'BODY SIDE' (Figure 5).

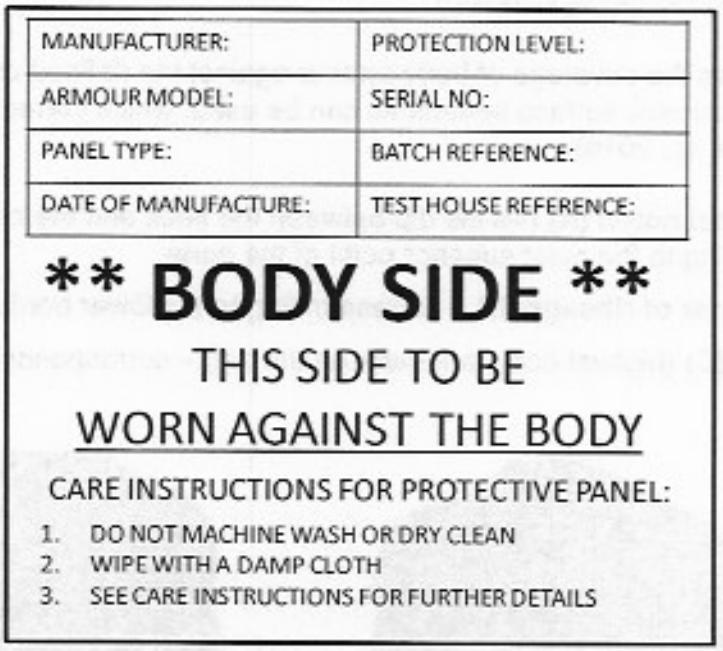


Figure 5: Example of a label compliant with the 2017 standard (NOT TO SCALE)

Body armour should be worn close to the body, with minimal material in between (e.g. a cotton shirt). Hard objects such as metal buttons, press studs or badges placed beneath the armour should be avoided due to the potential risk of injury on impact.

Some certified armours are constructed from a series of certified armour solutions to provide enhanced protection; these are known as a 'scalable solutions'. All scalable solutions will be clearly labelled with information indicating the construction order and body sides. This must not be altered as it will change the level of protection afforded by the armour and may place the wearer at greater risk.

Extended coverage panels are panels providing protection to areas outside of the torso region. A body side will be marked on each and should be fitted and worn according to manufacturer's instructions. On some extended coverage panels, an area may be marked 'Area of Full Protection' – this represents the region in which the armour has been tested to the given protection level. Areas outside of this zone may provide some protection but have not been tested.

3.2. Coverage, comfort and fit

3.2.1. Critical organs

The organs in the torso considered as critical to protect, defined by Breeze *et al.* (2015), are the heart and great valves (superior and inferior vena cavae, pulmonary arteries and veins, and aorta), liver and spleen. These organs were assessed based on the timeframe in which a penetrating wound in these regions would be fatal without surgical interventions. Coverage of these regions should be met in all protection types.

Further consideration should also be given to protect the lungs, kidneys, trachea and main bronchi, spinal cord and intestines. In each of these regions, a penetrating wound may not be immediately fatal but if not treated in a short timeframe can lead to long-term debilitation or potential mortality.

3.2.2. Anthropometric landmarks

To effectively assess the coverage of body armour against the defined critical organs, a series of external anthropometric surface landmarks can be used, which correspond to internal organ positions (Breeze *et al.*, 2016).

- **Suprasternal notch (A)** (visible dip between the neck and the collar bone) – corresponding to the most superior point of the aorta.
- **Lower border of ribcage (B)** – corresponding to the lower border of the liver.
- **Iliac crest (C)** (highest bony landmark on the hip) – corresponding to the bifurcation of the aorta.

