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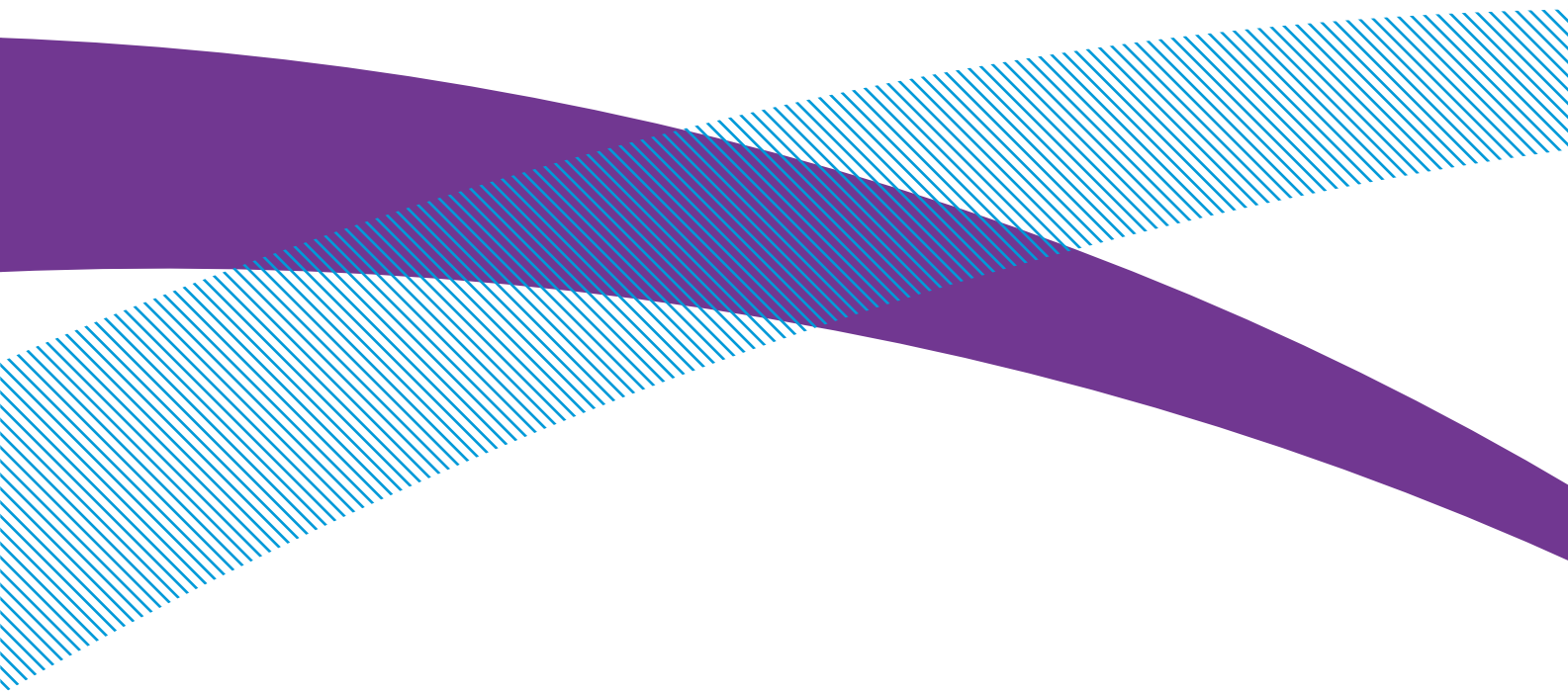
Scientific
Development Branch

HOSDB Body Armour Standards for UK Police (2007)

Part 3: Knife and Spike Resistance

Publication No. 39/07/C

John Croft
Daniel Longhurst



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1 Introduction

This part of the standard provides information on the stab resistant 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 a choice to police purchasing units and wearers through three levels of knife and spike protection. These levels are described below:

KR1 & KR1+SP1 is the lowest protection level allowed and is tested at a performance level of 24 joules of energy. It should offer maximum periods of wear in a low risk-patrolling environment. Armour tested to this level would be suitable for covert or overt use;

KR2 & KR2+SP2 is a medium protection level, tested at a performance level of 33 joules. This should provide a general duty garment for extended wear and may be covert or overt;

KR3 & KR3+SP3 is a high protection level tested at a performance level of 43 joules. This would be suitable for short periods of wear in high-risk situations. Armour manufactured to this level would normally be overt.

All of the above protection levels can be combined with ballistic protection levels - described in part 2 of this Standard - to offer dual stab and ballistic protection.

2 Scope

This document is Part 3 of the standard and contains the performance requirements and test protocol for the testing of body armour to knife and spike threat levels.

3 Associated Documents

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

HOSDB Body Armour Standards for UK Police Part 2: Ballistic Resistance.

PSDB Portable Ballistic Standard for UK Police (2004)

HOSDB Slash Resistance Standard for UK Police (2006)

4 Requirements

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

5 Test Methodology

5.1 The Test Equipment

The test shall be performed using the HOSDB guided rail drop tube assembly, which will enable the knife/spike missile to fall under the influence of gravity and strike the armour sample at a pre-determined point of impact. The guide rails, situated inside the tube, prevent the knife/spike missile from rotating about its vertical axis during its descent. These rails also ensure that the test implement strikes at the correct orientation so that any weakness in the armour design can be fully determined. The drop tube assembly must be rigidly secured to a supporting wall or frame, and care must be taken when installing the system to ensure that the tube is mounted vertically. Drawings of the drop tube and knife/spike missile are available from HOSDB.

5.2 The Knife/Spike Missile

The knife/spike missile consists of separate steel and alloy knife and spike holders of mass $0.65\text{kg} \pm 6.5\text{g}$ (including the knife or spike) housed in a nylon missile casing of mass $1.25\text{ kg} \pm 13\text{g}$. The casing is designed to ensure minimal friction between the missile and the inner walls of the tube during its falling motion (figure 1). The missile length is sufficient to ensure that part of the body remains inside the drop tube throughout a test drop impact. The nylon body must be replaced if it becomes damaged.

The knife/spike holder is free to slide vertically within the nylon body casing. However, sandwiched between the base of the knife/spike holder and the nylon casing, are two 50mm diameter discs of Plastazote® foam. As the knife/spike holder is forced into the casing under load, the foam is increasingly compressed.



FIGURE 1 Knife Missile

5.3 The Engineered Test Knife and Spike

The engineered test knife has been designed to replicate the broad spectrum of knives used in assaults on Police Officers. The spike represents a typical spiked implement that is considered to be a greater threat to UK Prison Officers than to UK Police. The engineered test implements used in this standard are described as HOSDB/P1/B for the knife and HOSDB/SP/B for the spike (figures 2 and 3).

