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# National Institute of Justice

## Law Enforcement and Corrections Standards and Testing Program

### **Stab Resistance of Personal Body Armor**

**NIJ Standard–0115.00**

## ABOUT THE LAW ENFORCEMENT AND CORRECTIONS STANDARDS AND TESTING PROGRAM

The Law Enforcement and Corrections Standards and Testing Program is sponsored by the Office of Science and Technology of the National Institute of Justice (NIJ), U.S. Department of Justice. The program responds to the mandate of the Justice System Improvement Act of 1979, which directed NIJ to encourage research and development to improve the criminal justice system and to disseminate the results to Federal, State, and local agencies.

The Law Enforcement and Corrections Standards and Testing Program is an applied research effort that determines the technological needs of justice system agencies, sets minimum performance standards for specific devices, tests commercially available equipment against those standards, and disseminates the standards and the test results to criminal justice agencies nationally and internationally.

The program operates through:

The *Law Enforcement and Corrections Technology Advisory Council (LECTAC)*, consisting of nationally recognized criminal justice practitioners from Federal, State, and local agencies, which assesses technological needs and sets priorities for research programs and items to be evaluated and tested.

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# **Stab Resistance of Personal Body Armor**

## **NIJ Standard–0115.00**

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## FOREWORD

This document, NIJ Standard–0115.00, Stab Resistance of Personal Body Armor, is an equipment performance standard developed by the Office of Law Enforcement Standards at the National Institute of Standards and Technology in collaboration with the Police Scientific Development Branch (PSDB) in the United Kingdom (UK). It is produced as part of the Law Enforcement and Corrections Standards and Testing Program of the National Institute of Justice. A brief description of the program appears on the inside front cover.

This standard specifies the minimum performance requirements for body armor that is resistant to attack by typical pointed and edged weapons; and it describes the test methodology to be used for this assessment. This is the first true United States (U.S.) standard dealing with the threat posed by pointed and edged weapons. This standard is modeled around the 1999 version of the PSDB Stab Resistant Body Armor Test Procedure, and benefits from a number of improvements that were made to that standard. Those improvements, resulting from a large program of work conducted by PSDB, the Royal Military College of Science, and Strathclyde University, are aimed at increasing the realism and reproducibility of the test. The standard provides improved choices to police purchasing units and wearers through the introduction of a number of levels of protection.

The primary focus of the research program dealt with the threat from readily available knives that may be purchased from sports equipment retailers. These weapons are typically of high quality and feature very sharp machine-ground cutting edges and fine points. The threats from ice picks and lower quality, prison-made knives and shivs were not addressed to the same extent, as these threats are much more difficult to quantify. Research addressing these threats will continue, even after the initial publication of this standard, and any improvements will be incorporated in future revisions. Until then, a preliminary version of a spike-threat test is proposed. It is based on the same test methodology described for the knife blades, but the threat weapon is a modified ice pick commonly used in the “California Ice Pick” test.

Because this NIJ standard is designed as a procurement aid, it provides precise and detailed test methods. For those who seek general guidance concerning the selection and application of law enforcement and corrections equipment, the National Law Enforcement and Corrections Technology Center (NLECTC), described inside the front cover of this standard, can provide assistance.

NIJ standards are subject to continuing research, development, testing, change, and review. This standard and its successors will be reevaluated periodically. These reviews will be based upon data collected through the Compliance Program and its certified test laboratories, as well as from comments from the user and manufacturing communities. Technical comments and recommended revisions are welcome. Please send all written comments and suggestions to the Director, Office of Science and Technology, National Institute of Justice, U.S. Department of Justice, 810 7<sup>th</sup> St., NW, Washington, DC 20531.

Before citing this or any other NIJ standard in a contract document, users should verify that the most recent edition of the standard is used. Write to the Director, Office of Law Enforcement Standards, National Institute of Standards and Technology, 100 Bureau Drive, Stop 8102, Gaithersburg, MD 20899-8102

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## ACKNOWLEDGMENTS

This standard was developed through a collaborative effort between the United States and the United Kingdom. The mechanism that allowed this collaboration to take place was secured by a bilateral agreement established between the Technical Support Working Group (TSWG) in the U.S., and the Police Scientific Development Branch in the UK. Significant contributions were made by Martin Pettit and John Croft of the Police Scientific Development Branch, Home Office Science and Technology Group, Hertfordshire, UK. They and their technical team performed much of the research utilized in the development of this standard. Timothy Thomas of the United States Secret Service, Department of the Treasury, provided coordination of the technical and administrative effort in the United States.

This standard has been reviewed and approved by the Weapons and Protective Systems Subcommittee and the Executive Committee of the Law Enforcement and Corrections Technology Advisory Council (LECTAC) and by the National Armor Advisory Board (NAAB), comprised of representatives from:

Accordis, Inc.  
Honeywell, Inc.  
American Body Armor & Equipment Co.  
Arlington County, Virginia, Sheriff's Dept.  
California Department of Corrections  
Chesterfield County, Virginia, Police Dept.  
DHB Armor Group  
DuPont Advanced Fiber Systems  
Federal Bureau of Investigation  
Fraternal Order of Police  
Guardian Technologies, International  
Hexcel Schwebel High Performance Fibers  
International Association of Chiefs of Police  
International Brotherhood of Police Officers  
National Association of Police Organizations  
Office of Community Oriented Policing Services  
Protective Apparel Corporation of America  
Safariland Ltd., Inc.  
U.S. Armor Corporation  
U.S. Secret Service, TSD/P&D

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## COMMONLY USED SYMBOLS AND ABBREVIATIONS

A	ampere	H	henry	nm	nanometer
AC	alternating current	H	hour	No.	number
AM	amplitude modulation	Hf	high frequency	o.d.	outside diameter
Cd	candela	Hz	hertz	$\Omega$	ohm
Cm	centimeter	i.d.	inside diameter	p.	page
CP	chemically pure	In	inch	Pa	pascal
c/s	cycle per second	IR	infrared	pe	probable error
d	day	J	joule	pp.	pages
dB	decibel	L	lambert	ppm	parts per million
DC	direct current	L	liter	qt	quart
$^{\circ}$ C	degree Celsius	Lb	pound	rad	radian
$^{\circ}$ F	degree Fahrenheit	Lbf	pound-force	rf	radio frequency
diam	diameter	lbf·in	Pound-force inch	rh	relative humidity
emf	electromotive force	Lm	Lumen	s	second
eq	equation	Ln	Logarithm (base e)	SD	standard deviation
F	farad	Log	Logarithm (base 10)	sec.	section
fc	footcandle	M	Molar	SWR	standing wave ratio
fig.	figure	M	Meter	uhf	ultrahigh frequency
FM	frequency modulation	min.	Minute	UV	ultraviolet
ft	foot	mm	Millimeter	V	volt
ft/s	foot per second	mph	Mile per hour	vhf	very high frequency
g	acceleration	m/s	Meter per second	W	watt
g	gram	N	Newton	$\lambda$	wavelength
gr	grain	N·m	Newton meter	wt	weight

area=unit<sup>2</sup> (e.g., ft<sup>2</sup>, in<sup>2</sup>, etc.); volume=unit<sup>3</sup> (e.g., ft<sup>3</sup>, m<sup>3</sup>, etc.)

### PREFIXES

d	deci (10 <sup>-1</sup> )	da	deka (10)
c	centi (10 <sup>-2</sup> )	h	hecto (10 <sup>2</sup> )
m	milli (10 <sup>-3</sup> )	k	kilo (10 <sup>3</sup> )
$\mu$	micro (10 <sup>-6</sup> )	M	mega (10 <sup>6</sup> )
n	nano (10 <sup>-9</sup> )	G	giga (10 <sup>9</sup> )
p	pico (10 <sup>-12</sup> )	T	tera (10 <sup>12</sup> )

### COMMON CONVERSIONS

(See ASTM E380)

0.30480 m = 1 ft	4.448222 N = 1 lbf
2.54 cm = 1 in	1.355818 J = 1 ft·lbf
0.4535924 kg = 1 lb	0.1129848 N·m = 1 lbf·in
0.06479891 g = 1 gr	14.59390 N/m = 1 lbf/ft
0.9463529 L = 1 qt	6894.757 Pa = 1 lbf/in <sup>2</sup>
3600000 J = 1 kW·hr	1.609344 km/h = 1 mph

Temperature:  $T_{\text{C}} = (T_{\text{F}} - 32) \times 5/9$

Temperature:  $T_{\text{F}} = (T_{\text{C}} \times 9/5) + 32$

# NIJ STANDARD FOR STAB RESISTANCE OF PERSONAL BODY ARMOR

## 1. PURPOSE AND SCOPE

The purpose of this standard is to establish minimum performance requirements and methods of test for the stab resistance of personal body armor intended to protect the torso against slash and stab threats. This standard is based on technical work performed by many organizations: in the United Kingdom by the Police Scientific Development Branch, and in the United States by the National Institute of Standards and Technology and its subcontractors.

The scope of the standard is limited to stab resistance only. The standard does not address ballistic threats, as those are covered by NIJ Standard–0101.04, *Ballistic Resistance of Personal Body Armor*. The standard does not directly address slash threats; however, testing has shown that stab threats are by far the more difficult to defeat, and that body armor capable of defeating stab threats will perform satisfactorily against slash threats.

The threat posed by a knife depends, among other things, on its sharpness, pointedness, style, handle and blade design, attacking angle, the physical condition of the attacker, and the skill of the attacker. Because these parameters can vary widely from one situation to the next, armors that will defeat a standard test blade may not defeat other knife designs under similar conditions or the same knife design if other attacking parameters are changed. The threats treated in this standard are from hand-delivered impacts with sharp-edged and/or pointed instruments whose points or tips lie near the centerline of the clenched fist holding the weapon. Weapons that are not wielded in this fashion, such as axes, hatchets, claw hammers, adzes, and the like, where the threatening edge of the weapon does not lie near the line of action of the fist, are not addressed by this standard. While stab resistant armor could provide some modest level of protection from these threats, the impact velocities, energies, and contact surface characteristics of these weapons are much different, and in most cases more severe, than what was considered in this standard.

## 2. NIJ STAB RESISTANT BODY ARMOR CLASSIFICATION

Personal body armors covered by this standard are classified into one of two distinct **protection classes** depending upon the type of threat environment. Within each threat protection class, the armor is further classified into one of three **protection levels**. The levels of protection indicate the stab energy the vest is expected to satisfactorily handle.

The classification of an armor panel that provides two or more levels of protection at different locations on the panel shall be that of the minimum protection provided at any location on the panel. Level 1 armor is low-level protection armor suitable for extended wear and is

generally concealable (covert). Level 2 armor is a general duty garment suitable for extended wear. It may be either overt or covert. Level 3 is high level protection armor suitable for wear in high risk situations. It is usually overt.

