Home Office

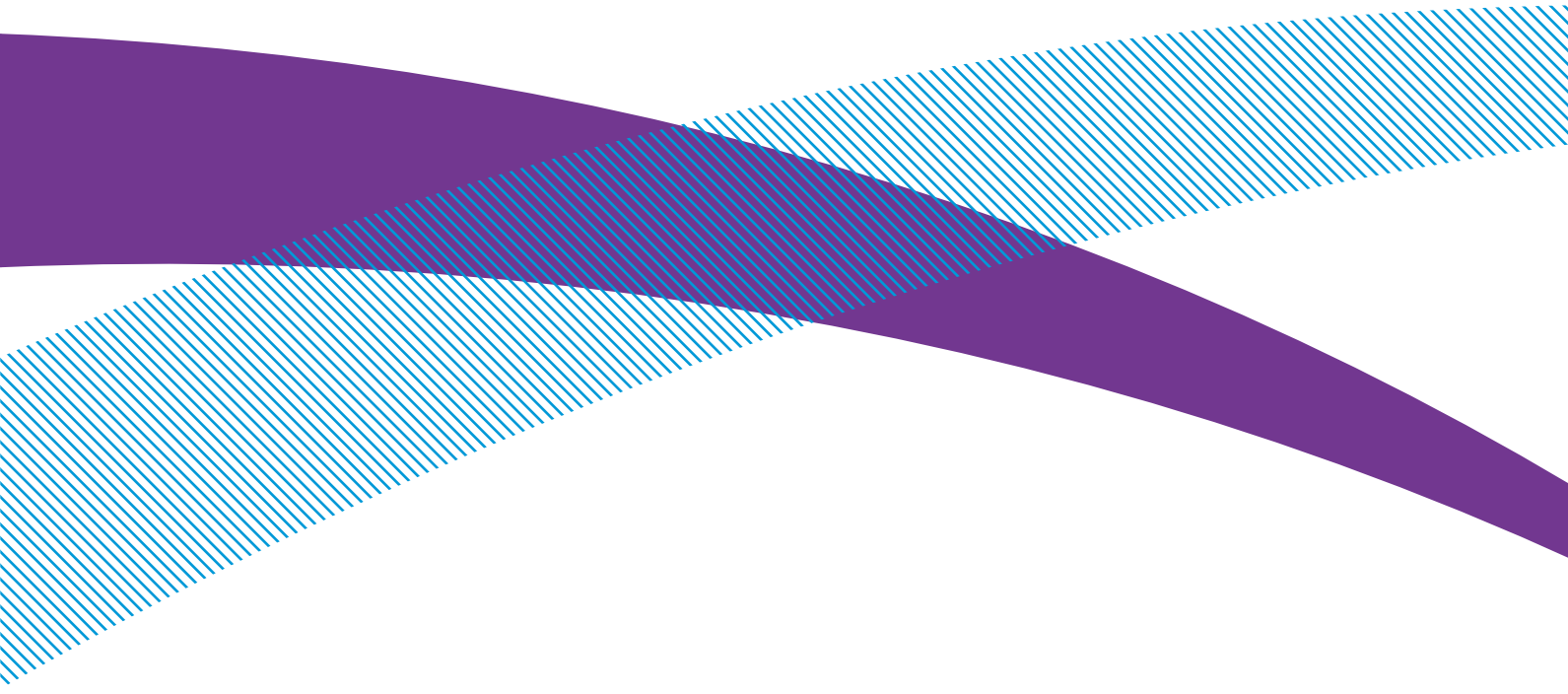
Scientific Development Branch

HOSDB Body Armour Standards for UK Police (2007)

Part 2: Ballistic Resistance

Publication No. 39/07/B

John Croft
Daniel Longhurst



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Contents

1 Introduction

This part of the standard provides information on the ballistic test requirements and methods for manufacturers of body armour to achieve successful compliance testing within the Home Office Scientific Development Branch (HOSDB) voluntary testing programme. This standard is part of a series of documents currently being produced within the HOSDB Police Protection Programme and is supported by:

- The Association of Chief Police Officers (ACPO) Conflict Management Portfolio;
- The ACPO Body Armour Sub-group;
- The Home Office Public Order Unit;
- The Police Federation of England and Wales.

The standard provides an increased choice to police purchasing units and wearers through seven levels of ballistic protection. These levels are described below:

- **HG1/A:** Lightweight-flexible soft armour intended for use by the unarmed officer in very low risk patrolling situations. Suitable for both overt and covert use;
- **HG1:** General Duty soft armour for low risk situations. May be overt or covert;
- **HG2:** Special duty soft armour intended for use in firearms operations. Can be used in conjunction with RF1 and SG1 plates. Usually overt;
- **HG3**: Heavy duty armour intended for use in firearms operations. Can be used in conjunction with RF and SG plates. overt;
- **SG1:** Offers protection from full-length shotguns at close range. Usually used in conjunction with HG2 armour;
- **RF1:** Offers protection against soft-core ammunition fired from rifles. Usually used in conjunction with HG2 armour;
- **RF2:** Offers protection against steel core high power ammunition fired from rifles. Intended for use in conjunction with HG2 or HG3 armour.

All of the above protection levels can be combined with stab protection levels - described in part 3 of this standard - to offer dual stab and ballistic protection.

2 Scope

Part 2 of the standard contains the performance requirements and test protocol for the testing of body armour to HOSDB ballistic threat levels.

3 Associated Documents

HOSDB Body Armour Standards for UK Police (2007) Part 1: General Requirements;

HOSDB Body Armour Standards for UK Police (2007) Part 3: Knife and Spike Resistance;

PSDB Portable Ballistic Protection Standard for UK Police (2004);

HOSDB Slash Resistance Standard for UK Police (2006)

4 Requirements

Ballistic resistant body armour shall also meet the requirements described in Part 1 of this standard. Compliance with Parts 1 and 2 of the HOSDB Body Armour Standard does not imply that the body armour provides protection from stabbing by knives or spikes. Compliance with Parts 1 and 3 of this standard is necessary for knife or knife + spike protection. For dual-purpose body armour, compliance with Parts 1, 2 and 3 is required.

5 Test Methodology

5.1 The Test Equipment

The tests shall be performed using suitable ballistic test equipment that will ensure the striking velocities specified in figure 4 can be achieved.

To attain the correct striking distances and velocities, special barrels, alignment aids and hand loading of the rounds may be required.