Each armour sample shall be tested using either the HOSDB/P1B knife for knife resistance or both the HOSDB/P1/B and HOSDB/SP/B for knife and spike resistance. Detailed manufacturing drawings of each of the test implements are given in appendix A.

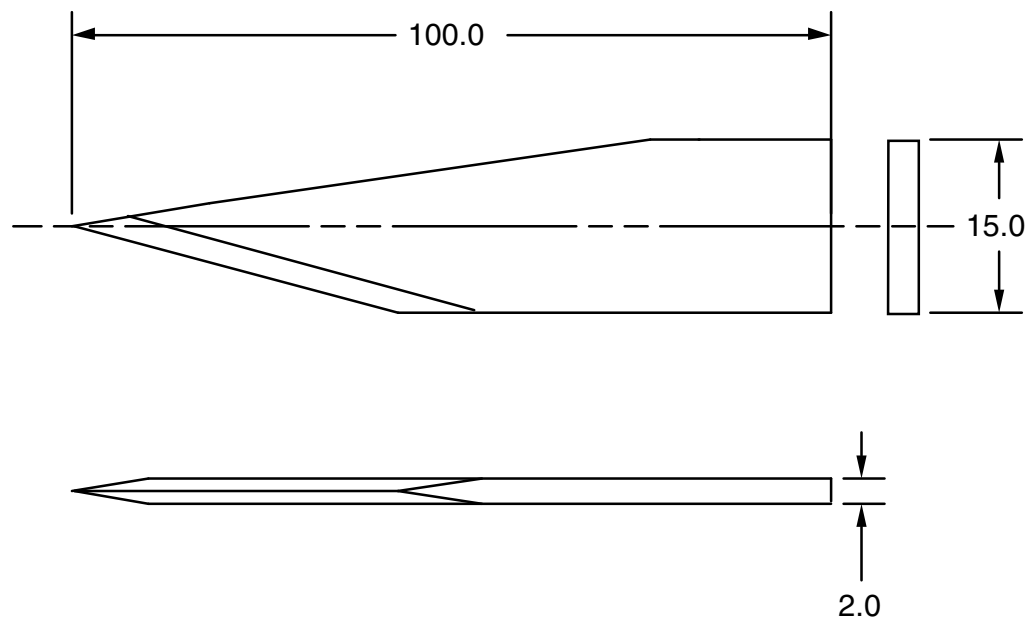


FIGURE 2 HOSDB P1B Knife (dimensions in mm)

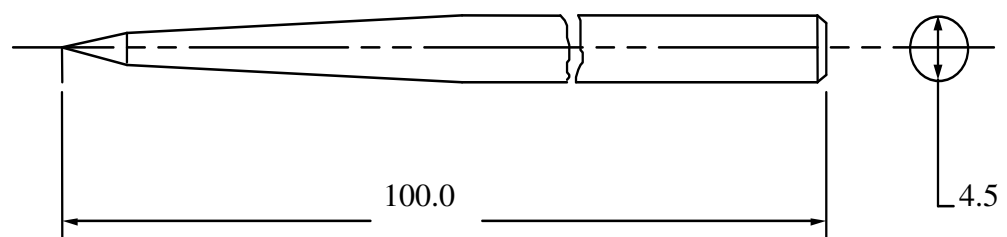


FIGURE 3 HOSDB SP/B Spike (dimensions in mm)

5.4 Velocity Measurement

A suitable method of accurately measuring the velocity of the missile at 25mm ±2mm before impact shall be employed (figure 6). Recommended types of equipment for velocity measurement include:

- Photoelectric light screens;

- Laser/light sensor diode light screens.

If light screens are used the base length of the timing sensors shall be a maximum of 50mm (HOSDB test houses use a base length of 30mm). The measuring equipment shall be calibrated so that it is capable of measuring the velocity to an accuracy of $\pm 0.2\text{m/s}$.

5.5 The Composite Backing Material

The composite backing material is supplied in packs measuring 400mm x 333mm and consists (from the strike face down) of four layers of 6mm RA110 neoprene, followed by a single 30mm layer of 33kgm^{-3} Plastazote® foam, backed by 2 layers of 6mm natural rubber to BS 2494D (figure 4). These packs have been given the designation HOSDB/BM/4/99.

A list of suggested manufacturers and suppliers is given in appendix B.

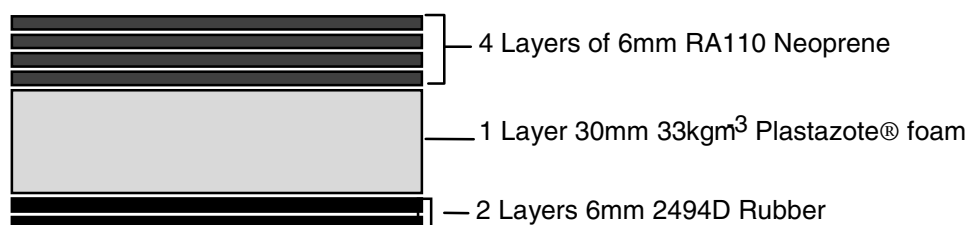


FIGURE 4 Composite Backing Material.

6 Preparation of the Test Equipment

6.1 Velocity Measuring Equipment Calibration

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

6.2 Selecting the Test Knife/Spike

For compliance testing, a total of forty (40) P1/B test knives shall be selected at random for knife resistant testing. If spike resistance is required, ten (10) SP/B spikes shall be selected in addition to the knives. A new knife/spike shall be used for each test. A visual check must be made to ensure the overall finish of the knife/spike is clean and free from rough edges, and that it meets the general requirements of the technical specification given in appendix A.

6.3 The Tip Sharpness Test

Prior to testing, the knife/spike shall first be subjected to a tip-sharpness test¹.

This standard addresses two methods of assessing tip sharpness:

The first method consists of a standard Rockwell Hardness Testing Machine, Mitutoyo model ATK-F1000, with a modified indenter holder to accept the knife or spike. The machine must be pre-set to give minor and major loads of 3kg and 5kg respectively as detailed in appendix A5.

The knife/spike shall first be wiped with heavy duty degreaser solvent wipes² to remove any traces of lubricant and allowed to dry. From this point onwards, the knives should only be handled whilst wearing suitable cotton/linen gloves. The tip sharpness shall then be tested by applying the load at the knife/spike tip into a small sample block of 99.997% pure aluminium that has been machined to a smooth surface finish.

A list of suggested suppliers of pure aluminium is given in appendix B.

Operation and calibration instructions for the sharpness test are given in appendix A.

The test value from a new, unused blade shall lie between – 100HRC and 140HRC. These values can also be expressed in terms of indentation depth in

¹ To accommodate manufacturers carrying out development testing, High Speed and Carbide (contact details in Appendix B) have agreed to stock limited supplies of P1/B knives and SP/B spikes with certified tip sharpness courtesy of the Cutlery and Allied Trades Research Association (CATRA) of Sheffield.