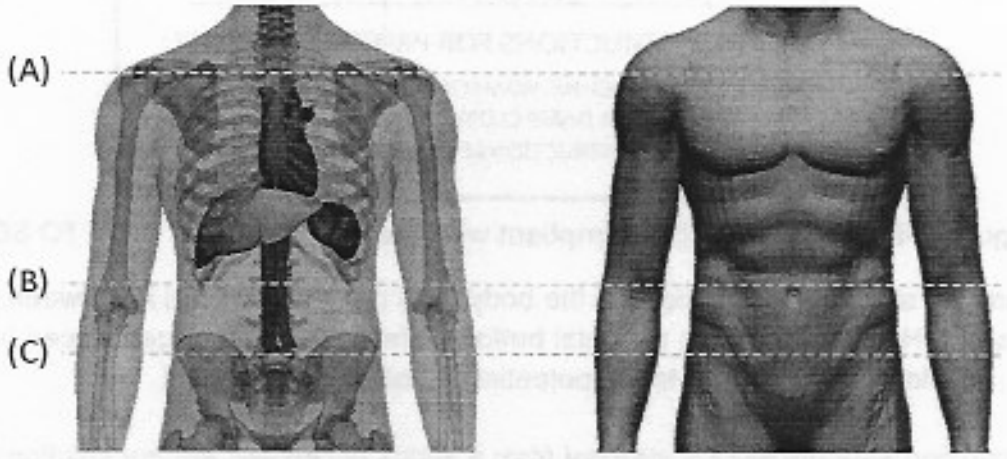


Figure 6: Images showing indicative internal organ positioning and the external landmarks to which they relate

3.2.3. Guidelines

These guidelines should be considered the minimum necessary to protect the critical regions of the torso.

Vertical dimensions

The three surface landmarks outlined should be used to determine the vertical measurements for protective panel coverage on the individual. For plates, the minimum vertical coverage should be the region between the suprasternal notch (A) and the lower border of the ribcage (B). For soft armour, the minimum vertical coverage should be the region between the suprasternal notch (A) and the iliac crest (C).

Vertical measurements between these landmarks, based on data acquired by Breeze *et al.* (2016), has been given in the Appendix A for different sizes of male military volunteers.

Horizontal dimensions

There is little reported correlation between stature and the width of organs such that position and sizing could be scaled (Breeze *et al.*, 2016). For military armour, width recommendations for hard armour plates have been based upon CT scans of male military users (Fryer, 2016). It was recommended that:

- the upper section of plate should have a width spanning a minimum of 150 mm, corresponding to the 95th percentile width of the heart;
- the lower region of the plate covering the liver and spleen should have a minimum width of 270 mm, corresponding to the 50th percentile distance from the outer liver to outer spleen.

To provide the minimum level of plate protection, it is recommended that the ratio of top vertical length (covering the heart region) to bottom vertical length (covering the liver, spleen and lower regions of the aorta) should be 0.42 to 0.58 (Fryer, 2016).

Soft armour should meet the above stated requirements for plates and also offer protection to the other specified key organs (Section 3.2.1).

3.2.4. Comfort and fit

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.

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.

4. Maintenance and lifecycle considerations

4.1. Records

When body armour is issued to a wearer, internal records should be kept detailing, at a minimum:

- manufacturer;
- armour model;
- protection level(s);
- batch number;
- serial number;
- wearer's name.

These records should be used in any inspections or in the event of a recall or request for in-life monitoring (ILM) of body armour. In the event of any changes, these records should be updated.

4.2. Inspections

Inspections of body armour should be conducted at intervals of no greater than 12 months and should be based upon the records generated when armour is issued.

During such inspections, the following assessments should be performed:

- **Non-destructive checks** – visual and tactile assessment of signs of damage or significant wear on the armour.
- **Carriers and covers** – visual and tactile assessment of signs of damage or wear significant enough to inhibit its primary function; should the damage be limited to these elements, they may be replaced independent of the protective panels.
- **Label** – is the label still attached to the armour and, if so, is the text still clearly readable; if not, the manufacturers are required to provide a replacement label at their own cost, as specified in the standard.
- **Fit** – the fit of body armour should be assessed and physical attributes should be compared to those measured at the time of original fit; if the armour no longer fits, it should be replaced to afford the wearer with adequate protection.

A method and guideline check sheet for such inspections has been provided in Appendix B. Supplementary guidance can also be attained through a DVD produced by Police Service Northern Ireland (PSNI), on behalf of the NPCC Body Armour Sub Group, that offers best practice guidelines for body armour inspections (PSNI, 2016).

In all instances if, following inspections, you are unsure about serviceability of body armour, contact the manufacturer for information and guidance.

4.3. Post-incident

Following any incident in which the body armour has been exposed to an impact, an immediate inspection should be conducted prior to any further use.

If the incident is a ballistic or stab impact, the body armour must always be replaced. CAST request the sample (post investigation) for analysis to enable improvements to the advice and guidance we offer. If the impact is a blunt trauma, for example an injury sustained in a road traffic accident or in a public disorder scenario, an inspection should be carried out in accordance with Section 4.2.

Should the armour be submerged in water, it should be dried naturally away from sunlight or a direct heat source until all moisture has evaporated prior to further use.

Should the body armour be exposed to chemicals, an inspection should be carried out in accordance with Section 4.2. Please contact the manufacturer for further advice.