A stab resistant body armor system should afford protection against injury from penetration by knives, edged weapons, and sharp-pointed weapons while ensuring that the movement of the wearer is not unduly restricted. The protected area ensures coverage of the vital organs; in particular, the heart, liver, spine, kidneys, and spleen. The protection required by the wearer should be determined from the specific threats they are likely to encounter. Departments must carefully consider their requirements for comfort, concealability, duration of wearing armor, projected threat levels, and climate to decide on the best type and style of armor to satisfy their needs.

## **2.1 Protection Classes**

There are two protection classes defined in this standard. One is intended to deal with threats that might be expected on “the street” from high quality, commercially machined edged knife blades. This class is referred to as the “Edged Blade” class.

The other protection class is intended to deal with threats that might be expected in a corrections environment. Lower quality knife blades and spike style weapons that have been improvised from other materials typically characterize these threats. This class is referred to as the “Spike” class.

## **2.2 Protection Levels**

The three levels of protection presented in this standard were derived from a 1997–1999 PSDB program where the frequency distribution of the energy that can be delivered by a male population using several stabbing techniques was characterized. The lowest energy level corresponds to the 85<sup>th</sup> percentile, the next energy level corresponds to the 90<sup>th</sup> percentile, and the highest energy level corresponds to the 96<sup>th</sup> percentile.

For any given protection level, the test protocol requires the knife blade or spike to impact the armor test sample at two distinct energy levels. The first energy level, called “E1,” corresponds to the percentiles described above. At this condition, a maximum blade or spike penetration of 7 mm (0.28 in) is allowable. The penetration limit was determined through research indicating that internal injuries to organs would be extremely unlikely at 7 mm (0.28 in) of penetration. The test protocol then requires an overtest condition where the knife blade or spike kinetic energy is increased by 50 %. At this higher energy condition, called “E2,” a maximum blade or spike penetration of 20 mm (0.79 in) is allowable. This overtest is required to ensure that there is an adequate margin of safety in the armor design.

Table 1 describes the three protection levels for stab resistant body armor.

*Table 1. Stab resistant protection level strike energies*

Protection Level	“E1” Strike Energy		“E2” Overtest Strike Energy	
	J	ft· lbf	J	ft· lbf
1	$24 \pm 0.50$	$17.7 \pm 0.36$	$36 \pm 0.60$	$26.6 \pm 0.44$
2	$33 \pm 0.60$	$24.3 \pm 0.44$	$50 \pm 0.70$	$36.9 \pm 0.51$
3	$43 \pm 0.60$	$31.7 \pm 0.44$	$65 \pm 0.80$	$47.9 \pm 0.59$

**2.3 Level 1**

This armor protects against low energy threats with a strike energy of 24 J (17.7 ft· lbf). The overttest condition for this level is 36 J (26.6 ft· lbf).

**2.4 Level 2**

This armor protects against medium energy threats with a strike energy of 33 J (24.3 ft· lbf). The overttest condition for this level is 50 J (36.9 ft· lbf).

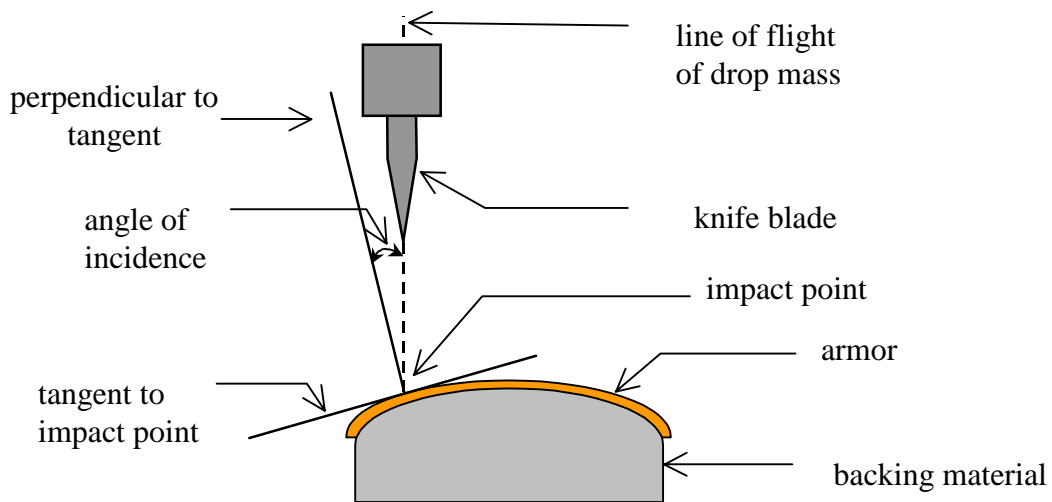
**2.5 Level 3**

This armor protects against high energy threats with a strike energy of 43 J (31.7 ft· lbf). The overttest condition for this level is 65 J (47.9 ft· lbf).

**3. DEFINITIONS**

**3.1 Angle of Incidence**

The angle between the line of flight of the drop mass and the perpendicular to the plane tangent to the point of impact. This is also known as the angle of obliquity (see fig. 1).



*Figure 1. Schematic of armor and knife arrangement*

### 3.2 Armor Carrier

A component of the armor sample or armor panel whose primary purpose is to retain the stab resistant panel and provide a means of supporting and securing the armor garment to the user. The carrier is not generally stab resistant.

### 3.3 Armor Panel

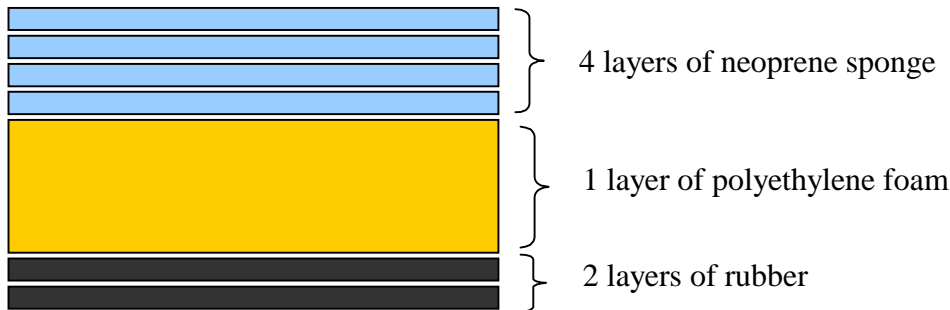
The portion of an armor sample that generally consists of an external carrier and its internal stab protective component(s) (e.g., the front and back panels).

### 3.4 Armor Sample

One complete armor garment consisting of a single wraparound style jacket, or a set of front and back armor panels.

### 3.5 Backing Material

A slab of material upon which the armor is placed for test. The slab consists of multiple layers of material: the strike face of four layers of neoprene sponge, a single layer of closed-cell polyethylene foam, and two layers of rubber. Section 5.5.6 describes the backing materials in greater detail. Figure 2 depicts the composite structure. Appendix D contains a list of possible suppliers.



*Figure 2. Composite backing material*

### 3.6 Certification of Compliance

Manufacturer's affidavit (certification) that a production unit of body armor complies with all of the requirements of this standard (sec. 4) for the labeled **protection class** and **protection level** (sec. 2).

### 3.7 Compliance Test Group

A group of armor samples submitted to the Compliance Test Program for testing according to this standard.

### **3.8 Drop Mass**

The apparatus that drops freely under its own weight to strike the armor panel at a specified energy. The drop mass consists of an engineered knife blade or spike, the clamping device to hold the knife blade or spike in place, and the nylon sabot designed to ensure that the knife blade or spike falls vertically within the drop tube apparatus. Operationally, the drop mass behaves as a dual-mass system coupled with a damping spring element so that the impact energy is delivered over the correct time period to more accurately reflect the action of a human hand stab.

### **3.9 Edge of Armor**

The extreme edge of the protected region of a body armor, defined by the edge of the protective panels that are contained within the armor's carrier.

### **3.10 Engineered Knife Blades**

The two engineered knife blades in this standard are designed to represent two types of edged weapons used in assaults. One represents a typical small knife and is referred to as the **P1** knife blade in this standard. The other knife blade represents the performance of larger commando-style blades or larger kitchen knives and is referred to as the **S1** knife blade in this standard. Both knife blades feature a pointed tip and a stiff backbone. The **P1** blade is thinner and has one cutting edge, while the **S1** blade is thicker and has two cutting edges. Detailed engineering drawings are given in appendix A.

### **3.11 Engineered Spike**

A spike-style weapon resembling an ice pick designed to represent a class of pointed weapons used primarily in assaults in corrections environments. There is one spike threat specified in this standard. It is based on the design commonly used in the "California Ice Pick" test. A detailed engineering drawing is provided in appendix A.

### **3.12 Fair Hit or Fair Strike**

A strike that meets all of the following conditions:

- (a) Has a strike energy that is within the specifications given in table 1 for the intended level of protection.
- (b) Strikes no closer than 51 mm (2.0 in) to the edge of the armor.
- (c) Strikes no closer than 51 mm (2.0 in) to the edge of the backing material.
- (d) Strikes no closer than 51 mm (2.0 in) to any prior strike.
- (e) Strikes the armor at an angle of incidence within  $\pm 5^\circ$  from the intended angle of incidence.

### **3.13 Impact Point**

The location on the armor panel where the test knife blade or spike is intended to strike.

### **3.14 Model**

A manufacturer's designation (name, number, or other description) that serves to uniquely identify a specific configuration of body armor based upon the details of the protective panel construction (i.e., number of layers of one or more types of stab resistant material assembled in a specific manner, or the manner in which the armor is held in place on the torso).

NIJ verifies the stab resistance of a *model* based on stab resistance testing of samples of the model in accordance with this standard. As an example, differences in stitching (e.g., box stitch versus quilt stitch) in otherwise identical armors, would cause them to be two different models. If a model of armor fails compliance testing, the manufacturer may never resubmit any stab resistant armor under that failed model designation.

Body armor designs that differ in any way to better fit the male and female torsos shall carry separate model designations. Female vests should be clearly marked "Female" in the model or style designation.

### **3.15 Penetration**

Perforation of an armor test sample by a test knife blade or spike, by a fragment of the knife blade or spike, or by portions of the armor itself, as evidenced by the presence of the knife blade or spike, the armor, or fragments of either, in the backing material, or of a hole in the first layer of neoprene backing material, or of a cut or tear in the witness paper.

### **3.16 Penetration Depth**

The length of the blade or spike that protrudes from the rear surface of the test sample.

### **3.17 Protection Class**

The protection class provides a general description of the types of threats for which a body armor model is designed to defeat. This standard describes two protection classes.

As described in section 2.1, the "Edged Blade" protection class is intended to deal with threats that might be expected on "the street" from high quality, commercially-machined edged knife blades. The "Spike" protection class is intended to deal with threats that would typically be encountered in a corrections environment.