² The Degreasing wipes used by HOSDB test hoses can be purchased using the order code: 28635 or 70683 from: www.screwfix.com. Free phone: 0500 414141.

the aluminium test block, produced by the major load application, and will correspond to depths of 0.40 to 0.48mm as detailed in appendix A.

A second method of determining tip sharpness has also been established. Both the PSDB P1/B knives and SP/B spikes may be tested for tip sharpness at the Cutlery and Allied Trades Research Association (CATRA). The Rockwell values of –100HRC to –140HRC compare (approximately) with CATRA values of 4.5N force to 0.66N force.

These tip sharpness values can be converted into the values on the Rockwell scale using the table shown in appendix A4.

6.4 Installing the Test Knife/Spike into the Missile

A socket head cap screw is located on the knife/spike holder of the missile (figure 5). This screw should be loosened to allow the base of the test knife/spike to be fully inserted into the knife/spike-fixing. The screw is then tightened firmly to hold the knife/spike securely.



FIGURE 5 Installing the Knife/Spike into the Missile.

6.5 Installing the Foam Damper into the Missile

The damping material consists of two discs of 50mm diameter x 30mm thick, 33kgm^{-3} Plastazote® foam. Both discs are fitted into the nylon sabot behind the knife/spike holder and are held in place by two socket head cap screws. To assemble the dual mass components, first insert both discs into the cavity of the nylon sabot. Slide the knife/spike holder into the cavity, compressing the discs until the screw holes appear in the guide slots of the nylon sabot. Insert and tighten the socket head cap screws. When fitted correctly, the discs will remain under compression with their total thickness reduced by $5\text{mm} \pm 0.5\text{mm}$.

For all strikes up to and including 36 joules, the dampers shall be renewed after a maximum of ten strikes. For strikes at or above 43 joules, the dampers shall be renewed after a maximum of five strikes.

A description of the damping material can be found in appendix B3.

6.6 Selecting the Backing Material

Two types of backing material are available for the test. For all flat and/or flexible armour samples the composite backing material shall be used. However, when testing specific weak points of shaped female armours, or where armours have a pre-formed curve to enable the armour to fit more closely to the body, it may not be possible for the rear face of the armour sample to lie in close contact with the surface of the composite backing material. In these cases, Roma Plastilina® No 1 may be used for this portion of the test.

Before testing, the appropriate backing material shall be prepared as described in the relevant sections (6.7 to 6.11).

6.7 Preparing the Composite Backing Material

The composite backing material pack shall be placed in a room held at a temperature of $20^{\circ}\text{C} \pm 3^{\circ}\text{C}$ and between 40% and 70% humidity for at least 12 hours prior to the trial.

6.8 Calibrating the Composite Backing Material

After conditioning the composite backing material, calibration shall be carried out using the methods and equipment specified below:

- Drop test sphere: Steel sphere grade '100' PN3606³;
- Sphere diameter: $63.5\text{mm} \pm 0.05\text{mm}$;
- Sphere mass: $1.043\text{kg} \pm 5\text{g}$;
- Drop height: $1.5\text{m} \pm 0.02\text{m}$;
- Drop spacing: 75mm minimum from any edge and 100mm between indent centres.

The calibration drop shall consist of a free fall of the sphere onto the backing material. To achieve this, the pack should be placed on a solid concrete floor. Three drops shall be completed and the arithmetic mean height of rebound achieved from three drops shall be $425\text{mm} \pm 75\text{mm}$.

A list of suggested manufacturers and suppliers of the composite backing materials is given in appendix B.

6.9 Preparing the Roma Plastilina® No 1 Backing Material

Steel trays measuring approximately 420mm x 350mm x 100mm, open on one large face only, shall be filled with Roma Plastilina® No 1. The Roma Plastilina® No 1 in each tray shall be manipulated to ensure no air gaps exist. The trays shall be date marked with the date they were filled with new Roma

³ This sphere: ref P/N 3606 is available from: Salem Speciality Ball Co, Inc, PO Box 145 West Simsbury, CT 06092. USA.

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®.

6.10 Conditioning the Roma Plastilina® No 1 Backing Material

The conditioning of the Roma Plastilina® No 1 shall be carried out in a heated enclosure for at least 3 hours at a temperature above 30°C. Actual conditioning temperature and recovery time between strikes shall be determined by calibration results described in section 6.11. Conditioning time, temperature and drop test performance may change as a function of the age and usage of the Roma Plastilina® No 1.

6.11 Calibrating the Roma Plastilina® No 1 Backing Material

After conditioning of the Roma Plastilina®, calibration must be carried out using the methods and equipment specified below:

- Drop test sphere: Steel sphere grade '100' PN3606⁴;
- Sphere diameter: 63.5mm ± 0.05mm;
- Sphere mass: 1.043kg ± 5g;
- Drop height: 1.5m ± 0.02m;
- Drop spacing: 75mm minimum from any edge and 100mm between indent centres.

The calibration drop shall consist of a free fall of the sphere onto the Roma Plastilina®. 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 stab test.

6.12 Mounting the Armour Sample

The appropriately conditioned backing material shall be placed beneath the drop tube assembly, and the body armour securely fastened onto the backing material. When testing body armours using the composite backing material, a sheet of 140g/m² Polyart® paper may be placed between the backing material and the armour to allow penetration measurements to be made. If it becomes necessary to use Roma Plastilina® No 1 as the backing material, (i.e. when testing armours with pre-curved surfaces), the Roma Plastilina® No 1 shall be built up to ensure contact with the wear face of the armour. When using the composite backing materials the armour shall be held in place using standard webbing type strapping (supplied by HOSDB) ensuring that there is no visible compression of the backing material.

⁴ This sphere: ref P/N 3606 is available from: Salem Speciality Ball Co, Inc, PO Box 145 West Simsbury, CT 06092. USA.

7 Testing

7.1 Threat Levels

An armour model submitted for either knife resistance testing, or knife + spike resistance testing⁵, should be designed to meet one of the three protection levels listed below:

KR1 or KR1+SP1

The lowest protection level allowed, and tested at a performance level of 24 joules of energy. Armour at this level should offer maximum periods of wear in low risk patrolling environments and would be suitable for covert use;

KR2 or KR2+SP2

A medium protection level, which is tested at a performance level of 33 joules. This level should provide for a general duty garment for extended wear and may be covert or overt;

KR3 or KR3+SP3

A high protection level tested at a performance level of 43 joules. This level should be suitable for short/medium periods of wear in high-risk situations. Armour manufactured to this level would normally be overt.