5.2 Velocity Measurement

The distance from the muzzle of the weapon to the front surface of the target shall be a minimum of 5 metres for HG1/A, HG1 and HG2 threat levels, and a minimum of 10 metres for HG3, RF1, RF2 and SG1 threat levels (figure 3). All velocities shall be measured such that the distance from the front face of the armour test sample to the centre of the velocity measuring sensors is 2m ± 0.1m. The velocity of each test shot shall lie within the limits specified in figure 4.

Suitable types of velocity measuring equipment are:

(a) Photo electric light screens;

(b) Printed make circuit screens;

(c) Printed break circuit screens;

(d) Ballistic radar.

5.3 Upper Prediction Limit (UPL)

The upper prediction limit is a prediction of the likely maximum Back Face Signature (BFS) that would be seen over many hits, based upon the measurements obtained from the limited numbers of test samples.

This standard calculates the UPL at 95% based on a total of 18 shots for compliance testing and at 90% based on a total of 12 shots for Manufacturers Quality Testing (MQT) See appendix B for the method of calculating the UPL.

In determining the UPL, only BFS readings from the medium size test samples shall be used.

The UPL is required to be equal to or less than the reference (i.e. allowable) BFS for each threat level. Given that this is the case, it is nonetheless possible that one or more of the individual BFS readings will be greater than the reference BFS. Under such circumstances the highest single BFS reading shall determine the individual BFS limit for the small and large size test samples. For example:

If the highest BFS reading for a HG1 model on the medium size panel is 26mm and all other BFS readings are such that the UPL is calculated at

24mm, 26mm will become the maximum BFS allowed for the small and large sizes. However, if the highest BFS reading for a HG1 model on the medium size panels is less than 25mm, then 25mm will be the maximum BFS allowed for the small and large sizes. This criterion also applies at the HG1/A protection level where the maximum allowed UPL is 44mm.

6 Preparation of the Test Equipment

6.1 Velocity Measuring Equipment Calibration

The instrumentation used for measuring the velocity of the bullet shall be calibrated according to the manufacturer's instructions. Test calibration records must be maintained and shall be traceable to the requirements of a recognised Quality Assurance Standard e.g. ISO 9001:2000, UKAS, ISO 17025 etc.

6.2 Backing Material Preparation

Steel trays measuring approximately 420mm x 350mm x 100mm, open on one large face only, shall be filled with Roma Plastilina® No.1[1] backing material. The backing material in each tray shall be manipulated to ensure no air gaps exist. A smooth, flat top surface shall be produced for the accurate and consistent measurement of back-face deformation. The top face of the backing material shall be scraped level with the surface plane defined by the edges of the steel tray. The trays shall be date marked with the date they were filled with new Roma Plastilina® No 1, and the contents must be disposed of no more than six months after this date and the tray filled with fresh Roma Plastilina® No 1.

6.3 Backing Material Conditioning

The conditioning of the Roma Plastilina® No 1shall be carried out in a heated enclosure for at least 3 hours at temperatures above 30^{o} C. Actual conditioning temperature and recovery time between tests will be determined by calibration results described in section 6.4. Conditioning time, temperature and drop test performance may change as a function of the age and usage of the backing material.

6.4 Backing Material Calibration

After conditioning of the Roma Plastilina® No 1, calibration shall be carried out using the methods and equipment specified below:

- Drop test sphere: Steel sphere grade '100' P/N 3606 [2];
- Sphere diameter: 63.5mm ± 0.05mm;

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[1] Alternative modelling clays shall not be used. Whilst an alternative product may be conditioned to give the correct indentation at typical drop weight velocities, there may still be a discrepancy between the indentations from ballistic velocity impacts achieved using alternative clay when compared to the results obtained from a trial where Roma Plastilina® No 1has been used.

[2] This sphere: ref P/N 3606 is available from: Salem Speciality Ball Co, Inc, PO Box 145 West Simsbury, CT 06092 USA.

- Sphere mass: 1.043kg ± 5g;
- Drop height: 1.5m ± 0.02m;
- Drop spacing: 75mm minimum from any edge to indent centre and 100mm between indent centres.

The calibration drop shall consist of a free fall of the sphere onto the backing material. A minimum of three drops shall be completed and the arithmetic mean depth of depression from the drops shall be 15mm ± 1.5mm measured from the top edges of the steel tray. This condition shall apply throughout the duration of the firing test.

6.5 Backing Material for Female Armour Testing

For body armour shaped for females, the backing material shall be built up to ensure good contact with the inside of the bust cups. The backing material shall be temperature conditioned as in section 6.3. However, drop test calibration is not required in the built up area.

6.6 Mounting the Armour Sample

The tray of Roma Plastilina® No 1 shall be mounted vertically in the test area so that the line of flight is perpendicular to the front face of the backing material. The armour sample shall be fastened over the front face of the tray, using its own straps wherever possible. If this is not possible, the sample may be held in place using hook and pile or similar additional strapping. The position of the straps must not interfere with the impact points on the sample.

To prevent the body armour sample from bowing away from the surface of the backing material (this usually happens on large samples or where the armour is made from less flexible materials), special “shoulders” shown in figures 1 and 2 shall be fitted over the backing material tray. If necessary, the shoulders can be adjusted to accommodate the large sample. This has the effect of widening the front face and allowing the body side (wear face) of the sample to sit firmly against the backing material.

A detailed drawing of the special shoulders is given in appendix C.

Figure 1 Ballistic Shoulders

Figure 2 Ballistic Shoulders Positioned on Test Block

7 Testing

7.1 Threat Levels

All body armour samples submitted for ballistic testing to this standard shall be tested using the criteria given in figures 3 and 4. Ballistic levels in this standard cover the following threat groups.

7.1.1 HG1/A

LOW HANDGUN: Protection against standard ammunition fired from short-barrelled handguns. Maximum UPL shall be 44mm.

7.1.2 HG1

LOW HANDGUN: Protection against standard ammunition fired from short-barrelled handguns. Maximum UPL shall be 25mm.

7.1.3 HG2

HIGH HANDGUN/CARBINE: Protection against standard ammunition fired from long- barrelled handguns. Maximum UPL shall be 25mm.

7.1.4 HG3

CARBINE: Protection against specific 5.56mm (.223) ammunition up to 228mm barrel length, for example: the **H&K G36C**. This is a highly specified threat level intended to offer protection from ammunition used in Firearms Officers own weaponry. IT DOES NOT OFFER PROTECTION AGAINST FMJ or STEEL CORE AMMUNITION REGARDLESS OF CALIBRE. Maximum UPL shall be 25mm.