### **3.18 Protection Level**

The protection level provides a convenient measure for describing the severity of a stab for which the armor is designed to defeat. The protection levels are described as either "1," "2,"



or “3” (sec. 2.2, table 1). These levels are defined by an energy scale, with “1” describing low energy threats, “2” medium energy threats, and “3” high energy threats.

### **3.19 Stab Resistant Panel**

The protective component of an armor sample or panel, primarily consisting of stab resistant materials, usually enclosed in a nonremovable cover. The stab resistant panel is normally retained within the armor sample or panel by a separate fabric carrier and may be removable from the carrier.

### **3.20 Strike Energy**

The calculated kinetic energy of the drop mass when the tip of the knife blade or spike reaches a position just short of contacting the armor.

### **3.21 Strike Face**

The surface of an armor that is designed to face the stab threat.

### **3.22 Velocity Measurement Zone**

A zone located above the impact point, within which the velocity of the drop mass is measured. The length of the velocity measurement zone is less than 51 mm (2.0 in). When the drop mass crosses the lower edge of the velocity measurement zone, the tip of the knife blade or spike will be positioned between 0 mm (0.0 in) and 25 mm (1.0 in) above the impact point.

### **3.23 Wear Face**

The surface of an armor that is designed to be worn towards the body.

### **3.24 Witness Paper**

A single layer of Polyart™ paper<sup>1</sup> that is placed between the armor and the top layer of the composite backing material to provide one possible means of measuring penetration for the knife blade stab tests. If complete penetration of the armor occurs, the witness paper will be cut or pierced. The dimensions of the cut can be used to determine the depth of penetration. The witness paper is not used for spike tests. Appendix D identifies the manufacturer of this item.

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<sup>1</sup> The use of brand names in this standard does not constitute endorsement by the U.S. Department of Justice; National Institute of Justice; U.S. Department of Commerce; National Institute of Standards and Technology; Office of Law Enforcement Standards; or any other agency of the United States Federal Government, nor does it imply that the product is best suited for its intended applications.

## 4. REQUIREMENTS

### 4.1 Acceptance Criteria

An armor model satisfies the requirements of this standard if the manufacturer meets the Traceability (sec. 4.3) requirement; all armor samples meet the Workmanship (sec. 4.5) and Labeling (sec. 4.4) requirements; and the randomly chosen test samples meet the Stab Resistance (sec. 4.6) requirements of this standard.

### 4.2 Submission of Armor Samples for Testing

A Compliance Test Group shall consist of three armor samples, sized to fit a 117 cm (46.1 in) to 122 cm (48.0 in) chest circumference for males, or a 107 cm (42.1 in) to 112 cm (44.0 in) chest circumference for females. Two of these armors shall be selected at random by NLECTC or the NIJ-certified test laboratory and used for stab resistance testing. Unused armors shall be returned to the manufacturer.

### 4.3 Traceability

Manufacturers shall submit along with their samples, or have on file with NIJ's Compliance Program Office, documentation of the method(s) they use to ensure configuration control, uniformity of production methods, and materials traceability.

### 4.4 Labeling

When examined as described in section 5.3, each set of stab resistant armor shall be clearly and durably marked (labeled) in a readable type size with the information below.

#### 4.4.1 Labeling of Stab Resistant Protective Panels

4.4.1.1 Every stab resistant panel shall have a label. The label shall be permanently attached to the exterior surface of the panel. Figure 3 illustrates a *sample* label containing the required information for a hypothetical model that was tested and found to comply with the requirements of the standard for protection level 2 of the “Edged Blade” protection class and protection level 3 of the “Spike” protection class. The label shall contain the following information, written in English:

- (a) Name, logo or other identification of the manufacturer, and contact information for the manufacturer, including address and telephone number.
- (b) A colored symbol described in section 4.4.1.3
- (c) Size.
- (d) Lot number.
- (e) Date of manufacture.
- (f) Date of issue (to be filled in by user).
- (g) A model designation that uniquely identifies the panel for purchasing purposes.  
Female armor shall be clearly marked “Female.”

- (h) Strike face or wear face — the surface of the garment that is to face the threat or to be worn next to the body must be identified.
- (i) Serial number.
- (j) Care instructions for the material in accordance with 16 CFR 423.<sup>2</sup>
- (k) For armor that is not designed or intended to protect the wearer from ballistic threats, a warning in type at least twice the size of the rest of the type on the label (exclusive of the information required in “a” above) stating that the armor is not intended to protect the wearer from ballistic threats. (Note: printing color changes are acceptable but cannot be substituted for the type size requirement herein.)
- (l) Similarly, if the stab resistant protective panel is constructed from more than one insert, each separate insert shall also clearly display information to ensure that it is inserted correctly. The main stab resistant insert information panel shall include a warning describing how many inserts are required to meet the stated protection level.
- (m) For armor that has been successfully tested for compliance to this standard through NIJ’s voluntary compliance testing program at an NIJ-approved testing facility, the following statement shall be included on the label:



*“The Manufacturer certifies that this model of armor has been tested through NLECTC and has been found to comply with NIJ Standard–0115.00 for the (insert appropriate class designation) PROTECTION CLASS at PROTECTION LEVEL (insert appropriate level designation).”*

**4.4.1.2 THE COMPLIANCE STATEMENT ABOVE SHALL NOT APPEAR ON ARMOR THAT FAILED NIJ COMPLIANCE TESTING, OR ON ARMOR THAT HAS NOT BEEN TESTED FOR COMPLIANCE AS SPECIFIED BY THIS STANDARD. ONCE AUTHORIZED TO PLACE THIS STATEMENT ON A MODEL OF ARMOR, THE MANUFACTURER SHALL NOT ALTER OR MODIFY THIS STATEMENT IN ANY WAY.**

4.4.1.3 A colored shape containing a number shall be located in the upper right corner of the label. For body armor designed for the “Edged Blade” protection class, the shape shall be a solid blue square having a side length of at least 25.4 mm (1.0 in). For body armor designed to meet the “Spike” protection class, the shape shall be a solid green equilateral triangle having a height of at least 25.4 mm (1.0 in). The number inside each colored shape shall be at least 12.7 mm (0.5 in) high and white in color. The number shall correspond to the protection level, described in section 2.2, to which the body armor is certified. Body armor that is certified to meet both protection classes shall carry the appropriate colored shape and number for each protection class and protection level, respectively.

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<sup>2</sup> 16 CFR 423, Care Labeling of Textile Wearing Apparel and Certain Piece Goods, as amended effective January 2, 1984; Federal Trade Commission Rule.

<b>MANUFACTURER'S NAME</b> <b>MANUFACTURER'S ADDRESS</b> <b>AND PHONE NUMBER</b> (Logo may be used)	 
<b>STAB RESISTANT BODY ARMOR</b>	
SIZE: _____ DATE OF MFG: _____ DATE OF ISSUE: _____	MODEL: _____ SERIAL NO.: _____ LOT NO.: _____
<p><i>The Manufacturer certifies that this model of armor has been tested through NLECTC and has been found to comply with NIJ Standard-0115.00 for the EDGED BLADE PROTECTION CLASS at PROTECTION LEVEL 2 and the SPIKE PROTECTION CLASS at PROTECTION LEVEL 3.</i></p> <p><b><u>WARNING!</u></b></p> <p><b><u>This garment is rated ONLY for the stab threat level stated above. It is NOT intended to protect against ballistic threats unless it has been found to comply with the requirements of the appropriate NIJ Standard for ballistic resistance of armor.</u></b></p> <p><b><u>THIS SIDE TO BE WORN AWAY FROM BODY</u></b></p> <p>CARE INSTRUCTIONS FOR INSERT PANEL:  <small>(sample instructions shown – to be provided by Manufacturer)</small></p> <ol style="list-style-type: none"> <li>1) DO NOT MACHINE WASH OR DRY CLEAN</li> <li>2) WIPE WITH A DAMP CLOTH</li> </ol>	

*Figure 3. Sample stab resistant protective panel label*

#### 4.4.2 Labeling of Armor Carriers with Nonremovable Protective Panels

Armor with nonremovable protective panels shall, in addition to the label required for the protective elements, have a label on the carrier that is in conformance with the requirements for the protective panels (sec. 4.4.1), unless the armor is so constructed that the carrier does not cover the protective panel label.

#### 4.4.3 Labeling of Armor Carriers with Removable Protective Panels

Armor carriers with removable protective panels shall be labeled on an external surface. The number of labels required shall be as follows: If the carrier is one piece (i.e., all parts are sewn together into one garment), then one label shall suffice and may be placed on either the strike face or the wear face of either the front or back parts of the armor. If the front and back parts of the carrier are separable, then the front and back parts shall each be labeled. Figure 4

illustrates a *sample* label containing the required information. All labels shall contain the following information:

- (a) Name, logo or other identification of the manufacturer, and contact information for the manufacturer, including address and telephone number.
- (b) A statement telling the user to look at the stab resistant protective panels to determine the protection provided.
- (c) Size.
- (d) Date of issue (to be filled in by user).
- (e) A model designation that uniquely identifies the garment for purchasing purposes. Female armor shall be clearly marked “Female.”
- (f) For armors where the carrier extends beyond the protective panel more than 1½ in, the edge of the panel shall be clearly identified on the carrier by a label stating “NO PROTECTION BEYOND THIS POINT,” and a stitch line through both sides of the carrier at this location to keep the protective panel from shifting within the carrier.
- (g) Care instructions for the armor carrier in accordance with 16 CFR 423.

<b>MANUFACTURER’S NAME</b>	
<b>MANUFACTURER’S ADDRESS AND PHONE NUMBER</b>	
(Logo may be used)	
<b>STAB RESISTANT BODY ARMOR</b>	
SIZE: _____	MODEL: _____
DATE OF MFG: _____	SERIAL NO.: _____
DATE OF ISSUE: _____	LOT NO.: _____
<i><u>This carrier offers no stab protection unless stab resistant insert panels are properly installed. See stab resistant insert panel label for protection class and protection level provided in accordance with NIJ Standard–0115.00.</u></i>	
<b><u>CARE INSTRUCTIONS FOR CARRIER:</u></b>	
<i>(sample instructions shown — to be provided by Manufacturer)</i>	
1) Remove stab resistant insert panels from front and back of outer-shell vest (carrier).	
2) Hook and pile fasteners should be in closed position during washing cycle.	
3) Automatic machine wash the outer shell vest (carrier) only, using Permanent Press cycle and warm water settings. (approximately 120 °F).	
4) Use low sudsing detergent according to detergent manufacturer’s directions.	
5) <b>DO NOT USE BLEACH.</b>	
6) Carrier only may be tumble-dried at Medium temperature setting or may be line dried.	
7) Carrier only may be dry cleaned.	
8) Carrier must be completely dry before inserting stab resistant panels.	