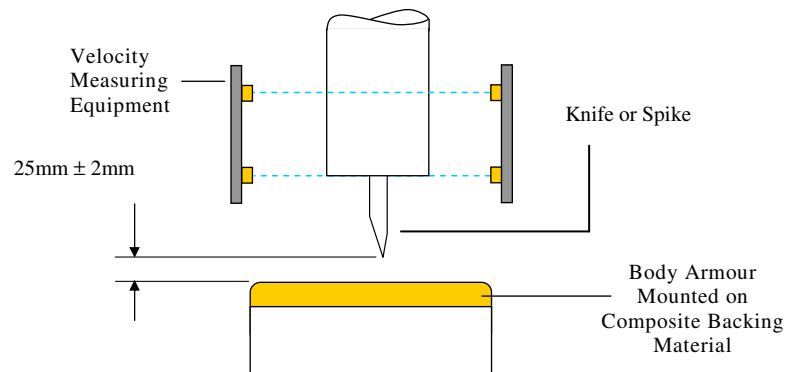


FIGURE 6 Typical Test Apparatus for Knife and Spike Testing

⁵ Armour will not be certified for dual knife + spike resistance at different threat levels, i.e. if KR1 is chosen for knife protection and spike resistance is required in addition, the level for spike protection will be limited to SP1. Conversely, KR2+SP1 will not be permitted.

7.2 Knife Resistance Testing

Each armour model shall be tested for its compliance to one of the knife protection levels shown in figure 7 by performing a series of test strikes using the knives described in section 5.3.

Three protective packs are required for this test; one complete armour and one front or back panel. These shall be large size. See Part 1 appendix B for size templates. The protective packs shall be removed from their carriers for the purpose of knife resistance testing.

A total of 30 (thirty) 0° strikes shall be conducted at energy level E1 using all three panels (10 strikes per panel). The maximum allowed penetration is 7mm. Any strike where the energy is less than E1 shall be discounted unless penetration exceeding the limit occurs. Particular areas of weakness (this will include any angled shots considered necessary) will be counted as extra shots at the discretion of the test house after consultation with HOSDB. No penetrations above the maximum will be permitted. Bust and overlap shots shall be extra shots and extra front panels shall be supplied.

The first set of tests consists of thirty (30) strikes, impacting at 0° angle of incidence using blade type P1B at a specified energy E1. This is followed by a further ten (10) strikes at energy E2. The values of E1 and E2 are described for each protection level in figure 7. Following each test strike the penetration of the impact shall be measured and shall not exceed the maximum permitted penetration depth described in figure 7.

7.3 Spike Resistance Testing (optional)

HOSDB certification will be given for spike resistance only in addition to knife resistance. Spike resistance was introduced into this standard primarily to address the additional threat faced by Prison Officers, therefore, is not available as a stand-alone protection level. If it is considered that spike resistance is required in addition to knife protection, each armour model shall be tested for its compliance to one of the protection levels shown in figure 7. Spike testing is described in detail in section 7.6. The protective packs shall be removed from their carriers prior to testing.

Protection Levels	Energy Level E1 (joules)	Maximum Penetration at E1 (mm)	Energy Level E2 (joules)	Maximum Penetration at E2 (mm)
KR1	24	7	36	20*
KR1+SP1	24	KR1=7, SP1 =0*	KR1= 36, SP1 = N/A	KR1=20*, SP1 = N/A
KR2	33	7	50	20*
KR2+SP2	33	KR2=7, SP2 =0*	KR2= 50, SP2 = N/A	KR2=20*, SP2 = N/A
KR3	43	7	65	20*
KR3+SP3	43	KR3=7, SP3 =0*	KR3= 65, SP3 = N/A	KR3=20*, SP3 = N/A

FIGURE 7 Description of Knife and Spike Protection Levels

Notes on Figure 7:

* One penetration not exceeding 30mm is permissible at E2 knife testing and one penetration (no depth limit) is permissible for spike testing.

All energies shall be recorded to the nearest whole number using conventional mathematical rounding.

N/A = Not Applicable

7.4 Test Procedure for Knife Protection Levels KR1, KR2 and KR3

The knife test sequence results in a total of 40 fair strikes (see Part 1 section 7.16 for definition of fair hit/strike) against each different model of body armour and shall be carried out at one of the three threat levels shown in figure 7.

7.5 Knife Test Strikes

The following test strikes shall be performed. A new knife shall be used for each test strike. To allow the damping discs to return to their original volume, a period of 5 minutes shall elapse between each test strike.

7.5.1 E1 Test Strike No. 1

Using a **P1B** test knife perform the test strike at energy **E1** (figure 7). The armour sample shall be fastened to the backing material beneath the drop apparatus such that the knife impacts the strike face of the armour sample at 0° angle of incidence. Ensure that the knife impact position is at least 50mm from the edge of the backing material and at least 50mm from the edge of the sample. Velocity measuring equipment as described in section 5.4 shall be

used to determine the impact velocity of the test knife. See also section 6.1 and figure 8.

If the impact fulfils the criteria of a fair strike as defined in Part 1 section 7.16, measure any penetration of the knife and record it along with the impact energy in a test report form. Reposition the armour sample onto the backing material and fasten the holding straps to secure it in place.

7.5.2 E1 Test Strike No. 2 - 30

Select a new area of the armour sample so that the knife impact position is at least 50mm from any other impact and at least 50mm from the edge of the sample and the edge of the backing material and repeat test strike procedure No.1 using a **P1/B** test knife at energy **E1**.

7.5.3 E2 Test Strike No. 31

Using a **P1B** test knife perform the first test strike at energy **E2** (figure 7). The body armour shall be fastened to the backing material beneath the drop apparatus such that the knife impacts the strike face at 0° angle of incidence. Ensure that the knife impact position is at least 50mm from any other impact and at least 50mm from the edge of the armour sample. Velocity measuring equipment as described in section 5.4 shall be used to determine the impact velocity of the test knife. See also section 6.1 and figure 8.

If the impact fulfils the criteria of a fair strike, measure any penetration of the knife and record it along with the impact energy, in the test report form. Reposition the armour sample onto the backing material and fasten the holding straps to secure it in place.

7.5.4 E2 Test Strikes No. 32 - 40

Select a new area of the armour sample so that the knife impact position is at least 50mm from any other impact and at least 50mm from the edge of the sample and repeat test strike procedure No.5 using a **P1/B** test knife at energy **E2**. Continue testing at **E2** until 10 fair strikes have been completed.

Note: One penetration not exceeding 30mm is permissible at **E2**.

Protection Level	Energy Level	Energy (joules)	Total Missile Mass (kg)	Velocity (m/s)
KR1 & SP1	E1	24	1.9	5.0
KR1	E2	36	1.9	6.2
KR2 & SP2	E1	33	1.9	5.9
KR2	E2	50	1.9	7.3
KR3 & SP3	E1	43	1.9	6.7
KR3	E2	65	1.9	8.3

FIGURE 8 Energy/Velocity Comparisons

7.6 Drop Test Procedure for Spike Protection Level (Only as an addition to knife protection)

The test sequence results in a total of 10 fair strikes (see Part 1 section 7.16 for definition of fair hit/strike against each different model of body armour and shall be carried out at one of the three threat levels shown in figure 7.