7.1.5 HG3 (Special)

CARBINE: Protection against specific 5.56mm (.223) ammunition at greater velocities than for the standard HG3 level, for example: the **H&K G36K and Colt M4**. This is a specialised threat level intended to offer protection from ammunition used in Firearms Officers own weaponry. IT DOES NOT OFFER PROTECTION AGAINST FMJ or STEEL CORE AMMUNITION REGARDLESS OF CALIBRE. Maximum UPL shall be 25mm. Test velocities for this special threat level shall be determined by the intended user according to the weapon platform used. The test method for the HG3 special protection level shall be the same as that for HG3.

7.1.6 RF1

RIFLE: Protection against soft-core ammunition fired from rifles. Maximum BFS shall be 25mm.

7.1.7 RF2

RIFLE: Protection against steel-core high power ammunition. Maximum BFS shall be 25mm;

7.1.8 SG1

SHOTGUN: Protection against BB and No. 6 shot fired from full-length shotguns at close range. For safety and consistency, a solid slug is used to simulate this threat. Maximum BFS shall be 25mm.

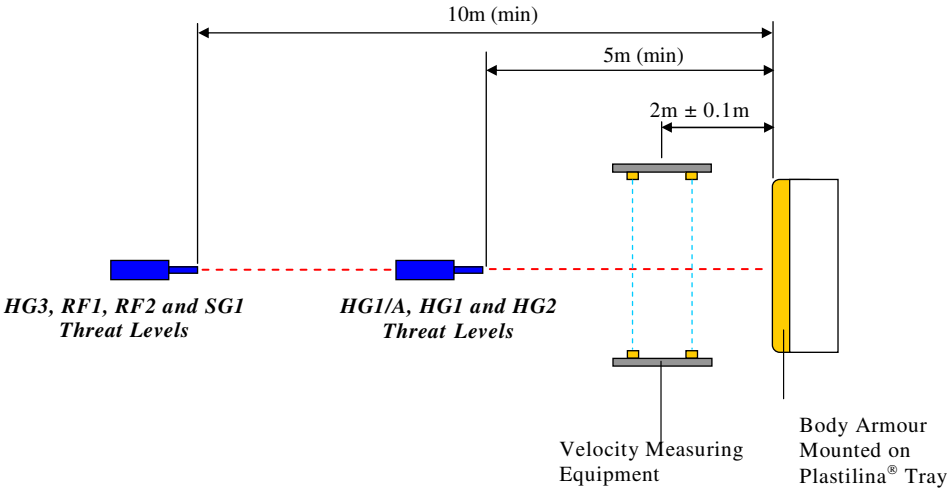


FIGURE 3: *Typical Test Apparatus for Ballistic Testing*

Performance Level	Calibre	Ammunition Description	Bullet Mass	Range (min) (m)	UPL (mm)	Velocity (m/s)
HG1/A	9mm	9mm FMJ Dynamit Nobel DM11A1B2	8.0g (124 grain)	5	44	365 ± 10
	0.357" Magnum	Soft Point Flat Nose Remington R357M3	10.2g (158 grain)	5		390 ± 10
HG1	9mm Calibre	9mm FMJ Dynamit Nobel DM11A1B2	8.0g (124 grain)	5	25	365 ± 10
	0.357" Magnum	Soft Point Flat Nose Remington R357M3	10.2g (158 grain)	5		390 ± 10
HG2	9mm Calibre	9mm FMJ Dynamit Nobel DM11A1B2	8.0g (124 grain)	5	25	430 ± 10
	0.357" Magnum	Soft Point Flat Nose Remington R357M3	10.2g (158 grain)	5		455 ± 10
HG3	Carbine 5.56x45 NATO 1 in 7" Twist	Federal Tactical Bonded 5.56mm (.223) LE223T3 Law Enforcement Ammunition	4.01g (62 grain)	10	25	750 ± 15

FIGURE 4: *HOSDB Ballistic Performance Levels*

Performance Level	Calibre	Ammunition Description	Bullet Mass	Range (min) (m)	BFS (mm)	Velocity (m/s)
RF1	Rifle 7.62mm Calibre 1 in 12" Twist	BAE Systems Royal Ordnance Defence Radway Green NATO Ball L2 A2	9.3g (144 grain)	10	25	830 ± 15
RF2	Rifle 7.62mm Calibre 1 in 12" Twist	BAE Systems Royal Ordnance Defence Radway Green Nato Ball L40A1 7.62 X 51mm High Power (HP)	9.7g	10	25	850 ± 15
SG1	Shotgun 12 Gauge True Cylinder	Winchester 1 oz. Rifled Lead Slug 12RS15 or 12RSE	28.4g (437 grain)	10	25	435 ± 25

NOTES:

- **The mean velocity of all shots at each of the above calibre must be ≥ the reference velocities shown in the above table, i.e. for HG1/A 9mm, the mean velocity of the 18 shots must be ≥ 365 m/s^{-1}**
- **The test house shall ensure that all rounds have fully stabilised at the point of impact.**
- **BFS and UPL readings shall be recorded to the nearest whole number using conventional mathematical rounding.**

FIGURE 4 *Continued: HOSDB Ballistic Performance Levels*

7.2 Handgun Shot Positions

The pattern of the test shots for protection levels HG1/A, HG1, HG2 and HG3 is shown in appendix A. The firing order shall be as follows:

7.2.1 Small Size Test Sample (front, figure 6)

- Shot 1: Top centre. 45° angle of incidence right shoulder forward (as viewed)
- Shot 2: Bottom right. 0° angle of incidence;
- Shot 3: Bottom left. 0° angle of incidence.

7.2.2 Small Size Test Sample (rear, figure 7)

- Shot 4: Top centre. 45° angle of incidence left shoulder forward (as viewed)
- Shot 5: Lower right. 0° angle of incidence;
- Shot 6: Lower left. 0° angle of incidence.

7.2.3 Medium Size Test Sample (front and rear, figure 8)

- Shot 1: Top centre. 0° angle of incidence;
- Shot 2: Bottom right. 0° angle of incidence;
- Shot 3: Bottom left. 0° angle of incidence;
- Shot 4: Upper left side. 0° angle of incidence;
- Shot 5: Lower right side. 0° angle of incidence;
- Shot 6: Bottom centre. 0° angle of incidence.