*Figure 4. Sample carrier label*

#### 4.5 Workmanship

When examined as described in section 5.4, each armor sample shall be free from wrinkles, blisters, cracks, tears, frays, holes, loose stitching, crazing, chipped or sharp corners, and any other evidence of inferior workmanship. Additionally, all samples shall be identical in appearance, size, and manner of construction.

## 4.6 Resistance to Stab Penetration

The stab resistance of body armor shall be evaluated using engineered test blades or spikes of uniform dimensions. In these tests, the test blades or spikes are held in a drop weight of specified mass. The drop weight is dropped from various heights in an apparatus that controls the orientation and position of impact of the test blade or spike. The body armor is supported on a composite backing material. The test measurement is the depth of blade or spike penetration through the armor at specified impact energies.

The test requester shall specify the protection class and protection level sought. The protection class will determine which of the test series (either those described in sec. 4.6.1 for “Edged Blade” or those described in sec. 4.6.2 for “Spike”) the armor shall be subjected to. The protection class determines which threat weapons are used, either the P1 and S1 knife blades for the “Edged Blade” class, or the spike for the “Spike” class. The protection level determines the stab energies.

### 4.6.1 Stab Resistance Drop Test Series for “Edged Blade” Protection Class

The front and back panels of two complete body armors shall be tested for resistance to stab penetration using the facilities and equipment described in section 5.5, the test methods described in section 5.6, and the test sequence described in section 5.7.

Armor that is intended to meet the “Edged Blade” protection class shall demonstrate protection from both the P1 and S1 knife blades. For a single test panel, the number of stab drop tests, the angle of incidence, and the threat weapon for the “Edged Blade” protection class are summarized in table 2. This series of drop tests shall be performed on each of the four test panels (there are two panels per body armor, and two body armor samples shall be tested).

*Table 2. Summary of drop tests for each test panel*

<b>Number of Drop Tests</b>	<b>Angle of Incidence</b>	<b>Threat Weapon</b>	<b>Energy Level</b>
1	0°	P1 knife blade	E1
1	0°	P1 knife blade	E2
1	0°	S1 knife blade	E1
1	0°	S1 knife blade	E2
1	45°	P1 knife blade	E1
1	45°	S1 knife blade	E1

The values for energy levels, E1 and E2, in table 2 shall comply with one of the protection levels defined in table 1 of section 2.2.

#### 4.6.2 Stab Resistance Drop Test Series for “Spike” Protection Class

The front and back panels of two complete body armors shall be tested for resistance to stab penetration using the facilities and equipment described in section 5.5, the test methods described in section 5.6, and the test sequence described in section 5.8.

Armor that is intended to meet the “Spike” protection class shall demonstrate protection from the spike threat only. For a single test panel, the number of stab drop tests, the angle of incidence, and the threat weapon for the “Spike” protection class are summarized in table 3.

*Table 3. Summary of spike drop tests for each test panel*

<b>Number of Drop Tests</b>	<b>Angle of Incidence</b>	<b>Threat Weapon</b>	<b>Energy Level</b>
1	0°	Spike	E1
1	0°	Spike	E2
1	45°	Spike	E1

The values for energy levels, E1 and E2, in table 3 shall comply with one of the protection levels defined in table 1 of section 2.2.

#### 4.6.3 Pass-Fail Criteria for Stab Drop Tests

The body armor shall not allow a knife blade or spike penetration greater than **7 mm (0.28 in)** from any fair strike for **E1** strike energies at impact angles of incidence of 0° and 45°.

The body armor shall not allow a knife blade or spike penetration greater than **20 mm (0.79 in)** from any fair strike for **E2** strike energies at impact angles of incidence of 0°.

If a penetration of greater than 7 mm (0.28 in) occurs from a strike whose energy is less than E1, but the strike would otherwise be considered a fair hit (sec. 3.12) except for the strike energy, then the armor fails the stab resistance drop test.

A strike delivered under more stringent conditions that produces an acceptable penetration shall be considered a fair hit. The “more stringent conditions” are specifically limited to strikes that are too close to the edge of the armor, are too close to a prior strike, have a strike energy too high, or any combination of the preceding three conditions.

## 5. TEST METHODS

### 5.1 Purpose

This section constitutes a formal test procedure for determining compliance to this standard. It specifies the equipment and techniques to be used by NIJ approved testing agents to qualify voluntarily submitted body armor samples for stab resistance compliance.

## **5.2 Test Sequence**

Tests shall be conducted in the order and as described in sections 4 and 5 of this standard.

## **5.3 Label Examination**

The complete armor and each of its parts shall be examined for conformance to the labeling requirements of section 4.4. Any deviations from the requirements shall be noted in the Compliance Test Report form (available from NLECTC upon request).

## **5.4 Workmanship Examination**

### **5.4.1 Carrier**

All armor sample carriers and protective panel coverings received for compliance testing shall be visually inspected for damage, material flaws, or poor workmanship as defined in section 4.5. All tears, fraying, holes, loose stitching, or other identified flaw(s) shall be noted on the Compliance Test Report form; documentary photographs may be taken and included in the Compliance Test Report.

### **5.4.2 Protective Panel**

*Pretest* – Prior to testing, all armor samples received for compliance testing shall be individually inspected for damage, material flaws, and poor workmanship. All tears, fraying, holes, loose stitching, or other identified flaw(s) shall be noted on the Compliance Test Report form; documentary photographs may be taken and included in the Compliance Test Report.

*Posttest* – Each armor sample's protective panels, front and back, shall be physically inspected immediately after stab resistance testing and their respective condition reported on the Compliance Test Report form for submission to the NIJ Compliance Testing Program (layers, weave, stitching, material, etc.).

*Inspection Notification* – The test facility shall notify the NIJ compliance testing program manager and the armor manufacturer within 24 h of discovery of any shipping damage, major product flaws or poor quality workmanship. Notification shall consist of a copy of the Compliance Test Report form and documentary photographs. Such discoveries and notices will result in suspension of the compliance test until NIJ Compliance Testing Program resolution or approval to proceed is received.

## **5.5 Description of Test Facilities and Equipment**

### **5.5.1 Test Facility Environmental Conditions**

The ambient conditions of the test site shall be:

- (a) Temperature:  $21\text{ }^{\circ}\text{C} \pm 6\text{ }^{\circ}\text{C}$  ( $70\text{ }^{\circ}\text{F} \pm 10\text{ }^{\circ}\text{F}$ ).
- (b) Relative humidity:  $50\% \pm 20\%$ .



- (c) Conditions shall be recorded before and after a complete test series for an armor model, and at every 4 h time interval during the test session.

### **5.5.2 Drop Tube Test Apparatus**

The tests shall be performed using a guided rail drop tube assembly depicted in appendix B. This system has been carefully designed to enable the drop mass to fall under the influence of gravity and to strike the armor sample at a predetermined point of impact. The guide rails situated inside the tube prevent the drop mass from rotating about its vertical axis during its descent and ensure that the test knife blade or spike strikes at the correct orientation and continues in that orientation until it comes to a stop.

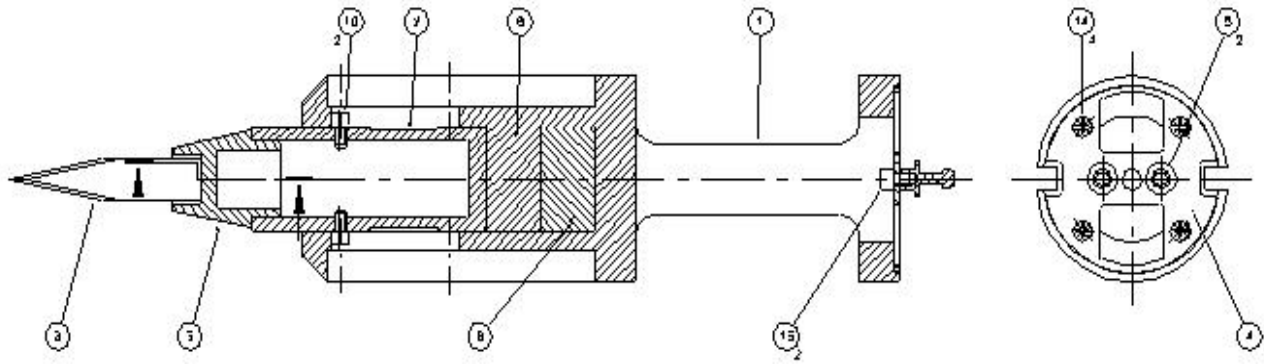
The tube and drop mass shall be checked regularly to ensure that the drop mass is free to fall through the tube without obstruction caused by damaged areas of the inner walls of the tube or by rough edges on the nylon body of the drop mass.

The drop tube apparatus shall be capable of demonstrating reproducible drop velocities within  $\pm 0.05$  m/s ( $\pm 0.16$  ft/s) of a nominal velocity.

### **5.5.3 Drop Mass**

The drop mass, depicted in figure 5, consists of four basic parts:

- (a) A threat weapon (i.e., one of the knife blades or the spike).
- (b) A steel and aluminum alloy bottom mass that holds the threat weapon and has a mass of  $650 \text{ g} \pm 7 \text{ g}$  ( $1.43 \text{ lb} \pm 0.02 \text{ lb}$ ) with a threat weapon installed.
- (c) A nylon upper mass that houses the bottom mass and allows it to slide vertically inside a cavity within the nylon body. The upper mass has a mass of  $1250 \text{ g} \pm 13 \text{ g}$  ( $2.76 \text{ lb} \pm 0.03 \text{ lb}$ ) with overall dimensions of 97 mm (3.82 in) diameter and 400 mm (15.75 in) length (not including threat weapon). The length of the upper mass ensures that part of it remains inside the drop tube as the knife blade or spike strikes its target.
- (d) Two closed cell polyethylene foam discs, each 30 mm (1.18 in) thick and 50 mm (1.97 in) diameter, installed inside the nylon upper mass and located between the base of the bottom mass and the nylon casing. They are compressed as the bottom mass is driven farther into the upper mass body. The foam elements create the damping effect. The foam elements are made from the same closed cell polyethylene foam material used for the backing material in section 5.5.6.



**Figure 5. Drop mass**

The drop mass shall securely hold the test knife blade or spike with  $83 \text{ mm} \pm 2 \text{ mm}$  ( $3.27 \text{ in} \pm 0.08 \text{ in}$ ) of the blade or spike length exposed. The shape of the lower surface of the drop mass shall permit at least  $30 \text{ mm}$  ( $1.18 \text{ in}$ ) of penetration to occur while striking the body armor panel at a  $45^\circ$  angle of incidence.