4.4. Hygiene

Protective panels of body armour should not be laundered in a washing machine under any circumstances. If a panel requires cleaning it should be conducted carefully with a damp sponge and allowed to dry naturally away from a direct sunlight or heat source. Do not fully submerge panels in water. If the carrier requires washing, the protective panels must be removed beforehand.

In all instances, please consult the manufacturer's guidelines for washing and handling instructions.

4.5. Storage

Body armour must be stored in line with manufacturer's guidance and it is the responsibility of the end user organisation to ensure suitable facilities are in place. Body armour should be hung from the shoulders or laid flat away from direct sunlight, heat sources and excessive humidity when not in use, as shown in Figure 7.

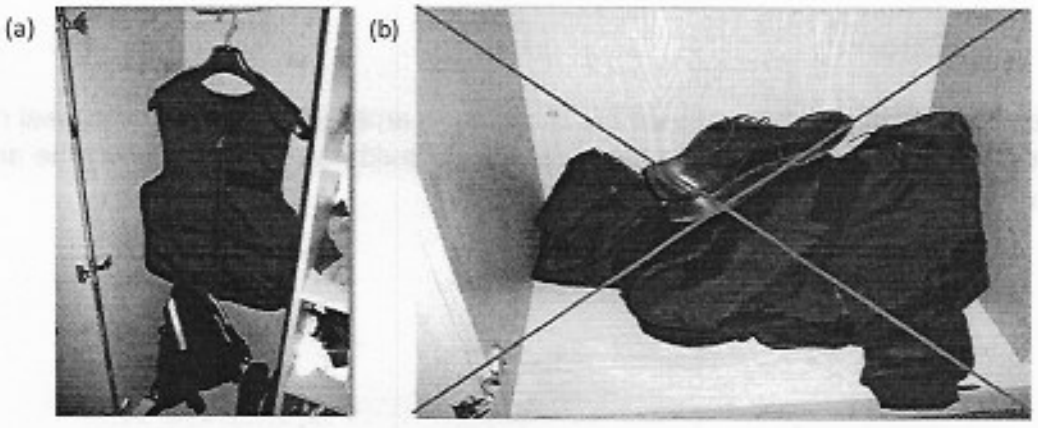


Figure 7: (a) recommended storage conditions; (b) unacceptable storage conditions

4.6. Quality assurance

The CAST Production Quality Testing (PQT) is a quality assurance tool to assist UK law enforcement agencies without access to professional management of the engineering and quality aspects required during a procurement process. Large volume procurements, that may require competitive tender, should consider a professional Quality Management System (QMS) offering bespoke guidance on how to approach each of the elements in this guidance document. This typically involves development of a specification detailing: user requirements, threat assessment (to establish the most appropriate protection levels and associated safety margins), production testing regime (if required, in addition to PQT methods) and acceptance strategies. In these circumstances, it is likely that specialists in the evaluation of body armour will be required to appraise submissions during the procurement process to determine suitability for use in operational scenarios, typically using ergonomic assessments.

4.7. In-Life Monitoring

ILM is a new element introduced in the Home Office Body Armour Standard (2017). This is a quality assurance measure that implements a structured series of tests to evaluate the performance of armour throughout its service life. Each manufacturer will specify a product life expectancy associated with their armour model, which is the period they have full confidence in the performance of the armour. During this period, certain armours may be periodically withdrawn for testing in accordance with methods in the standard. If an armour is subject to this scheme, this will be clearly indicated on the certificate.

4.8. Confidence testing

Armour may continue to provide the required level of protection beyond its specified product life expectancy. In order to provide confidence in the continued performance of armour, assessment should be conducted on a regular basis in line with methods outlined in ILM. In this situation it is the responsibility of the end user organisation (e.g. police service) to assure continued performance of armour. This may be completed in conjunction with manufacturers; however, it is recommended that any testing is completed at an independent facility or in the presence of a representative of the user community. Such testing should only be conducted by facilities with requisite expertise, experience and equipment to conduct such assessments.

4.9. Disposal

It is the responsibility of the end user organisation to arrange responsible disposal of body armour at the end of its usable life. Consideration should be given to whether the armour may be recyclable.

5. Other considerations

5.1. Physical conditioning

The information on the attached link has been put together by physiotherapists at the Police Treatment Centre to help users look after their body whilst wearing body armour. Printed copies have been produced by the Police Federation of England and Wales and can be obtained from a local federation office.

http://www.thepolicetreatmentcentres.org/physiotherapy-programme/physiotherapy-overview/BodyArmour

5.2. Additional equipment

The presence of additional equipment on the outside of body armour/officer clothing may potentially increase the risk of injury. This may occur through bullet deflection (ricochet) or if the bullet becomes fragmented and deformed following impact with additional equipment, which may perforate the armour. Such risks should be considered in an individual force's risk assessment.