7.2.4 Large Size Test Sample (front and rear, figure 8)

- Shot 1: Top Centre 45° angle of incidence right shoulder forward (as viewed)
- Shot 2: Bottom right. 0° angle of incidence;
- Shot 3: Bottom left. 0° angle of incidence;
- Shot 4: Upper left side. 0° angle of incidence;
- Shot 5: Lower right side. 45° angle of left shoulder forward (as viewed)
- Shot 6: Bottom centre. 0° angle of incidence.

7.3 Test Sample Requirements (HG1/A, HG1, HG2 (30 shots per calibre)

For compliance testing the following test samples are required:

7.3.1 Small Size Test Sample

Two complete armour samples. One **front** and **rear** for 9mm (three shots on each panel) and one **front** and **rear** for 0.357 (three shots on each panel);

7.3.2 Medium Size Test Sample

Three complete armour samples. Two **front** panels and one **rear** panel for 9mm (18 shots) One **front** panel and two **rear** panels for 0.357 (18 shots);

7.3.3 Large Size Test Sample

One complete armour sample. One **front** panel for 9mm and one **rear** panel for 0.357.

See Part 1 appendix B for size templates.

Extra samples may be requested by the test house.

7.4 Test Sample Requirements (HG3 [30 shots])

7.4.1 Small Size Test Sample

One complete armour sample (small size) three shots on each panel (6 shots)

7.4.2 Medium Size Test Sample

One complete armour sample plus one additional **front** panel (18 shots)

7.4.3 Large Size Test Sample

One complete armour sample (large size) using **front** panel (6 shots)

See Part 1 appendix B for size templates.

Note:
Test samples shall be supplied for compliance testing in plain single layer carriers and protective pack covers of density not exceeding 220g/m^2. See also Part 1 section 6.1.

7.5 Test Shots (HG1/A, HG1, HG2 and HG3)

7.5.1 Test Shot No. 1 (Small Size Panel Front) 45° Angle Shot.

Adjust the holding fixture so that the shot will impact at location 1 (appendix A figure 6) in accordance with section 7.2.1. Fire the test round against the armour sample. Ensure that the shot impacts at least 50mm from the edge of the sample and 50mm from the edge of the tray holding the backing material.

Remove the armour sample from the backing material and visually inspect the sample. No bullet or spall may exit the carrier. Hold the edges of the sample with both hands and lightly shake to remove any rucking caused by the shot. Place the sample on a clean flat surface and smooth out the material to return it to its original configuration. ***Do not remove any trapped bullets (unless they impede the firing of the next shot).***

Measure and record the depth of indentation (BFS) resulting from the test shot using a similar measuring device as that shown in figure 5. The measurement shall be taken from the top edges of the steel tray containing the backing material.

To ensure that the armour sample can be re-positioned firmly against the front face of the backing material, the top face of the backing material shall be scraped level with the surface plane defined by the edges of the steel tray using a rigid full width metal scraper.

7.5.2 Test Shot No. 2 (Small Size Panel Front)

Replace the armour sample on the backing material in its original position and adjust the fixture so that the shot will impact at location 2 (appendix A figure 6) in accordance with section 7.2.1. Ensure that the shot impacts the armour sample at least 50mm from any other shot, 50mm from the edge of the sample and 50mm from the edge of the tray holding the backing material. For inspection, measurement and replacement of the sample follow the instructions given for test shot 1.

7.5.3 Test Shot No. 3 (Small Size Panel Front)

Replace the armour sample on the backing material in its original position and adjust the fixture so that the shot impacts at location 3 (appendix A figure 6) in accordance with section 7.2.1. Ensure that the shot impacts the armour sample at least 50mm from any other shot, 50mm from the edge of the sample and 50mm from the edge of the tray holding the backing material. For inspection, measurement and refitting of the sample follow the instructions given for test shot 1.

7.5.4 Test Shot No. 4 (Small Size Panel Rear) 45° angle shot.

Adjust the holding fixture so that the shot will impact at location 4 (appendix A figure 7) in accordance with section 7.2.2. Fire the test round against the armour sample. Ensure that the shot impacts the armour sample at least 50mm from the edge of the sample and 50mm from the edge of the tray holding the backing material. For inspection, measurement and refitting of the sample follow the instructions given for test shot 1.

7.5.5 Test Shot No. 5 (Small Size Panel Rear)

Replace the armour sample on the backing material in its original position and adjust the fixture so that the shot will impact at location 5 (appendix A figure 7) in accordance with section 7.2.2. Ensure that the shot impacts the armour sample at least 50mm from any other shot, 50mm from the edge of the sample and 50mm from the edge of the tray holding the backing material. For inspection, measurement and refitting of the sample follow the instructions given for test shot 1.

7.5.6 Test Shot No. 6 (Small Size Panel Rear)

Replace the armour sample on the backing material in its original position and adjust the fixture so that the shot will impact at location 6 (appendix A figure 7) in accordance with section 7.2.2. Ensure that the shot impacts the armour sample at least 50mm from any other shot, 50mm from the edge of the sample and 50mm from the edge of the tray holding the backing material. For inspection, measurement and refitting of the sample follow the instructions given for test shot 1.

7.5.7 Test Shot 1 (Medium Size Panel Front & Rear)

Note:
All test shots on medium size samples shall be conducted at zero degrees (0°) Upper Prediction Limit (UPL) shall be determined using only the medium size BFS readings.

Adjust the holding fixture so that the shot will impact at location 1 (appendix A figure 8) in accordance with section 7.2.3. Fire the test round against the armour sample. Ensure that the shot impacts the armour sample at least 50mm from the edge of the sample and 50mm from the edge of the tray holding the backing material.

Remove the armour sample from the backing material and visually inspect the sample. No bullet or spall may exit the sample. Hold the edges of the sample with both hands and lightly shake to remove any rucking caused by the shot. Place the sample on a clean flat surface and smooth out the material to return it to its original configuration. ***Do not remove any trapped bullets (unless they impede the firing of the next shot).***

Measure and record the depth of indentation (BFS) resulting from the test shot using a similar measuring device as that shown in figure 5. The measurement shall be taken from the top edges of the steel tray containing the backing material.

To ensure that the armour sample can be re-positioned firmly against the front face of the backing material, the top face of the backing material shall be scraped level with the surface plane defined by the edges of the steel tray using a rigid full width metal scraper.