#### **5.5.4 Velocity Measurement Equipment**

A suitable method of accurately measuring the velocity of the drop mass within the velocity measurement zone shall be employed. The measuring equipment shall measure the velocity to an accuracy of  $\pm 0.05 \text{ m/s}$  ( $\pm 0.16 \text{ ft/s}$ ) or better. Test instrumentation calibration records shall be maintained and made available to the NIJ agent. All calibration procedures and values shall be traceable to the requirements of a recognized Quality Assurance organization, and the applicable standards of the National Institute of Standards and Technology (NIST).

#### **5.5.5 Test Knife Blades and Spike Specifications**

The engineered knife blades, described as P1 and S1, and the engineered spike have been designed to represent the broad spectrum of actual knives used in assaults on law enforcement and corrections officers.

Each test knife blade or spike shall be inspected to ensure that the overall finish is clean and free from rough edges, and that the knife blade or spike meets the requirements of the engineering drawings in appendix A.

After the inspection, each test knife blade or spike shall be subjected to a tip sharpness test and shall be considered acceptable for use in the stab test if it produces a “hardness” value of between -50 and -150 on the Rockwell C scale in the following modified Rockwell hardness tip sharpness test.

To conduct the tip sharpness test, a standard Rockwell Hardness Testing machine is modified as follows: The standard indenter shall be replaced with an adapter that will hold the test blade or spike. The machine shall be preset to give minor and major loads of  $3 \text{ kg}$  ( $6.61 \text{ lb}$ ) and  $5 \text{ kg}$  ( $11.0 \text{ lb}$ ) respectively, to produce a total load of  $8 \text{ kg}$  ( $17.64 \text{ lb}$ ). The sample block to be indented shall be a small flat block of 99.997 % nearly pure aluminum at least  $5 \text{ mm}$  ( $0.197 \text{ in}$ )

thick. The test knife blade or spike shall first be wiped with a clean dry cotton cloth to remove any traces of lubricant and then installed in the holder adapter. The tip sharpness shall then be measured by applying the load to the blade or spike tip, pressing it into the aluminum block and recording the reading from the Rockwell C scale.

Note that these are not actual Rockwell hardness values because of the modifications to the machine and test procedure. As an alternative means of assessing tip sharpness, the range of Rockwell C values are expressed in terms of indentation depth produced by the major load application, and correspond to indentation depths in the aluminum test block of 0.30 mm (0.012 in) and 0.50 mm (0.020 in), for “hardness” values of -50 and -150 respectively. See table 4 for a tabular listing relating the hardness values to indentation depth.

*Table 4. Conversion of HRC values to indentation depths*

HRC	D (mm)	HRC	D (mm)	HRC	D (mm)	HRC	D (mm)	HRC	D (mm)
-160	0.52	-130	0.46	-100	0.40	-70	0.34	-40	0.28
-150	0.50	-120	0.44	-90	0.38	-60	0.32	-30	0.26
-140	0.48	-110	0.42	-80	0.36	-50	0.30	-20	0.24

### 5.5.6 Composite Backing Material Specification

The composite backing material slab shall measure at least 381 mm (15.0 in) in length and 305 mm (12.0 in) in width. The components of the backing material slab shall consist of (from the strike face down) four layers of 5.8 mm (0.23 in) thick neoprene, followed by a single layer of 31 mm (1.22 in) thick 33 kg/m<sup>3</sup> (2.06 lb/ft<sup>3</sup>) closed-cell polyethylene foam, backed by two layers of 6.4 mm (0.25 in) thick natural rubber. A list of suggested manufacturers and suppliers is given in appendix D.

For all flat and flexible armor samples, a slab of composite backing material shall be used. For shaped female armors or where armors have a preformed curve, it may not be possible for the rear face of the armor sample to lie in close contact with the surface of the composite backing material. If this occurs, then the following should be attempted in the order described:

- (a) If the armor design permits, the armor shall be flattened so that the curved portions of the armor make good contact with the backing material.
- (b) If this cannot be done, then the backing material shall be laid over a curved wooden form to ensure that the armor lies in contact with the surface of the backing material.
- (c) If it is still not possible to achieve good contact between the armor and the backing material, then smaller pieces of the neoprene backing material shall be cut, and then stacked together to make good contact with the tight curvature of the armor.

### **5.5.7 Composite Backing Material Acceptance Criteria**

Before using any backing material layers, either whole or in cut form for the construction of special shapes as described in section 5.5.6, the materials shall meet the following acceptance test.

The armor backing material shall be conditioned at ambient test facility conditions, described in section 5.5.1, for a minimum of 12 h before being used in the drop test.

Following this conditioning period, the backing material pack shall meet a restitution test. In this test, the pack is assembled in the correct order as described in section 5.5.6 and placed on a rigid surface. A 1.042 kg (2.297 lb) spherical steel ball shall then be dropped from a vertical height of 1500 mm  $\pm$  15 mm (59 in  $\pm$  0.59 in) above the surface of the pack. The height of rebound achieved from each of two drops shall be 450 mm  $\pm$  102 mm (17.7 in  $\pm$  4.0 in). The point of impact of the steel sphere on the backing material shall be marked, and this area shall not be positioned immediately below the impact point for any of the stab resistance drop tests.

### **5.5.8 Damping Disks**

The damping disks that are installed in the drop mass shall be fabricated from the same closed cell polyethylene foam material that is used for the backing material. The damping disks shall have a diameter of 50 mm  $\pm$  1 mm (1.97 in  $\pm$  0.04 in).

### **5.5.9 Polyart™ Witness Paper**

The Polyart™ paper shall have a basis weight of 140 g/m<sup>2</sup> (0.46 oz/ft<sup>2</sup>) and a thickness of 0.178 mm (7 mil).

## **5.6 Conducting the Stab Tests**

### **5.6.1 Calibration Trials to Confirm Strike Energies**

Before conducting stab tests on the armor sample, preliminary drop test trials shall be conducted to determine the drop heights necessary to produce velocities that correspond to the specified impact energies.

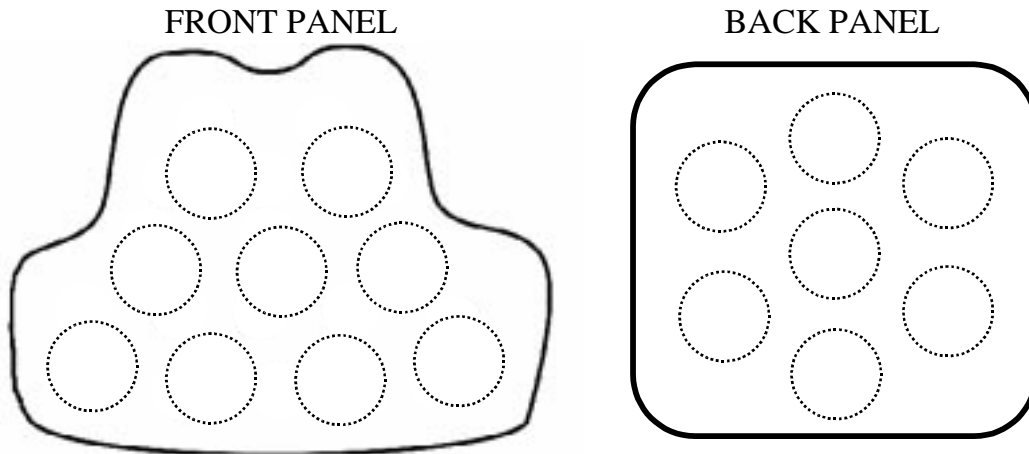
### **5.6.2 Temperature/Humidity Conditioning**

All armor samples received for compliance testing shall be stored and conditioned for a minimum of 12 h at the ambient test facility conditions specified in section 5.5.1. Other components used in the test shall comply with their individual requirements.

### **5.6.3 Stab Location Marking**

The intended stab locations shall be clearly marked on the armor panel. The intended stab locations shall satisfy section 3.12 (parts b, c, and d), the definition for a Fair Hit.

A template shall be used to mark the intended stab impact locations. Figure 6 illustrates a typical template pattern for a front and back panel. A single impact may be placed in each impact zone shown in figure 6. The center location shall be used. All impact zones may not be used, depending upon whether additional strikes are necessary to produce a fair hit.



*Figure 6. Template pattern for stab impact locations*

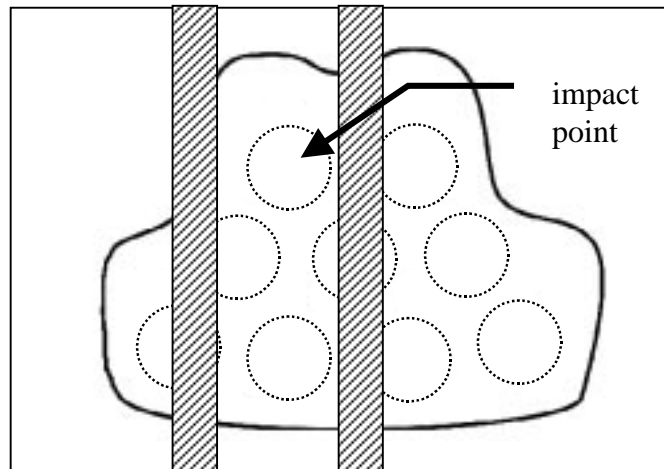
#### **5.6.4 Preparation of Backing Material and Mounting of Armor**

A backing material pack that complies with the requirements of sections 5.5.6 and 5.5.7 shall be used. A sheet of Polyart™ paper shall then be placed on top of the backing material to allow penetration measurements to be made.

The composite backing material shall be replaced when it is no longer possible to conduct a strike greater than 51 mm (2.0 in) from the edge and from previous strikes.

The premarked body armor shall be placed on top of the Polyart™ paper and both the Polyart™ paper and the body armor shifted such that the intended strike location is located over unused sections of the paper and the backing material. The body armor panel shall be smoothed, flattened, and then fastened with straps to the armor support table.

The armor panel shall be secured to the armor support table using 51 mm (2.0 in) wide elastic straps, held together using Velcro® attachments. Figure 7 details the location of the straps. The placement of the straps shall be such that they do not interfere with the impact point on the panel.



*Figure 7. Acceptable strapping method*

### **5.6.5 Assembly of Drop Mass**

Two damping disks shall be installed in the nylon body of the upper mass. For damping disks that are used for drop tests at less than 65 J (47.9 ft· lbf), they shall be replaced after being subjected to no more than 12 drop tests. For damping disks that are used for at least one drop test at 65 J (47.9 ft· lbf) or greater, they shall be subjected to no more than 4 drop tests. Used disks shall be discarded.

After installation of the damping disks, the lower drop mass shall be inserted into the upper mass, and the damping disks shall be compressed to permit the insertion of the cap screws through the guide slots to hold the assembly together.

### **5.6.6 Installation of Knife Blade or Spike into Drop Mass and Drop Test Procedure**

A new knife blade or spike, tested for sharpness, shall be used for each test strike.