Similarly, where zips are being used in carrier systems, the zip may present an additional injury risk when impacted. All zips shall be covered to reduce the risk of fragmentation injury from bullet impacts.

5.3. Wet/extreme temperature testing

Additional testing may be conducted on body armour to simulate its performance either after being submerged in water or pre-conditioned in an extremely hot or cold temperature environment. If an armour has been subject to this testing, it will be indicated on the certificate and label.

5.4. Legal

This guidance document does not override any legal obligations relating to health and safety or procurement. Pertinent legislation relating to body armour usage includes:

Personal Protective Equipment at Work Regulations (1992)

Police (Health & Safety) Act (1997)

6. References

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Fryer, R. (2016) *VIRTUS Pulse 2 Coverage Definition and Assessment Method*. DSTL, DSTL/TR097315, [UK OFFICIAL].

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Nicol. A.C., Chadwick, E.K.J. and J.V.; Gray, T.G.F. (1998) *Investigation of knife stab characteristics – development of body tissue simulant*. Technical Report, University of Strathclyde, Scottish Executive Central Research Unit, Edinburgh.

PSNI (2016) *Body Armour Inspection Guidance* [DVD]. Police Service Northern Ireland, United Kingdom.

Appendix A: Measurements between body landmarks

Table 1: Vertical measurements between key body landmarks for UK male military personnel, derived from Breeze *et al.*, (2016)

Percentile	Suprasternal notch to lower border of ribcage (mm)	Suprasternal notch to iliac crest (mm)
1	248	333
5	266	342
25	285	358
50	300	371
75	314	385
90	330	405
95	336	411
99	354	422

Appendix B: Body armour inspection

Body armour inspection method

1. Lay the soft body armour on a large, flat, clean surface.

2. Carefully inspect the outer carrier (jacket) for damage, paying particular attention to the fastenings and straps. Check that they are secure and are not showing excessive signs of wear (e.g. fraying, splitting); ensure that the fastening mechanism (e.g. Velcro®) ladder locks) are clean and that they grip properly.

3. Open all straps and unzip/open the body armour carrier to remove the protective panels.

4. Lay the protective armour inserts flat on a table and carefully inspect the waterproof cover. There should be no cuts, nicks, punctures or any significant deterioration in the cover, which could allow water or other fluids into the armour pack and could adversely affect the performance the armour. If there is any damage to the cover, the protective panel should be sent to the manufacturer for inspection and may be re-covered or, where necessary, replaced.

5. With the armour still on the flat surface, carefully feel for its protective element. The protective element should be the same thickness across the entire area of the armour (except for a slight tapering/feathering at the edges, which may be included for comfort).

6. If the armour has a chain mail component for knife protection this can usually be felt through the surface of the cover on the strike face. Carefully check the full face of the armour and satisfy yourself that the chain mail is securely in place and there is no evidence of broken chain links (sharp pieces) across the full surface of the panel.

7. In scalable solutions where multiple certified protective panels are used in combination to provide an enhanced level of protection, it is ESSENTIAL that these packs are fitted together in the correct order and are the same size. They must be placed in the carrier in the correct orientation (taking note of the Body Side label) and all elements should be checked in the above manner. If in any doubt, please contact either the manufacturer or CAST for advice.

8. Once all components of the armour have been visually inspected and manually checked (as outlined above) they need to be placed back in the carrier. For the armour to perform as intended, it is essential that the inserts are placed back in the carrier in the correct orientation and in accordance with the labelling, ensuring it is not creased or folded at the edges. The performance of the armour can be reduced, and may fail, if the armour inserts are not reinserted correctly.

Body armour inspection check list

Inspecting Officer:		**Date:**	
Armour Issued to:			
Armour Model:		**Protection Level:**	

	Please tick as appropriate		
	Yes	**No**	**N/A**
Does the armour still correctly fit the wearing officer?			
Are the carrier and fastening in good working condition?			
Is the armour inserted into the carrier correctly?			
Are the protective panels correctly labelled? *(e.g. model number, protection level, serial number)*			
Is the label still readable? Is the 'Body Side' clearly marked?			
Is the armour cover intact (the material covering the protective pack)?			
Can you feel any irregularities or defects in the protective panel or plate?			
Is the protective element of the armour an even thickness across the full surface (excluding edge)?			
Is any chain-mail or other metallic element still in position and secure?			
Does the armour contain any addition inserts/upgrades packs?			
Are the inserts/upgrade packs fitted correctly?			

Additional comments:

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OGL

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