7.5.8 Test Shots 2-6 (Medium Size Panel Front & Rear)

Replace the armour sample on the backing material in its original position and adjust the fixture so that the shot will impact at the correct location in sequence (appendix A figure 8) in accordance with section 7.2.3. Ensure that the shot impacts the armour sample at least 50mm from any other shot, 50mm from the edge of the sample and 50mm from the edge of the tray holding the backing material. For inspection, measurement and replacement of the sample follow the instructions given for test shot 1.

7.5.9 Test Shot No. 1 (Large Size Panel Front & Rear) 45° angle shot.

Adjust the holding fixture so that the shot will impact at location 1 (appendix A figure 8) in accordance with section 7.2.4. Fire the test round against the armour sample. Ensure that the shot impacts the armour sample at least 50mm from the edge of the sample and 50mm from the edge of the tray holding the backing material.

Remove the armour sample from the backing material and visually inspect the sample. No bullet or spall may exit the carrier. Hold the edges of the sample with both hands and lightly shake to remove any rucking caused by the shot. Place the sample on a clean flat surface and smooth out the material to return it to its original configuration. ***Do not remove any trapped bullets (unless they impede the firing of the next shot).***

Measure and record the depth of indentation (BFS) resulting from the test shot using the measuring device shown in figure 5. The measurement shall be taken from the top edges of the steel tray containing the backing material.

To ensure that the armour sample can be re-positioned firmly against the front face of the backing material, the top face of the backing material shall be scraped level with the surface plane defined by the edges of the steel tray using a rigid full width metal scraper.

7.5.10 Test Shot No. 2 (Large Size Panel Front & Rear)

Replace the armour sample on the backing material in its original position and adjust the fixture so that the shot will impact at location 2 (appendix A figure 8) in accordance with section 7.2.4. Ensure that the shot impacts the armour sample at least 50mm from any other shot, 50mm from the edge of the sample and 50mm from the edge of the tray holding the backing material. For inspection, measurement and refitting of the sample follow the instructions given for test shot 1.

7.5.11 Test Shot No. 3 (Large Size Panel Front & Rear)

Replace the armour sample on the backing material in its original position and adjust the fixture so that the shot will impact at location 3 (appendix A figure 8) in accordance with section 7.2.4. Ensure that the shot impacts the armour sample at least 50mm from any other shot, 50mm from the edge of the sample and 50mm from the edge of the tray holding the backing material. For inspection, measurement and refitting of the sample follow the instructions given for test shot 1.

7.5.12 Test Shot No. 4 (Large Size Panel Front & Rear)

Replace the armour sample on the backing material in its original position and adjust the fixture so that the shot will impact at location 4 (appendix A figure 8) in accordance with section 7.2.4. Ensure that the shot impacts the armour sample at least 50mm from any other shot, 50mm from the edge of the sample and 50mm from the edge of the tray holding the backing material. For inspection, measurement and refitting of the sample follow the instructions given for test shot 1.

7.5.13 Test Shot No. 5 (Large Size Panel Front & Rear) 45° angle shot.

Replace the armour sample on the backing material in its original position and adjust the fixture so that the shot will impact at location 5 (appendix A figure 8) in accordance with section 7.2.4 Ensure that the shot impacts the armour sample at least 50mm from any other shot, 50mm from the edge of the sample and 50mm from the edge of the tray holding the backing material. For inspection, measurement and refitting of the sample follow the instructions given for test shot 1.

7.5.14 Test Shot No. 6 (Large Size Panel Front and Rear)

Replace the armour sample on the backing material in its original position and adjust the fixture so that the shot will impact at location 6 (appendix A figure 8) in accordance with section 7.2.4. Ensure that the shot impacts the armour sample at least 50mm from any other shot, 50mm from the edge of the sample and 50mm from the edge of the tray holding the backing material. For inspection, measurement and refitting of the sample follow the instructions given for test shot 1.

7.6 Additional Test Strikes at Specific Points of Weakness (Waistcoat Fastenings) (HG1/A, HG1, HG2 and HG3)

The shots shall be performed with each calibre used in the specified protection level. A new armour sample shall be used for each calibre test.

Shot 1:

Centre of fastening between panels. A 0° angle of incidence shot, striking within 5mm of join, and at least 50mm from the top or bottom of the armour sample and 50mm from the edge of the tray holding the backing material.

Shot 2:

Centre of fastening between panels. A 45° angle of incidence shot, striking within 5mm of join, at least 50mm from shot 1, 50mm from the top or bottom of the armour sample and 50mm from the edge of the tray holding the backing material. The shot shall be angled in the worst-case direction i.e. to travel between any overlaps beneath the zip or other type of fastening. No bullet or spall may exit the carrier.

7.7 Additional Test Strikes on Female Armour (HG1/A, HG1, HG2 and HG3)

All female armour constructions shall be subject to the following test shots. The shots shall be performed with each calibre used in the specified protection level. For each calibre used, a minimum of two shots shall be fired on a separate front female panel as described below. Also, a minimum of one shot shall be fired at any other area of perceived weakness at the discretion of the test house. All shots shall be spaced at a distance of at least 50mm from one another.

The test shots shall be performed with the backing material built up to remove any air gaps between the face of the backing material and the armour sample.

Shot 1:

A 0° angle of incidence shot striking within 5mm of the tip of the breast cup, at least 50mm from any other shot and 50mm from the edge of the tray holding the backing material.

Shot 2:

A 0° angle of incidence shot shall be fired at each line or area of weakness, e.g. a join between two sections of fabric (where a fabric is cut and stitched) or a significant change in direction of the fabric fibres.

7.8 SG1

Two samples are required for SG1 testing, one shot on each plate.

The shotgun test consists of a single strike on each plate located centrally. Where a ceramic or other hard plate is tested, it must be backed with the appropriate soft armour with which it is designed to be used[3]. If the plate is designed for use without a soft armour backing, it shall be placed directly onto the backing material.

7.9 RF1 and RF2

Two samples are required for each of RF1 and RF2 testing, three shots on each plate.

The rifle test consists of three shots positioned on each plate as shown in appendix A figure 9, with all six shots fired at 0° angle of incidence. No shot shall be closer than 50mm to any edge of the RF1 or RF2 plate and 50mm to the edge of the tray holding the backing material. Where a ceramic or other hard plate is tested, it must be backed with the appropriate soft armour with which it is designed to be used (see footnote at part 1 section 7.4). If the plate has been designed for use without soft armour backing, it should be placed directly onto the backing material.

7.10 Firing

For RF1 and RF2 testing, the armour sample shall be of sufficient size that no shot strikes the target at a distance less than 100mm from another shot or 50mm from any edge of the plate.