The specified knife blade or spike shall be affixed to the drop mass and the assembly shall be weighed to the nearest gram. The mass measurement method shall have an accuracy of  $\pm 1$  g ( $\pm 0.002$  lb) or less. The drop mass shall then be installed in the drop tube. For the  $0^\circ$  tests, the blade orientation does not matter. For the  $45^\circ$  tests, the cutting edge of the knife blade shall face the armor. The drop mass shall be raised to the proper height determined in section 5.6.1 so that it will strike with the specified energy.

The armor and container assembly shall be repositioned below the drop tube such that the test knife blade or spike will strike the marked impact point. The velocity instrumentation shall be initialized in preparation for making a measurement. The drop mass shall be released.

### **5.6.7 Determination of Hit Fairness**

Following the strike, the impact velocity and the strike location shall be recorded on the test data sheet. The kinetic energy at impact shall be calculated from  $KE = \frac{1}{2}mv^2$ , where “KE” is kinetic energy, “m” is the drop mass, and “v” is the impact velocity. The result shall be recorded on the test data sheet. A determination of hit fairness, as defined in section 3.12, shall be made based on the strike location and impact kinetic energy.

If the strike is determined to be unfair, then subsequent attempts shall be made until a fair hit is achieved.

### **5.6.8 Measurement of Penetration**

If the strike meets the criteria for a fair hit, or if a favorable penetration result was obtained for a more stringent hit, the penetration depth shall be measured and recorded in the Compliance Test Report.

Carefully separate the armor from the backing material and examine it, the witness paper, and the backing material to determine if the knife or spike has penetrated the rear face of the armor panel. If any penetration has occurred, the depth shall be measured using the appropriate method described below.

If the design of the body armor permits, the penetration distance may be measured directly by placing a millimeter scale ruler alongside the penetrated knife blade or spike. The length of the knife blade or spike visible from the rear of the test panel is measured and recorded. In some cases, the measurement of penetration is complicated if the body armor, especially the rear face, is compressible. Upon impact, the compressible material collapses. After the strike, the soft rear face of the armor may return to its original thickness. This can lead to inaccuracies when measuring the penetration depth. Therefore, it may be necessary to determine the penetration depth by carefully measuring the length of the cut in the Polyart™ witness paper and consulting the chart in appendix C to find the depth of penetration. The length of the cut may be measured with a millimeter scale ruler. The Polyart™ paper is useful for determining the penetration depth only when knife blades are used. It is not effective for spike tests because the spikes do not leave a well-defined mark in the witness paper. Spike penetration depth shall be measured directly with a millimeter scale ruler.

In other cases, the drop mass may bounce, causing the knife blade or spike to impact the armor multiple times. Should this occur, the first impact only shall be used. If the knife blade or spike bounced out of the initial hole, then it shall be manually reinserted into the hole until it fits snugly, but not forced beyond this point.

## **5.7 Drop Test Series for “Edged Blade” Protection Class**

The entire “Edged Blade” stab test sequence results in a total of 24 fair hit drop tests against a model of body armor. The front and back panels of two body armor samples shall be subjected to this test sequence, requiring a total of four test panels. The body armor panels shall be numbered one through four.

For each test condition specified, one fair hit per panel is required. The test sequence is defined in sections 5.7.1 and 5.7.2. The values of E1 and E2 are described for each protection level in section 2.2, table 1.

### 5.7.1 0° Angle Test Strikes

Test Strike No. 1 - Perform the test strike at energy **E1** using a **PI** test knife blade at an impact angle of incidence of **0°** on test panel number one.

Test Strike No. 2 (Repeat of Test Strike No. 1) - Perform the test strike at energy **E1** using a **PI** test knife blade at an impact angle of incidence of **0°** on test panel number two.

Test Strike No. 3 (Repeat of Test Strike No. 1) - Perform the test strike at energy **E1** using a **PI** test knife blade at an impact angle of incidence of **0°** on test panel number three.

Test Strike No. 4 (Repeat of Test Strike No. 1) - Perform the test strike at energy **E1** using a **PI** test knife blade at an impact angle of incidence of **0°** on test panel number four.

Test Strike No. 5 - Perform the test strike at energy **E2** using a **PI** test knife blade at an impact angle of incidence of **0°** on test panel number one.

Test Strike No. 6 (Repeat of Test Strike No. 5) - Perform the test strike at energy **E2** using a **PI** test knife blade at an impact angle of incidence of **0°** on test panel number two.

Test Strike No. 7 (Repeat of Test Strike No. 5) - Perform the test strike at energy **E2** using a **PI** test knife blade at an impact angle of incidence of **0°** on test panel number three.

Test Strike No. 8 (Repeat of Test Strike No. 5) - Perform the test strike at energy **E2** using a **PI** test knife blade at an impact angle of incidence of **0°** on test panel number four.

Test Strike No. 9 - Perform the test strike at energy **E1** using an **SI** test knife blade at an impact angle of incidence of **0°** on test panel number one.

Test Strike No. 10 (Repeat of Test Strike No. 9) - Perform the test strike at energy **E1** using an **SI** test knife blade at an impact angle of incidence of **0°** on test panel number two.

Test Strike No. 11 (Repeat of Test Strike No. 9) - Perform the test strike at energy **E1** using an **SI** test knife blade at an impact angle of incidence of **0°** on test panel number three.

Test Strike No. 12 (Repeat of Test Strike No. 9) - Perform the test strike at energy **E1** using an **SI** test knife blade at an impact angle of incidence of **0°** on test panel number four.

Test Strike No. 13 - Perform the test strike at energy **E2** using an **SI** test knife blade at an impact angle of incidence of **0°** on test panel number one.

Test Strike No. 14 (Repeat of Test Strike No. 13) - Perform the test strike at energy **E2** using an **SI** test knife blade at an impact angle of incidence of **0°** on test panel number two.



Test Strike No. 15 (Repeat of Test Strike No. 13) - Perform the test strike at energy *E2* using an *SI* test knife blade at an impact angle of incidence of  $0^\circ$  on test panel number three.

Test Strike No. 16 (Repeat of Test Strike No. 13) - Perform the test strike at energy *E2* using an *SI* test knife blade at an impact angle of incidence of  $0^\circ$  on test panel number four.

### **5.7.2 45° Angle Test Strikes**

Test Strike No. 17 - Perform the test strike at energy *E1* using a *PI* test knife blade at an impact angle of incidence of  $45^\circ$  on test panel number one.

Test Strike No. 18 (Repeat of Test Strike No. 17) - Perform the test strike at energy *E1* using a *PI* test knife blade at an impact angle of incidence of  $45^\circ$  on test panel number two.

Test Strike No. 19 (Repeat of Test Strike No. 17) - Perform the test strike at energy *E1* using a *PI* test knife blade at an impact angle of incidence of  $45^\circ$  on test panel number three.

Test Strike No. 20 (Repeat of Test Strike No. 17) - Perform the test strike at energy *E1* using a *PI* test knife blade at an impact angle of incidence of  $45^\circ$  on test panel number four.

Test Strike No. 21 - Perform the test strike at energy *E1* using an *SI* test knife blade at an impact angle of incidence of  $45^\circ$  on test panel number one.

Test Strike No. 22 (Repeat of Test Strike No. 21) - Perform the test strike at energy *E1* using an *SI* test knife blade at an impact angle of incidence of  $45^\circ$  on test panel number two.

Test Strike No. 23 (Repeat of Test Strike No. 21) - Perform the test strike at energy *E1* using an *SI* test knife blade at an impact angle of incidence of  $45^\circ$  on test panel number three.

Test Strike No. 24 (Repeat of Test Strike No. 21) - Perform the test strike at energy *E1* using an *SI* test knife blade at an impact angle of incidence of  $45^\circ$  on test panel number four.

## **5.8 Drop Test Series for “Spike” Protection Class**

The entire “Spike” stab test sequence results in a total of 12 fair hit drop tests against a model of body armor. The front and back panels of two body armor samples shall be subjected to this test sequence, requiring a total of four test panels. The body armor panels shall be numbered one through four.

For each test condition specified, one fair hit per panel is required. The test sequence is defined in sections 5.8.1 and 5.8.2. The values of *E1* and *E2* are described for each protection level in section 2.2, table 1.

### **5.8.1 0° Angle Test Strikes**

Test Strike No. 1 - Perform the test strike at energy *E1* using a *Spike* at an impact angle of incidence of  $0^\circ$  on test panel number one.

Test Strike No. 2 (Repeat of Test Strike No. 1) - Perform the test strike at energy **E1** using a **Spike** at an impact angle of incidence of **0°** on test panel number two.

Test Strike No. 3 (Repeat of Test Strike No. 1) - Perform the test strike at energy **E1** using a **Spike** at an impact angle of incidence of **0°** on test panel number three.

Test Strike No. 4 (Repeat of Test Strike No. 1) - Perform the test strike at energy **E1** using a **Spike** at an impact angle of incidence of **0°** on test panel number four.

Test Strike No. 5 - Perform the test strike at energy **E2** using a **Spike** at an impact angle of incidence of **0°** on test panel number one.

Test Strike No. 6 (Repeat of Test Strike No. 5) - Perform the test strike at energy **E2** using a **Spike** at an impact angle of incidence of **0°** on test panel number two.

Test Strike No. 7 (Repeat of Test Strike No. 5) - Perform the test strike at energy **E2** using a **Spike** at an impact angle of incidence of **0°** on test panel number three.

Test Strike No. 8 (Repeat of Test Strike No. 5) - Perform the test strike at energy **E2** using a **Spike** at an impact angle of incidence of **0°** on test panel number four.

### **5.8.2 45° Angle Test Strikes**

Test Strike No. 9 - Perform the test strike at energy **E1** using a **Spike** at an impact angle of incidence of **45°** on test panel number one.

Test Strike No. 10 (Repeat of Test Strike No. 9) - Perform the test strike at energy **E1** using a **Spike** at an impact angle of incidence of **45°** on test panel number two.

Test Strike No. 11 (Repeat of Test Strike No. 9) - Perform the test strike at energy **E1** using a **Spike** at an impact angle of incidence of **45°** on test panel number three.

Test Strike No. 12 (Repeat of Test Strike No. 9) - Perform the test strike at energy **E1** using a **Spike** at an impact angle of incidence of **45°** on test panel number four.

### **5.9 Test Surveillance**

NIJ representatives may witness compliance testing at any time. The manufacturer shall inform NIJ Compliance Program personnel of the intent to test at least 2 weeks prior to the start of testing. NIJ or its designated representatives shall be afforded the opportunity to examine the test set-up prior to beginning a new series of compliance armor testing. If NIJ or its designee elects not to examine the test setup, this shall be noted on the Compliance Test Report form.

In the event that NIJ representatives do not witness compliance testing, NIJ or its designee will authorize a representative of the test laboratory to perform the sign-off activity, as required by the Compliance Test Report.