10 (ten) strikes at **E1** allowing for one penetration shall be carried out on one or more of the three panels used for the knife test. The protective packs will be removed from their carriers for the purpose of spike resistance testing.

For all strikes up to and including 36 joules, the dampers shall be renewed after a maximum of ten strikes. For strikes at or above 43 joules, the dampers shall be renewed after a maximum of five strikes.

7.7 Spike Test Strikes

The following test strikes shall be performed. A new spike shall be used for each successive test strike. To allow the damping discs to return to their original volume, a period of not less than 5 minutes shall elapse between each test strike.

7.7.1 Test Strike No. 1

Using a new **SP/B** test spike perform the test strike at energy **E1** (figure 7). The armour sample shall be fastened to the backing material beneath the drop apparatus, such that the spike impacts the strike face of the sample at 0° angle of incidence. Ensure that the spike impact position is at least 50mm from any other impact and at least 50mm from the edge of the armour sample. Velocity measuring equipment as described in section 5.4 shall be used to determine the impact velocity of the test knife. See also section 6.1 and figure 8.

If the impact fulfils the criteria of a fair hit, examine the body-side of the sample to determine whether the spike has “HELD” or “PENETRATED” and record it along with the actual impact energy, in the test report form. Reposition the armour onto the backing material and fasten the holding straps to secure it in place.

7.7.2 Test Strike No. 2 - 10

Select a new area of the armour sample so that the spike impact position is at least 50mm from any other impact, and at least 50mm from the edge of the armour sample, and repeat test strike procedure No.1 using a **SP/B** test spike at energy **E1**.

Note: One penetration of the spike (no depth limit) is permissible.

7.8 Additional Test Strikes at Specific Points of Weakness

Potential points of weakness, such as seams or other joints between materials used in the protective pack of the body armour, shall be subjected to at least one additional strike at energy level **E1**. These strikes shall be carried out at each seam or joint type, in an orientation most likely to show weaknesses in the joint or seam. Ensure that the knife and/or spike impact position is at least 50mm from any other impact and at least 50mm from the edge of the

sample. Additional armour samples may be necessary to meet this requirement.

The maximum knife penetration allowed for these strikes is 7mm. No penetration of the spike is permitted.

7.9 Additional Test Strikes on Female Armour

The strikes shall be performed with the knife or spike (or both) as specified in the relevant protection level. A minimum of two strikes shall be carried out on a separate front female panel as described below. All strikes shall be spaced at a distance of at least 50mm from one another.

The test strikes 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.

Strike 1: A 0° angle of incidence strike at **E1** striking within 5mm of the tip of the breast cup, at least 50mm from any other strike.

Strike 2: A 0° angle of incidence strike at **E1** shall be carried out at each line or area of weakness, i.e. a join between two sections of fabric (where a fabric is cut and stitched or folded) or a significant change in direction of the fabric fibres.

The maximum penetration allowed for the knife strikes on breast cups is 7mm. No penetration of the spike is permitted.

7.10 Additional 45° Angle Test Strikes

The following test strikes shall be performed at the discretion of the test house if overlapping plates have been used in the armour construction or where a construction may be compromised by an angled attack. A new knife/spike should be used for each successive test strike. To allow the damping discs to return to their original volume, a period of not less than 5 minutes shall elapse between each test strike.

Using the **P1/B** test knife or **SP/B** spike, perform a minimum of three test strikes for the knife test and three test strikes for the spike test as required at energy **E1** (figure 7). The armour shall be fastened to the backing material beneath the drop apparatus such that the knife impacts the strike face of armour sample at a 45° angle of incidence. Ensure that the knife impact position is at least 50mm from any other impact and at least 50mm from the edge of the armour sample. Velocity measuring equipment as described in section 5.4 shall be used to determine the impact velocity of the test knife/spike. See also section 6.1 and figure 8.

If the impact fulfils the criteria of a fair strike, measure any penetration of the knife and record it along with the impact energy in the test report form.

The maximum knife penetration allowed on angle strikes is 7mm. No penetration of the spike is permitted.

7.11 Measurement of Penetration (Knife Test Only)

Following a test strike, the armour should be carefully removed from the backing material and examined to ensure that the **P1/B** knife has not penetrated the rear face of the protective pack. If any penetration has occurred, the depth shall be measured as follows:

The penetration depth shall (where possible) be determined by measuring the length of the **P1B** knife protruding from the rear surface of the sample. In cases where the rear face of the armour sample is soft, the armour material may become compressed as the knife penetrates the backing material. When the armour is then removed from the backing material, the soft back face of the armour may return to its original thickness. This can lead to inaccuracies when measuring the penetration depth. Under these circumstances, the depth shall be measured using the appropriate method described in section 7.12 or 7.13.

7.12 Measurement of Penetration for Composite Backing Material (Knife Test Only)

Carefully measure the penetration of the knife through the rear face of the armour, if this is in excess of the maximum allowed no further measurements are required. If the measurement is within the tolerances it should be compared with the width of the cut in the wear face of the armour or if necessary the body side layer of protective element within the armour cover. By consulting the appropriate table in appendix A3, the depth of knife penetration can be determined.

7.13 Measurement of Penetration for Roma Plastilina® No 1 Backing Material (Knife Test Only)

Carefully insert a **P1/B** knife into the witness mark in the backing material. Once resistance is met, a mark should be made on the knife/spike to indicate the point of maximum penetration. The test knife can then be withdrawn and the penetration depth measured.

7.14 Measurement of Penetration for Composite Backing Material (Spike Test Only)

If the spike remains in the armour sample, carefully release the missile from the spike by undoing the holding screws in the spike holder and raising and securing the missile in the drop tube. Remove the armour sample (spike still embedded) from the backing material and examine the body-side of the sample for perforation.

The armour has failed the spike test if (on more than one strike):

- *Penetration of the spike causes a clearly visible hole through the wear face of the armour sample;*
- *Penetration evidence can be seen on the wear face of the armour sample.*

If the spike bounces out of the armour sample, examine the body-side of the armour sample for signs of perforation. Holding the 140g/m² Polyart®

witness paper (if used) up to a good light, examine for any sign of perforation (not tearing) that may have been caused by the spike.

The armour has failed the spike test if (on more than one strike):

- *Light can clearly be seen through the perforation;*
- *Penetration evidence can be seen on the wear face of the armour sample.*

7.15 Measurement of Penetration for Plastilina® Backing Material (Spike Test Only)

If the spike remains in the armour sample, carefully release the missile from the spike by undoing the holding screws in the spike holder and raising and securing the missile in the drop tube. Remove the armour sample (spike still embedded) from the backing material and examine the body-side of the sample for perforation.

The armour has failed the spike test if (on more than one strike)::

Penetration of the spike causes a clearly visible hole through the wear face of the armour sample;

Penetration evidence can be seen on the wear face of the armour sample or on the surface of the Plastilina® No 1.