[3] All female armour constructions shall be subject to these additional test shots.

8 Performance Assessment

8.1 Ballistic Performance

Before a body armour model is deemed to comply with HOSDB compliance testing requirements, the following criteria must have been met:

- The velocity of each shot must be within the limits specified in Figure 4, also, see Figure 4 notes;
- No bullet may have passed completely though the sample, nor may any part of the bullet be visible from the body side of the sample;
- No bullet may exit the outer carrier;
- If a rigid panel is incorporated into the design of the armour, no part of that panel, i.e. pieces of metal or ceramic plate, may be found in the backing material.

8.2 Back-face Signature (BFS) Measurement

For all ballistic performance levels, the armour sample shall be removed from the backing material and the indentation depth (BFS) resulting from each test shot shall be measured from the top edges of the steel tray, using similar apparatus to that shown in figure 5. Where the backing material is built up as in female bust shapes, BFS is not measured.

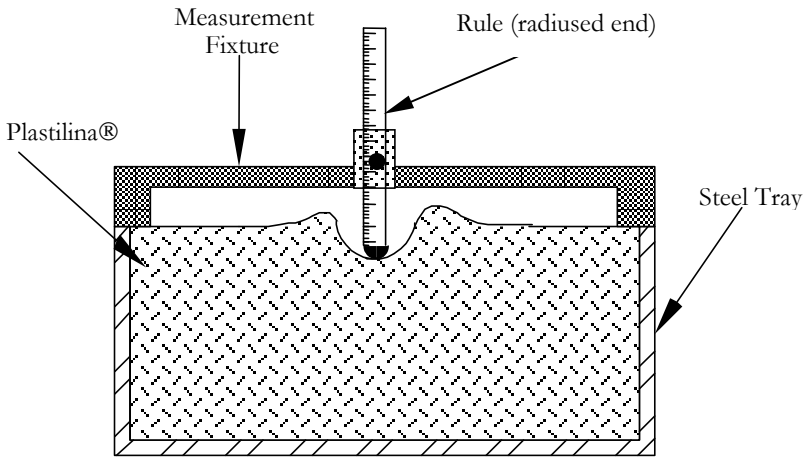


FIGURE 5: *Method of Measuring Back-face Signature*

8.3 HG1/A, HG1, HG2 and HG3 BFS Measurement

8.3.1 Determining the UPL (Medium Size Test Samples Only)

When the ballistic test is complete and all BFS readings have been recorded, the Upper Prediction Limit (for UPL calculation see appendix B) shall be used to determine if the armour model has met the requirements of the standard. To determine the UPL, each set of 18 zero degree shots on the **medium size samples** (per calibre) shall be used. The upper **95%** prediction limit shall be used for compliance testing and the UPL shall be no greater than 25mm for HG1/HG2 and HG3 and 44mm for HG1/A.

BFS on small and large size test samples and angled shots shall be measured and must be no greater than the maximum allowed (see section 5.3) but they will not be counted for the purpose of calculating the Upper Prediction Limit (UPL)

Note:

If the resultant UPL for a HG1/A (declared) model is 25mm or less, the model will be certified at either HG1/A or HG1 (not both) at the request of the manufacturer. If the resultant UPL for an HG1 (declared) model is greater than 25mm (but no greater than 44mm) it may at the request of the manufacturer be certified at HG1/A level.

8.4 RF1, RF2 and SG1 BFS Measurement

When all shots have been fired, remove the armour sample from the backing material. Measure and record the depth of indentation resulting from the test shots using the measuring device shown in figure 5. The maximum indentation depth (BFS) permitted from any test shot is **25mm** measured from the top edges of the steel tray containing the backing material[4]

8.5 Pencilling (narrow indentation BFS)

Where the bullet has forced the armour sample into the backing material causing a narrow indentation – the depth of the indentation shall be no more than 20mm for all threat levels on all sample sizes. BFS readings on medium size panels (provided they are no more than 20mm) will be counted as fair shots for the purpose of calculating the UPL. If any fair shot causes pencilling in excess of 20mm on all sample sizes, the model will have failed the compliance test.

[4] Where it is necessary for the Roma Plastilina® No 1 to be built up to allow the testing of curved SG1, RF1 or SG1 plates, the back face deformation may be measured from the original surface of the Roma Plastilina® No 1

9 Manufacturers Quality Testing (MQT)

9.1 MQT 1 and MQT 2

For the purpose of MQT1 and MQT2 ballistic testing, the armour samples shall be fitted in plain single layer carriers of maximum density 220g/m^2. MQT2 in-service testing may (at the discretion of the customer) be conducted with the protective packs fitted in the lightest carriers supplied for use with the model.

9.1.1 HG1/A, HG1, HG2 and HG3

Two **medium** size protective packs are required for each calibre: One **front** panel and one **rear** panel for 9mm (twelve 0^o shots) One **front** panel and one **rear** panel for 0.357 (twelve 0^o shots) using the medium/large HOSDB handgun test pattern. One penetration is allowed per 12 shots.

See Part 1 appendix B for medium size template.

Note:
The penetration allowance is a stand-alone allowance per 12 (or 18, see 9.1.3) shot sample. It is not cumulative i.e. a 12 (or 18) shot sampling with zero penetrations cannot be carried forward to the next 12 (or 18) shot sampling to give an allowance of two penetrations.

9.1.2 Back Face Signature (BFS)

BFS on the twelve 0^o shots per calibre will be assessed by the UPL method. For the purpose of MQT1 and MQT2 testing, the upper **90%** prediction limit shall be determined and shall be no more than 25mm for HG1, HG2 and HG3 and 44mm for HG1/A. If the UPL is exceeded as a result of the twelve 0^o shots per calibre, a further six 0^o shots may be carried out using a new front panel and a fresh UPL can be calculated on the eighteen shot total. However, in this case, the upper **95%** prediction limit must be used.

9.1.3 RF1, RF2 and SG1

One plate is required for this test. Three shots as per the test pattern for RF1 and RF2 and one shot for SG1. No penetrations and no BFS readings above 25mm are permitted.