## **6. DATA COLLECTION AND REPORTING**

The protection class and protection level to which the armor has been tested shall be clearly marked, along with the manufacturer's name and the armor model designation. For each test strike the threat weapon will be given, and also the velocity of the impact, the impact angle of incidence and the depth of penetration (if any) of the knife blade or spike through the sample. Finally, the armor will be assessed an overall Pass/Fail rating according to section 4.6.3.

### **6.1 Test Documentation**

#### **6.1.1 Data Storage**

All test data shall be archived by the test laboratory for a minimum of 5 years following the completion of each compliance test series.

#### **6.1.2 Data Recording**

The results of each armor test shall be recorded on the Compliance Test Report form. The Compliance Test Report form specifically identifies the test being performed, the test item, the test part and serial numbers, and the applicable test specification. All test data and activities shall be recorded in sufficient detail such that a reconstruction of the test based on the material contained in the Compliance Test Report form can be performed.

When completed, the responsible test engineer or technician shall sign the Compliance Test Report form and all attachments.

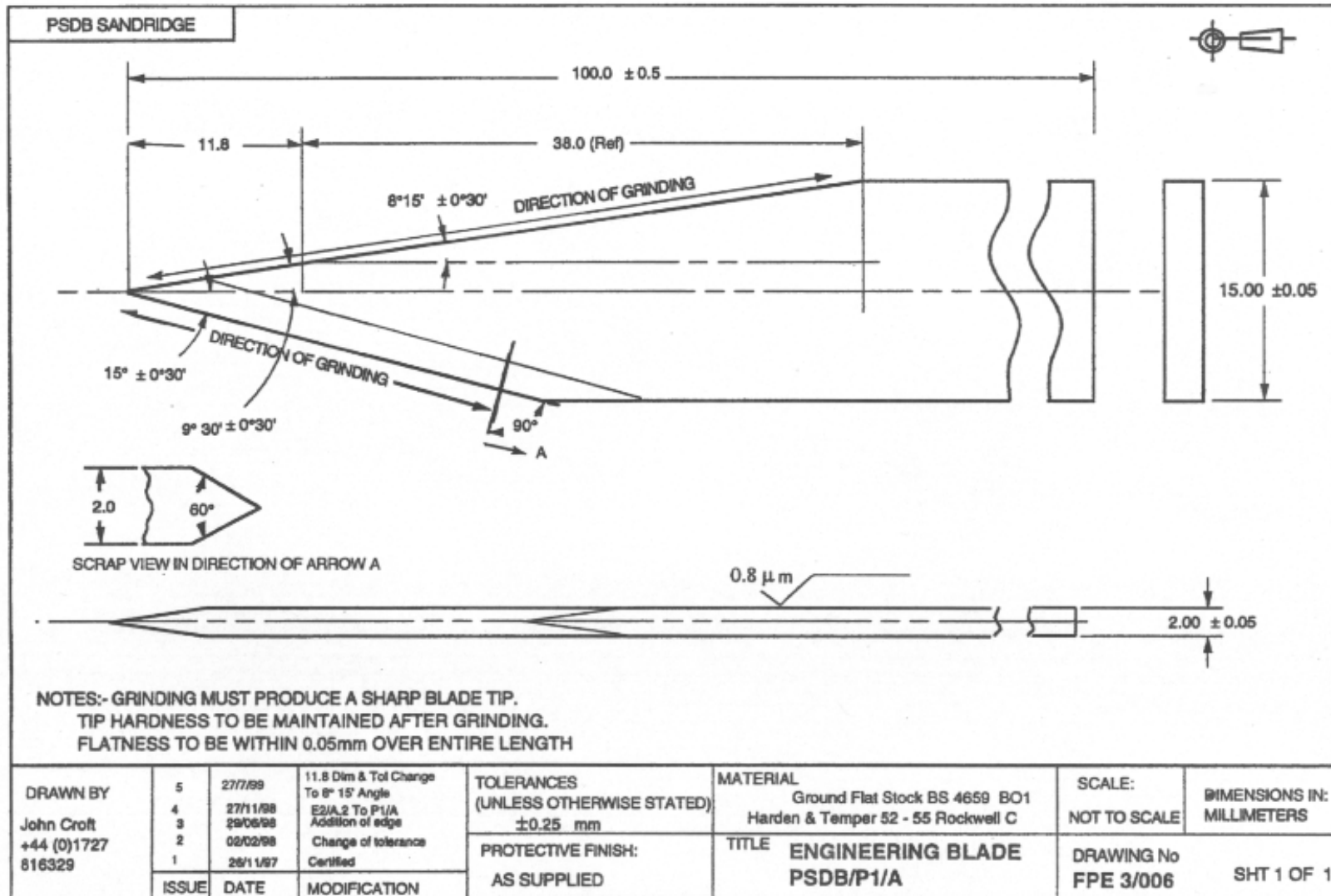
### **6.2 Test Report**

#### **6.2.1 Requirements**

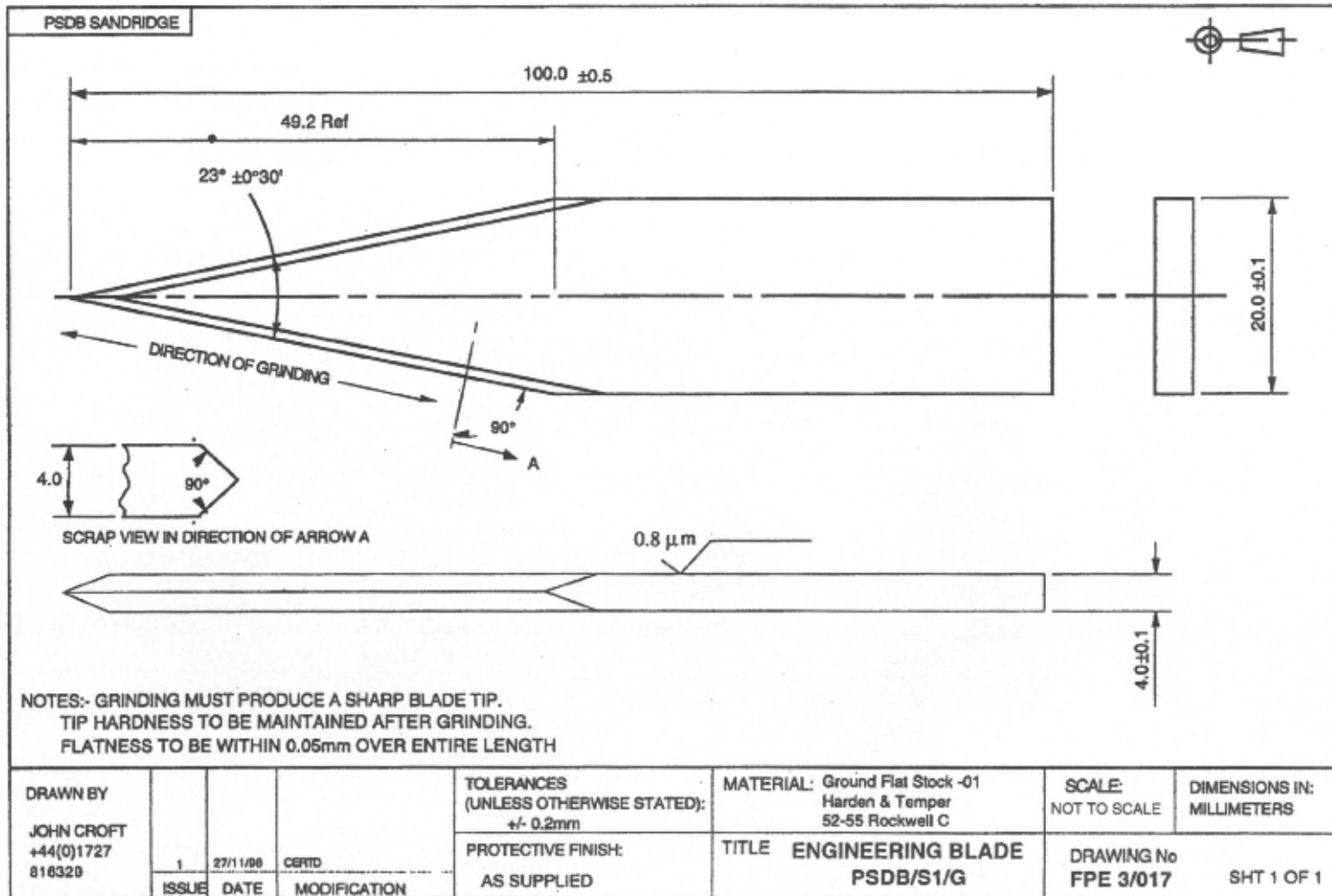
A summary test report shall be submitted to the NIJ Compliance Program office within 10 working days of the completion of testing. Inclusion of the following minimum support documentation shall be required.

- (a) Submission letter stating the outcome of the testing.
- (b) Compliance Test Report.
- (c) Pass/Fail Statement.
- (d) Failure Documentation if applicable.
- (e) Photographs of each armor panel before and after testing with scale and identification sign.