If the spike bounces out of the armour sample, examine the body-side of the armour sample for signs of perforation.

The armour has failed the spike test if (on more than one strike):

Penetration evidence can be seen on the wear face of the armour sample.

8 Manufacturers Quality Testing (MQT)

8.1 MQT 1 and MQT 2

For the purpose of MQT1 knife and spike testing the armour samples shall be removed from carriers. For the purpose of MQT 2 in-service testing, the armour may be tested in the carriers supplied. Two medium or large size panels are required for these tests.

8.2 MQT 1 and MQT 2 Knife Test Protocol

A total of 10 (ten) 0° strikes at **E1** shall be carried out 5 (five strikes on each panel). The allowed maximum penetration is 7mm. However, one strike not exceeding 9mm shall be permitted. Any strike where the energy is less than E1 shall be discounted unless penetration exceeding the allowed limit occurs. Bust, overlap and angled shots two strikes each (if considered necessary) shall be in addition to the 10 strikes. No penetrations exceeding 7mm is permitted for the additional knife strikes

A further 10 (ten), 0° strikes at **E2** shall be carried out (five strikes on each panel). The allowed maximum penetration is 20mm. However, one strike not exceeding 30mm shall be permitted.

Note:

The penetration allowance is a stand-alone allowance per 10 shot sampling. It is not cumulative e.g. a 10 shot sampling with no more than 7mm penetration cannot be carried forward to the next 10 shot sampling to give an allowance of two penetrations

8.3 MQT 1 and MQT 2 Spike Test Protocol

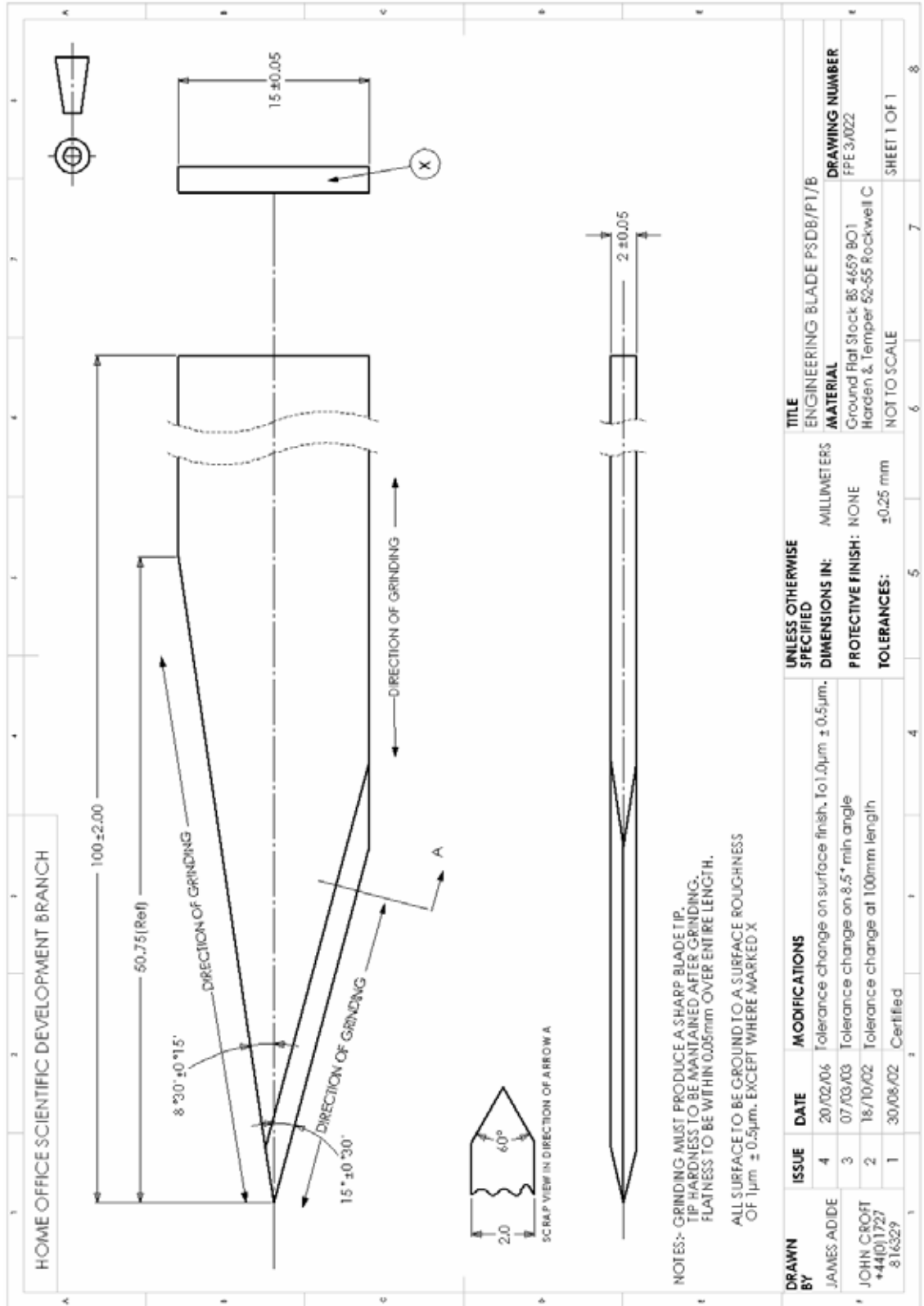
10 (ten) strikes at **E1** allowing for one penetration shall be carried out on the two panels (five strikes on each panel) used for the knife test.

Bust, overlap and angled shots two strikes each (if considered necessary) shall be in addition to the 10 strikes. No penetrations are permitted for the additional spike strikes