Appendix A: Armour Shot Patterns:

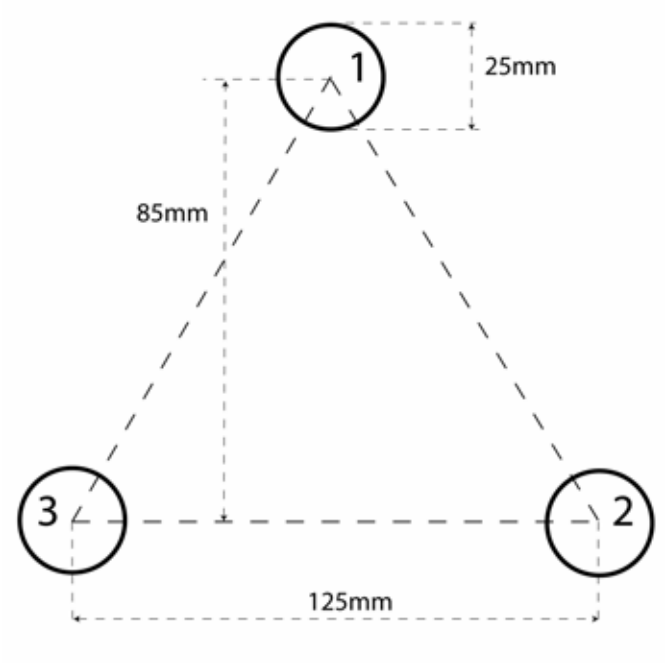


FIGURE 6: *Small Size Front Panel*

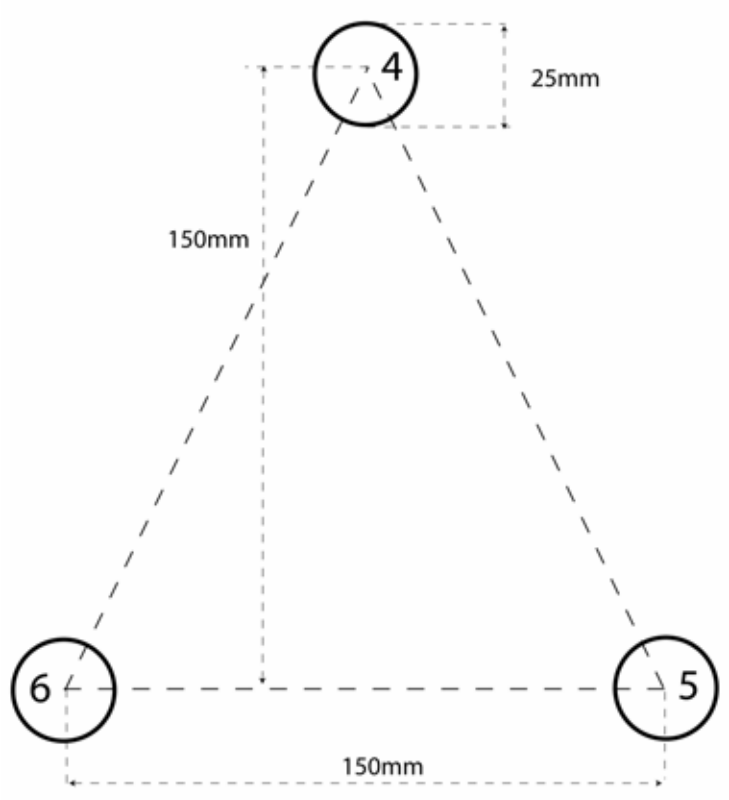


FIGURE 7: *Small Size Rear Panel.*

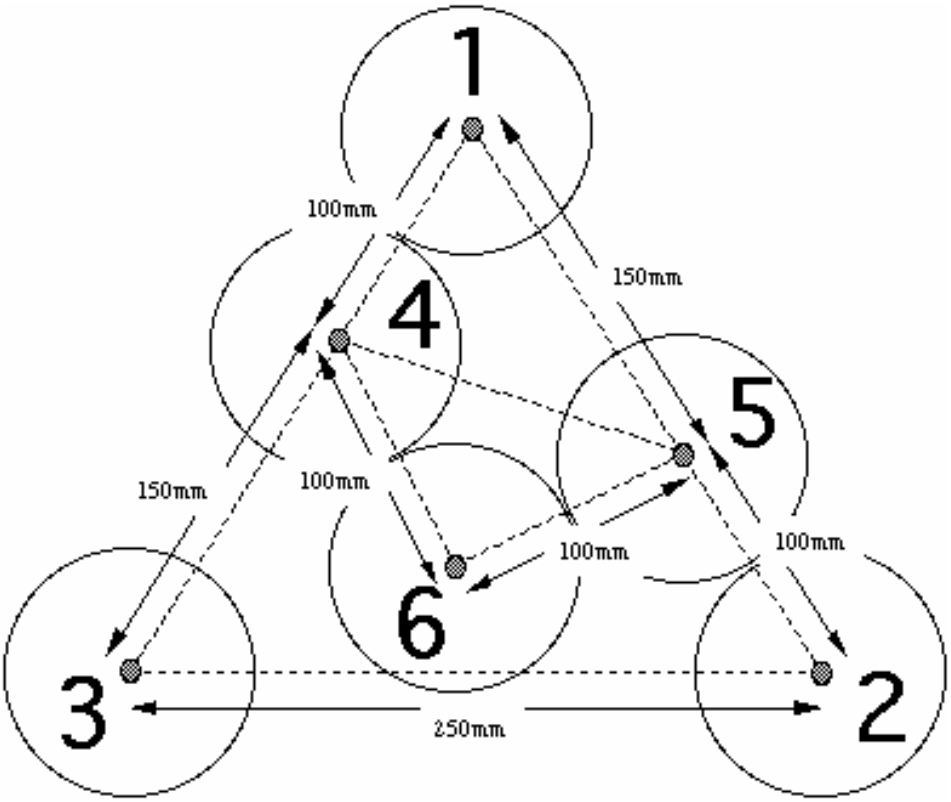


FIGURE 8: *Medium and Large Panel (Front & Rear)*

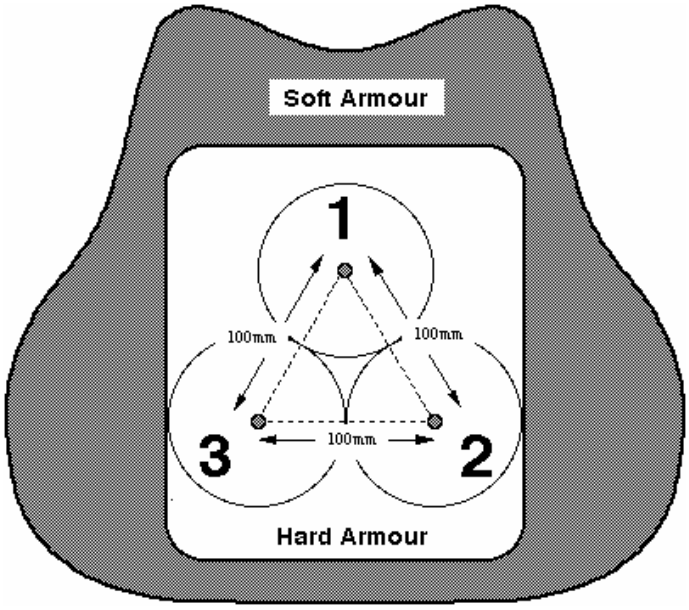


FIGURE 9: *Shot Pattern for Rifle Ammunition*

Appendix B: Calculation Of Upper Prediction Limit (HG1/A, HG1, HG2 & HG3)