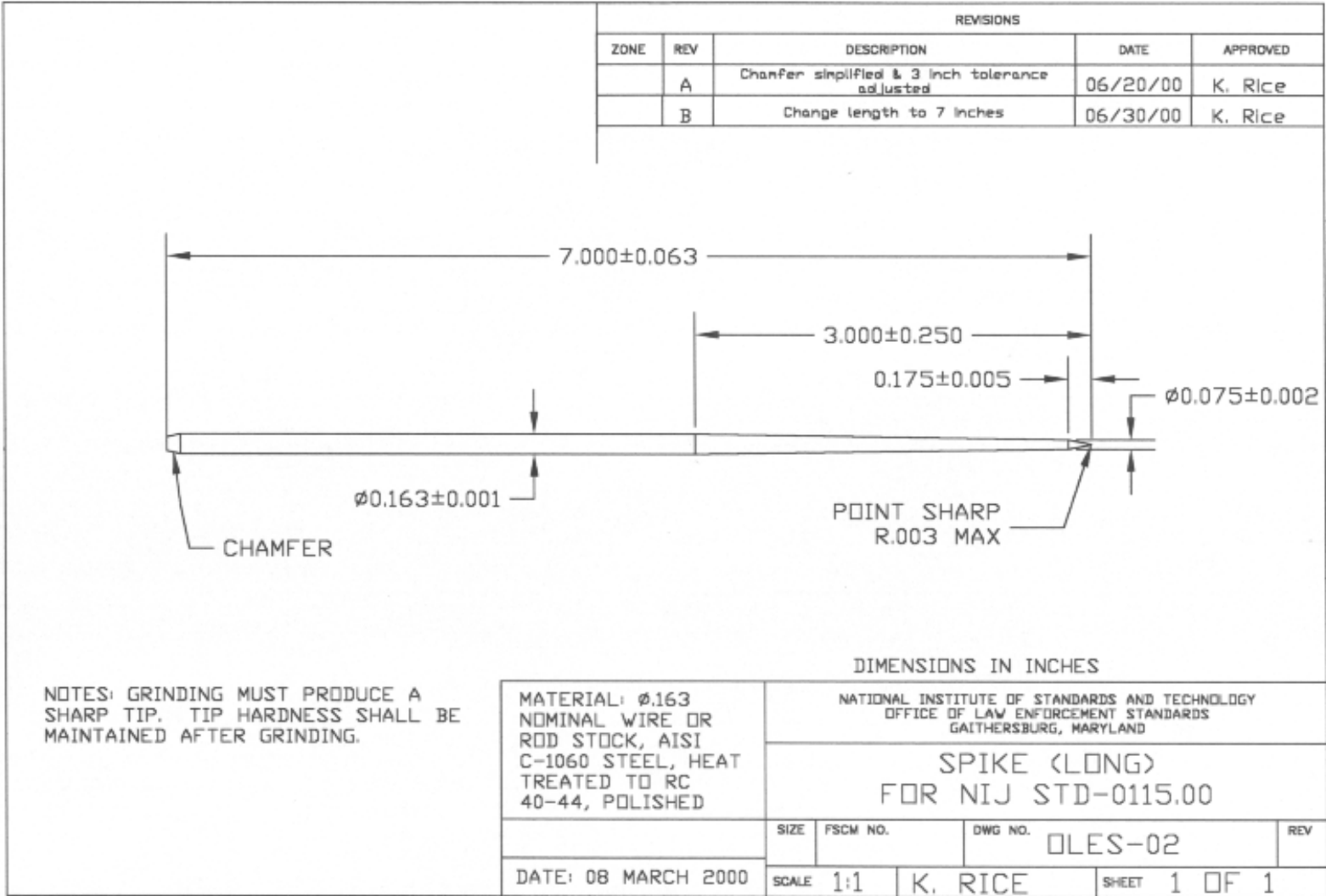
## **Appendix A: Engineered Drawings of Threat Weapons**



*Engineered Knife Blade P1*



*Engineered Knife Blade S1*



*Engineered Spike*

## **Appendix B: Drop Test Fixture**

Photos below show the lower portion of the test fixture (left) and the upper portion (right).





## Appendix C: Conversion Tables for Penetration Depth

P1 Knife Blade Penetration Depths from Witness Paper Cut Length  
for 0° Angle of Incidence

Length (mm)	Depth (mm)	Length (mm)	Depth (mm)	Length (mm)	Depth (mm)	Length (mm)	Depth (mm)
0.42	1	6.04	14	11.41	27	13.56	40
0.85	2	6.46	15	11.82	28	13.71	41
1.29	3	6.87	16	11.97	29	13.85	42
1.72	4	7.28	17	12.11	30	14.00	43
2.16	5	7.69	18	12.26	31	14.14	44
2.60	6	8.11	19	12.40	32	14.29	45
3.03	7	8.52	20	12.55	33	14.43	46
3.46	8	8.93	21	12.69	34	14.58	47
3.90	9	9.35	22	12.84	35	14.72	48
4.33	10	9.76	23	12.98	36	14.87	49
4.77	11	10.17	24	13.13	37	15.00	50
5.22	12	10.58	25	13.27	38		
5.63	13	11.00	26	13.42	39		

S1 Knife Blade Penetration Depths from Witness Paper Cut Length  
for 0° Angle of Incidence

Length (mm)	Depth (mm)	Length (mm)	Depth (mm)	Length (mm)	Depth (mm)	Length (mm)	Depth (mm)
0.41	1	5.70	14	10.98	27	16.27	40
0.81	2	6.10	15	11.38	28	16.67	41
1.22	3	6.51	16	11.79	29	17.08	42
1.63	4	6.92	17	12.20	30	17.49	43
2.03	5	7.32	18	12.60	31	17.89	44
2.44	6	7.73	19	13.00	32	18.30	45
2.85	7	8.13	20	13.42	33	18.71	46
3.25	8	8.64	21	13.82	34	19.11	47
3.66	9	8.90	22	14.23	35	19.52	48
4.07	10	9.31	23	14.64	36	20.00	49
4.47	11	9.76	24	15.05	37		
4.88	12	10.16	25	15.45	38		
5.29	13	10.57	26	15.86	39		

## **Appendix D: Sources of Consumable Supplies**

### **99.997 % Pure Aluminum for Tip Sharpness Test**

The aluminum is supplied as an ingot measuring 38 mm x 38 mm x 127 mm (1.5 in x 1.5 in x 5.0 in). For the test, a block should be cut from the ingot. The cut surfaces must be machine-smoothed (not ground). Grinding will embed hardened particles into the surface and influence test results. A known supplier of the aluminum:

Aldrich Chemical Company P.O. Box 355 Milwaukee, Wisconsin 53201 USA Tel: 414-273-3850	Sigma Aldrich Chemical Company The Old Brickyard, New Road Gillingham Dorset SP8 4XT Tel: +44 1 747822211
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### **Polyart™ Paper**

Polyart™ is a synthetic paper made of high-density polyethylene film with a matte clay coating on both sides. It is very durable and tear-resistant. It is produced in several thicknesses. This standard requires a basis weight of 140 g/m<sup>2</sup>, (0.46 oz/ft<sup>2</sup>) or 7 mils thickness. Polyart™ can be obtained at many paper and art supply companies, and is manufactured by:

ARJOBEX North America (Canada, United States and Mexico)  
10901 Westlake Dr.  
Charlotte, NC 28273  
Fax: 704-587-1174

### **Spherical Steel Ball**

A known U.S. supplier of the steel ball is identified below.

Salem Specialty Ball Co., Inc.  
P.O. Box 145  
West Simsbury, CT 06092  
Part number 3606

## **Backing Material**

The components used to construct the composite backing material slab can be ordered to the following specifications.

<b>Component Materials</b>	<b>U.S. Specification</b>	<b>UK Specification</b>	<b>UK Reference Part Number</b>
Neoprene sponge	5.8 mm (0.23 in) thick, SCE45, Shore A20-30	6 mm thick, firm density	PSDB/BM/1/99
Polyethylene foam (Plastizote®) <sup>3</sup>	closed cell, 31 mm (1.22 in) thick, LD45, Shore A14	expanded closed cell to density of 33 kg/m <sup>3</sup> , 30 mm (1.18 in) thick	PSDB/BM/2/99
Rubber	6.4 mm (0.25 in) thick, Shore A45-50	BS2494D, 6 mm thick	PSDB/BM/3/99

Known UK suppliers who can supply the complete composite backing material (part number PSDB/BM/4/99) in individual sealed packs of size 420 mm x 350 mm (16.54 in x 13.78 in) are shown below.

Limpet Safety Products Unit 27, Victoria Industrial Park Victoria Road Dartford Kent DA1 5AJ Tel: 01322 280888	RPI Plasma Neachells Lane Wednesfield Wolverhampton West Midlands WV11 3QG Tel: 01902 307711
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The above suppliers can also supply individual components. Other known UK manufacturers who can supply individual components of the composite backing material are listed below.

<b>Manufacturer</b>	<b>Components Available</b>
R.A. International Ltd. Kings Hill Business Park Darlaston Road Wednesbury West Midlands MS10 7SH Tel: 01215 564271	Neoprene sponge to reference RA110  Polyethylene foam (Plastizote®) to reference RA12
Wm. Johnston & Co. 39 Mauchline Street Glasgow G5 8HQ Tel: 01414 201131	Natural rubber

<sup>3</sup> The use of brand names in this standard does not constitute endorsement by the U.S. Department of Justice; National Institute of Justice; U.S. Department of Commerce; National Institute of Standards and Technology; Office of Law Enforcement Standards; or any other agency of the United States Federal Government, nor does it imply that the product is best suited for its intended applications.

Known U.S. suppliers of these components are listed below. The complete composite backing material of size 381 mm x 305 mm (15 in x 12 in) can be purchased by referencing NIJ Standard-0115.00.

PCF Foam Corporation  
 9486 Sutton Place  
 Hamilton, Ohio 45011  
 Tel: 513-874-8580  
 Fax: 513-874-3144

**Knife Blades**

As U.S. suppliers of knife blades are identified, they will be listed on the NLECTC web site given inside the front cover of this standard. Known UK suppliers of the knife blades are listed below:

High Speed and Carbide Ltd. Clough Bank, Off Edmond Road Sheffield S2 4EL England Tel: +44 1 142796197	Mifas Knife and Tool Company Ltd. Faith Works, Club Mill Road Sheffield S6 2FH England Tel: +44 1 142854500
Fernite Of Sheffield Ltd Fernite Works, Coleford Road Sheffield S9 5NJ England Tel: +44 1 142440527	Wardson Tools Limited Centenary Works, Woodseats Road Sheffield S8 0PE England Tel: +44 1 142552451 Fax: +44 1 142584491

**Spikes**

A known U.S. supplier of the spike specified in this standard is identified below:

John M. Dean, Inc.  
 20 Mechanics Street  
 P.O. Box 924  
 Putnam, Connecticut 06260-1406  
 Tel: 860-928-7701  
 Part number A-693

## **Appendix E: Stab Resistant Body Armor Selection**

Police and corrections administrators should make every effort to encourage their officers to wear body armor throughout each duty shift. Traditional body armor was designed primarily to provide protection against handgun assault; although there are many examples where body armor has prevented serious and potentially fatal injuries in traffic accidents (both in automobiles and while operating motorcycles), from physical assault with improvised clubs, and to some extent, from knives. Within the last few years, a new class of body armor was developed specifically to counter the threats posed by edged and pointed weapons. This standard addresses the penetration performance measurement of such armors.

A fundamental consideration in selecting body armor is determining the threat to which officers are exposed. Knowledge of the common weapons in the local area (confiscated weapons are a good indicator) is essential, for stab resistant armor should be selected to protect against the prevalent “street” or prison/corrections threat.

NIJ Guide 100–98, *Selection and Application Guide to Police Body Armor*, should be read carefully to provide additional insight into the issues concerning proper selection of body armor. While 100 % protection in all circumstances is impossible, the routine use of appropriate body armor significantly reduces the likelihood of fatal injury. Body armor selection is to some extent a tradeoff between protection and wearability. The weight and bulk of body armor are generally inversely proportional to the level of protection it provides; therefore, comfort decreases as the protection level increases.

Law enforcement officer fatality statistics are compiled annually by the Federal Bureau of Investigation. Analysis of the statistics suggests that a large percentage of officer fatalities reported each year could have been prevented if the officer had been wearing armor.

All departments should strive to select body armor that their officers will wear, consistent with their protection requirements. Agencies should ensure that each officer knows and understands the protection that it affords, as well as its limitations. Body armor *not worn* provides *no protection*.

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*<http://www.ojp.usdoj.gov>*

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