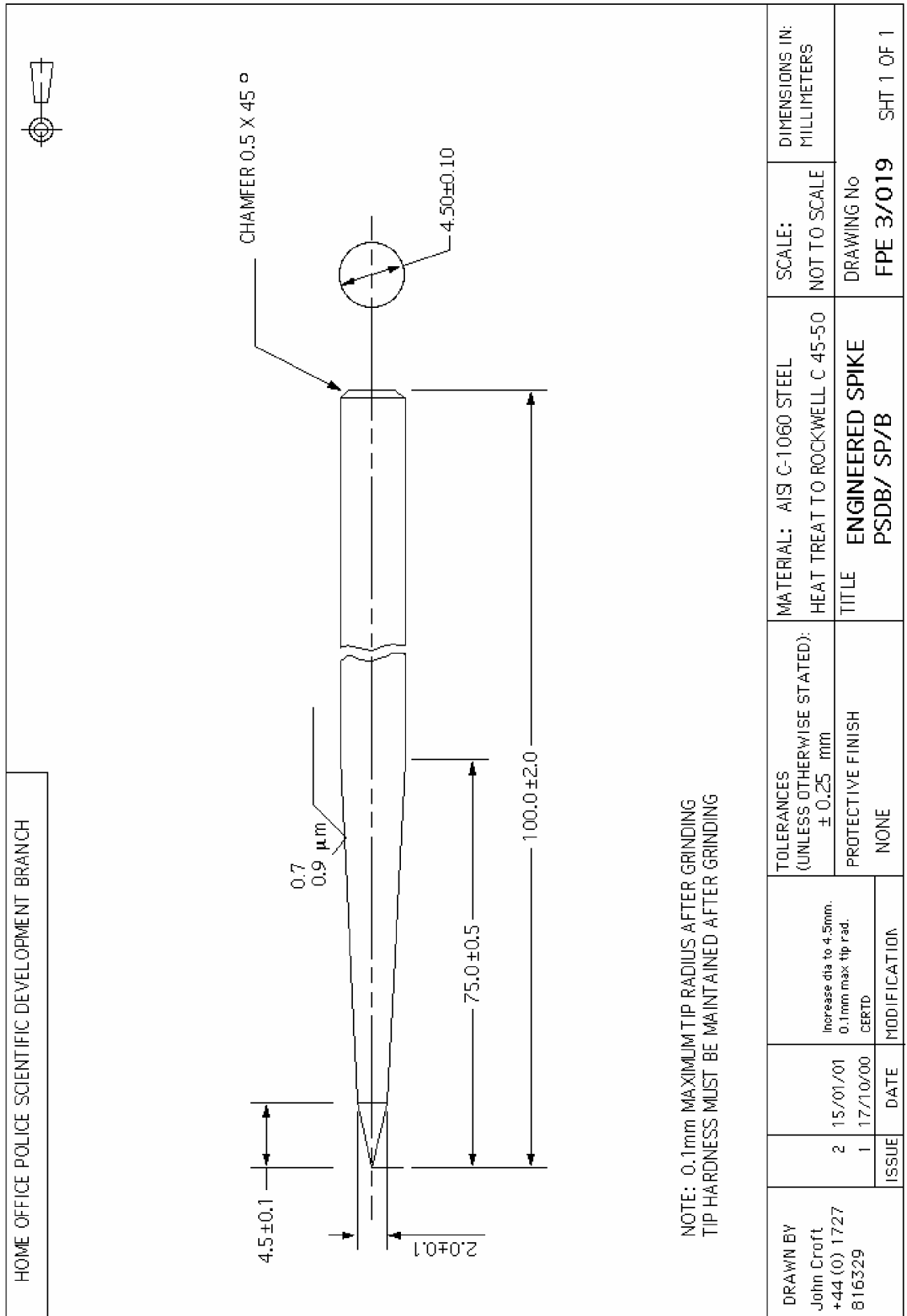
The penetration allowance is not cumulative.

Appendix A:

A.1 HOSDB P1/B Test Knife



A.2 HOSDB SP/B Test Spike



A.3 Conversion Chart for P1/B Knife Penetration Depths from Witness Paper Cut Length

Cut length (mm)	Depth (mm)	Cut length (mm)	Depth (mm)	Cut length (mm)	Depth (mm)	Cut length (mm)	Depth (mm)
0.42	1	5.91	14	11.39	27	13.66	40
0.84	2	6.33	15	11.81	28	13.81	41
1.27	3	6.75	16	11.96	29	13.96	42
1.69	4	7.17	17	12.12	30	14.12	43
2.11	5	7.59	18	12.27	31	14.27	44
2.53	6	8.02	19	12.43	32	14.43	45
2.95	7	8.44	20	12.58	33	14.58	46
3.37	8	8.86	21	12.73	34	14.73	47
3.80	9	9.28	22	12.89	35	14.89	48
4.22	10	9.70	23	13.04	36	15.00	49
4.64	11	10.12	24	13.19	37		
5.06	12	10.55	25	13.35	38		
5.48	13	10.97	26	13.50	39		

Note: SP spike penetration depth is not measured

A.4 Conversion Chart for Modified Rockwell values to CATRA Force Values

HRC Value	CATRA Value (N)	HRC Value	CATRA Value (N)	HRC Value	CATRA Value (N)	HRC Value	CATRA Value (N)
-100	3.47	-111	2.69	-122	1.92	-133	1.15
-101	3.40	-112	2.62	-123	1.85	-134	1.08
-102	3.33	-113	2.55	-124	1.78	-135	1.01
-103	3.26	-114	2.48	-125	1.71	-136	0.94
-104	3.19	-115	2.41	-126	1.64	-137	0.87
-105	3.12	-116	2.34	-127	1.57	-138	0.80
-106	3.05	-117	2.27	-128	1.50	-139	0.73
-107	2.98	-118	2.20	-129	1.43	-140	0.66
-108	2.90	-119	2.13	-130	1.36		
-109	2.84	-120	2.06	-131	1.29		
-110	2.76	-121	2.00	-132	1.22		

Using $y=14.235x-149.38$

A.5 Operation and Calibration of Mitutoyo ATk F1000 Hardness Tester When Used as a Sharpness Tester

- Complete stages 1 - 4 on page 4 of the Mitutoyo Instruction Manual.
- *Do not* attach poise hanger and weight assembly (26). Instead, screw the special 10g threaded weight onto the end of the loading level (27).
- Set minor load selector ring (13) to ‘S’.
- Place suitable calibrated laboratory scales with a flat surface (range 0 - 10kg) on anvil (17) and set to zero.
- Insert special knife holder (without knife) into indenter (15).
- Press the mode button 5 times. You should now see *TEST MODE* flashing at the bottom of the display.
- Press ‘SEL’ once and check that the display reads ‘SPER 100’.
- Raise the shaft (19) using handle (20) until the display reads ‘630’, and the scales $3\text{kg} \pm 50\text{g}$. If the display does not give a reading between these tolerances, contact the supplier of the machine as the minor load is non user adjustable.
- Press the ‘ τ ’ button to apply the major load, the display on the scales should now read $8\text{kg} \pm 80\text{g}$.

Note: The special 10g weight may give a higher than 8kg reading. If so, material should be removed from the weight until $8\text{kg} \pm 80\text{g}$ is achieved.

- Press the ‘ σ ’ button.
- Lower table.
- When ready to begin testing, the knife or spike to be evaluated must be wiped using a clean cotton cloth and a suitable degreasing agent. This is to ensure that all traces of lubricant are removed.
- The knife should be mounted in the special holder, and then slotted into position on the hardness tester.
- The sharpness can now be tested by applying the load of the knife or spike tip to a small sample block of 99.997% pure aluminium.
- When put under load, the reading should be between -50 and -150 on the Mitutoyo scale. This scale can more usefully be expressed in terms of the indentation depth produced by the major load application.