Calculation of upper prediction limit

The upper prediction limit is a prediction of the upper tail of a normal distribution which provides a value that the next shot is unlikely to exceed. It is used to provide the value (of back face signature) which another observation will not exceed, with a specified probability (for example 95%).

The upper prediction limit is given by:

$$UPL = \bar{x} + t_{crit} s \sqrt{\frac{n+1}{n}}$$

Where

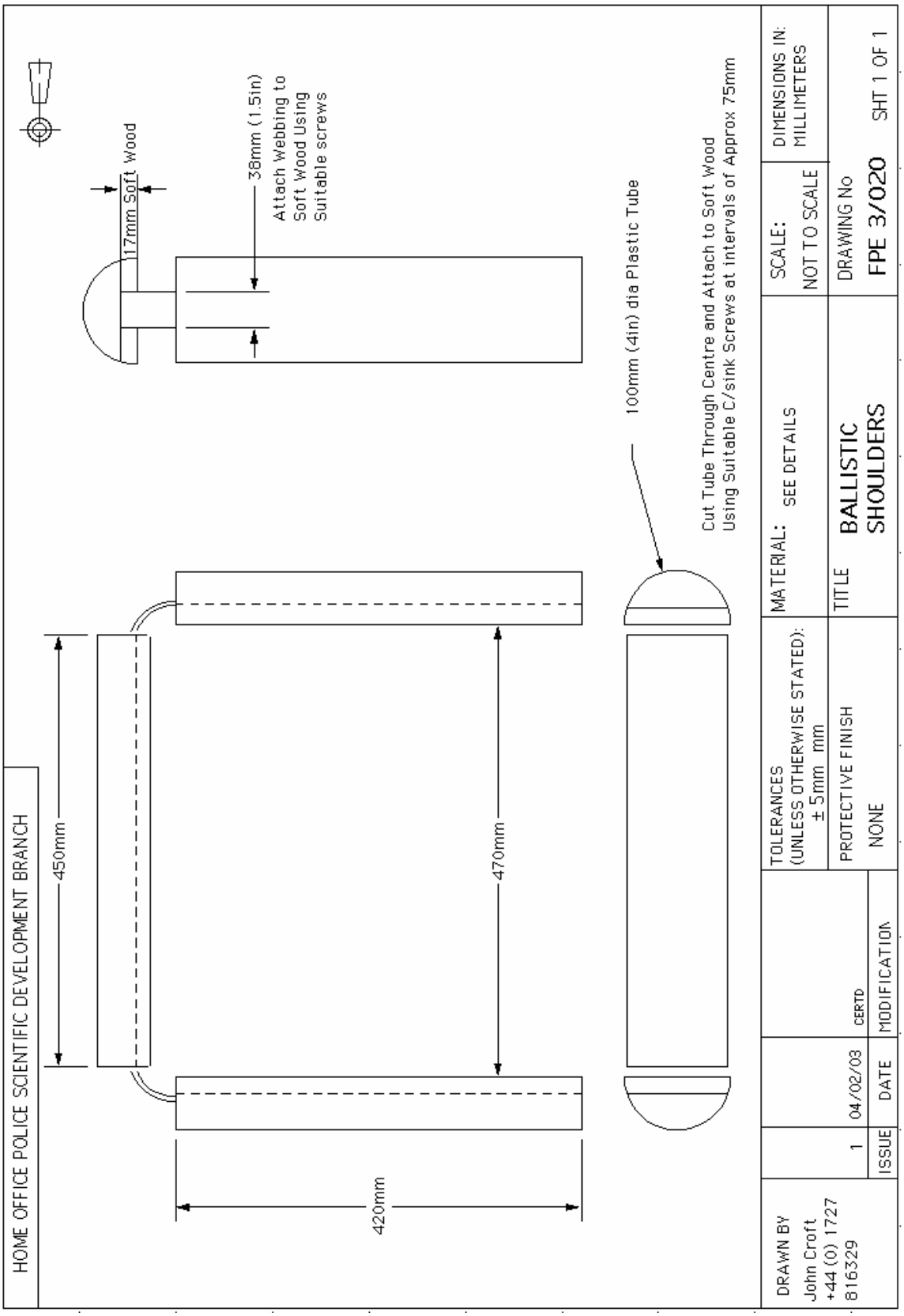
UPL the upper prediction limit for a single new observation
$\bar{x}$ the sample mean
t_{crit} t value from tables for a single tail of the specified confidence limit (shown below)
S sample standard deviation
n number of data points in the sample from which $\bar{x}$ and S are calculated

From - Hahn, G.J. and Meeker, W.Q. (1991).
Statistical Intervals: A Guide for Practitioners.
Wiley, New York. page 61, equation 4.2.

t_{crit} values

Number of data points (n)	t_{crit} for specified probability		Number of data points (n)	t_{crit} for specified probability	
	90%	95%		90%	95%
2	3.0777	6.3138	14	1.3502	1.7709
3	1.8856	2.92	15	1.345	1.7613
4	1.6377	2.3534	16	1.3406	1.7531
5	1.5332	2.1318	17	1.3368	1.7459
6	1.4759	2.015	18	1.3334	1.7396
7	1.4398	1.9432	19	1.3304	1.7341
8	1.4149	1.8946	20	1.3277	1.7291
9	1.3968	1.8595	25	1.3178	1.7109
10	1.383	1.8331	30	1.3114	1.6991
11	1.3722	1.8125	40	1.3036	1.6849
12	1.3634	1.7959	50	1.2991	1.6766
13	1.3562	1.7823			

Appendix C: Ballistic Shoulders



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