HRC	Depth (mm)	HRC	Depth (mm)	HRC	Depth (mm)
-160	0.52	-130	0.46	-100	0.40
-150	0.50	-120	0.44	-90	0.38
-140	0.48	-110	0.42	-80	0.36

Conversion of HRC values to indentation depths (mm)

Appendix B:

B.1 Packs and Components of the Composite Backing Material

The following suppliers have agreed to supply the complete composite backing material in individual sealed packs of size 400mm x333mm quoting reference: PSDB/BM/4/99.

Limpet Safety Products Unit 27, Victoria Industrial Park Victoria Road Dartford Kent DA1 5AJ Tel: +44 (0) 208 8598877	Beldam Burgmann Neachells Lane Wednesfield Wolverhampton West Midlands WV11 3QG Tel: +44 (0) 1902 307711
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Alternatively the component materials contained within the pack can be purchased separately from the above suppliers using the following codes:

Component Materials	Code Number
Neoprene 6mm thick	PSDB/BM/1/99
Plastazote® 30mm thick 33kgm ⁻³	PSDB/BM/2/99
Rubber BS2494D-6mm (nominal) thickness	PSDB/BM/3/99

B.2 Component Parts of the Composite Backing Material

The following manufacturers can supply individual components of the composite backing material in sheet or roll form:

Manufacturer Details	Component
Rubber Astic Vulcan Road Bilston West Midlands WV14 7HT Tel: +44 (0) 1902 407150	1) 6mm thick plainfirm density expanded neoprene to reference RA 110 2) Plain black cell/cell 30mm thick 33kgm ⁻³ expanded polyethylene closed cell Plastazote® foam to reference RA12
Wm. Johnston & Co. 39 Mauchline Street Glasgow G5 8HQ Tel: +44 (0) 1414 201131	1) Natural rubber to BS 2494 type D nominal 6mm thick

B.3 Damping Disc Material

The material used for the damping discs is identical to the thick 33kgm⁻³ expanded polyethylene closed cell Plastazote foam used in the backing material. Suppliers are listed at Appendix B1 and B2.

B.4 HOSDB Engineered Knife (P1B) and Spike (SP)

The HOSDB engineered knife and spike were designed so that they could be manufactured by any competent engineering workshops to the drawings supplied with this standard. The company currently supplying test knives and spikes to HOSDB approved test houses is listed below.

High Speed and Carbide Ltd
Clough Bank, Off Edmund Road
Sheffield S2 4EL
Tel: +44 (0) 1142 796197

B.5 99.997% Pure Aluminium for Knife Sharpness Test

The aluminium is supplied as an ingot measuring 38mm x 38mm x 130mm (1.5in x 1.5in x 5in). For the test, a 38mm x 38mm x 5mm block should be cut from the ingot. Both faces of the block should then be machined (not ground) smooth.

The ingots can be purchased from:

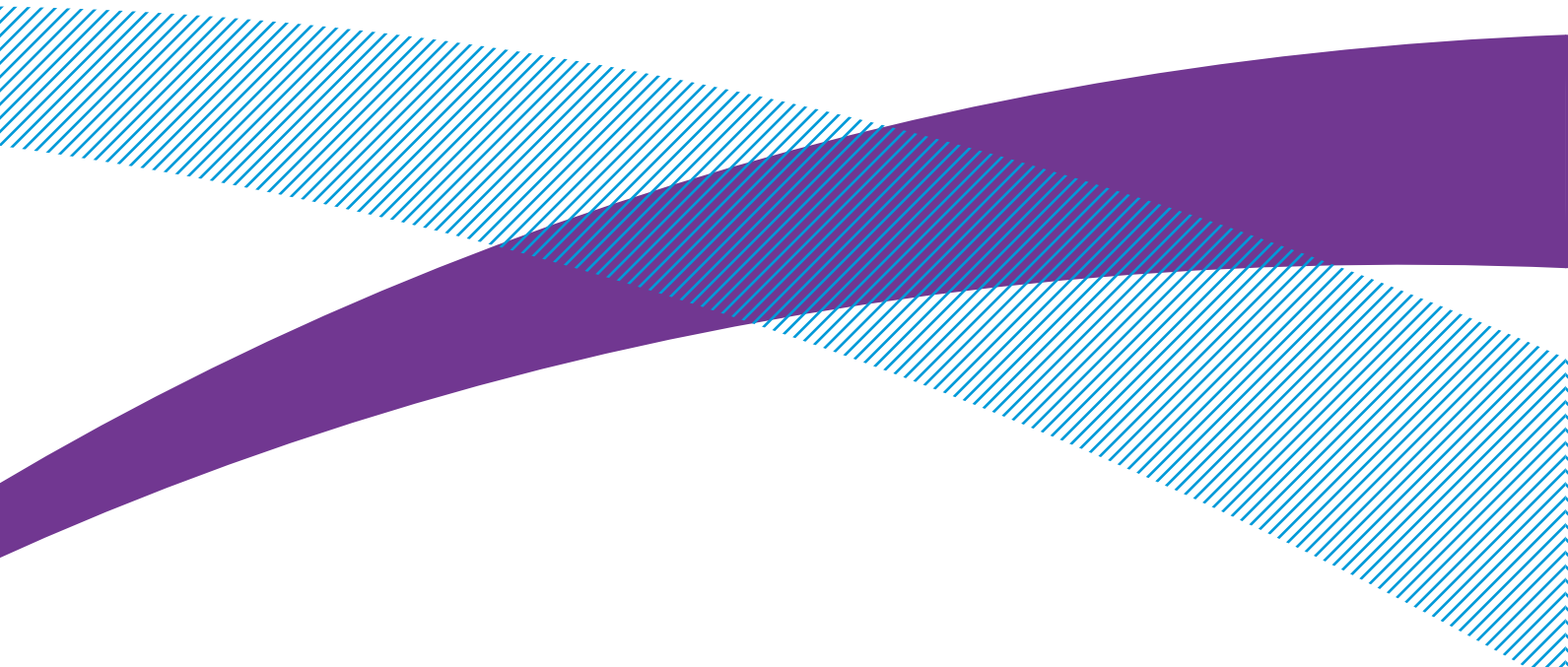
Sigma Aldrich Chemical Company The Old Brickyard, New Road Gillingham Dorset SP8 4XT Tel: +44 (0) 1747 822211	Alrich Chemical Company P.O. Box 355, Milwaukee Wisconsin 53201 USA Tel: 001 (414) 273-3850
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B.6 140g/m² Polyart[®] Paper

This paper can be purchased from:	Robert Horne Paper 7a St Paul's Court High Street, Stony Stratford Milton Keynes, MK11 1LJ Tel: +44 (0) 1908 560988
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B.7 1.043kg Spherical Steel Ball

<p>The 1.043kg, 63.5mm spherical steel ball grade 100 can be purchased from:</p>	<p>Salem Speciality Ball Co, Inc, PO Box 145 West Simsbury, CT 06092. USA.</p>
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