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James K. Stewart, Director
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Ballistic Resistance of Police Body Armor

NIJ Standard 0101.03

April 1987

U.S. DEPARTMENT OF JUSTICE
National Institute of Justice

James K. Stewart, Director

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FOREWORD

This document, NIJ Standard-0101.03, Ballistic Resistance of Police Body Armor, is an equipment standard developed by the Law Enforcement Standards Laboratory of the National Bureau of Standards. It is produced as part of the Technology Assessment Program of the National Institute of Justice (NIJ). A brief description of the program appears on the inside front cover.

This standard is a technical document that specifies performance and other requirements equipment should meet to satisfy the needs of criminal justice agencies for high quality service. Purchasers may use the test methods described in this standard to determine whether a particular piece of equipment meets the essential requirements, or they may have the tests conducted on their behalf by a qualified testing laboratory. Procurement officials may also refer to this standard in their purchasing documents and require that equipment offered for purchase meet the requirements. Compliance with the requirements of the standard may be attested to by an independent laboratory or guaranteed by the vendor.

Because this NIJ standard is designed as a procurement aid, it is necessarily highly technical. For those who seek general guidance concerning the selection and application of law enforcement equipment, user guides have also been published. The guides explain in nontechnical language how to select equipment capable of performance required by an agency.

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NIJ STANDARD FOR THE BALLISTIC RESISTANCE OF POLICE BODY ARMOR

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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 (c/s)	Ω	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	part per million
dc	direct current	L	liter	qt	quart
°C	degree Celsius	lb	pound	rad	radian
°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 (natural)	SD	standard deviation
F	farad	log	logarithm (common)	sec.	section
fc	footcandle	*M*	molar	SWR	standing wave radio
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	λ	wavelength
gr	grain	N·m	newton meter	wt	weight

area = unit^2 (e.g., ft^2, in^2, etc.); volume = unit^3 (e.g., ft^3, m^3, etc.)

PREFIXES

d	deci (10^{-1})	da	deka (10)
c	centi (10^{-2})	h	hecto (10^2)
m	milli (10^{-3})	k	kilo (10^3)
μ	micro (10^{-6})	M	mega (10^6)
n	nano (10^{-9})	G	giga (10^9)
p	pico (10^{-12})	T	tera (10^{12})

COMMON CONVERSIONS
(See ASTM E380)

ft/s × 0.3048000 = m/s
ft × 0.3048 = m
ft·lbf × 1.355818 = J
gr × 0.06479891 = g
in × 2.54 = cm
kWh × 3 600 000 = J
lb × 0.4535924 = kg
lbf × 4.448222 = N
lbf/ft × 14.59390 = N/m
lbf·in × 0.1129848 = N·m
lbf/in^2 × 6894.757 = Pa
mph × 1.609344 = km/h
qt × 0.9463529 = L

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

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

NIJ STANDARD FOR THE BALLISTIC RESISTANCE OF POLICE BODY ARMOR

1. PURPOSE AND SCOPE

The purpose of this standard is to establish minimum performance requirements and methods of test for the ballistic resistance of police body armor intended to protect the torso against gunfire. This standard is a revision of NIJ Standard-0101.02, dated March 1985, clarifying the labeling requirements, acceptance criteria, and backface signature measurement procedure. The scope of the standard is limited to ballistic resistance only; the standard does not address threats from knives and sharply pointed instruments, which are different types of threat. In addition, the standard does not address armor that incorporates inserts, or variations in construction of the ballistic panel over small areas of the torso, for the purposes of increasing the basic level of protection of the armor (whether ballistic or blunt trauma) on localized areas.

2. CLASSIFICATION

Police body armors covered by this standard are classified into seven types, by level of ballistic protection performance[1]. The classification of an armor panel that provides two or more levels of ballistic protection at different locations on the ballistic panel shall be that of the minimum ballistic protection provided at any location on the panel.

As of 1987, ballistic-resistant body armor suitable for routine full-time wear throughout an entire shift of duty is available in types I, II-A, and to a limited extent type II (depending largely upon climate) which will provide protection from common handgun threats. Type III-A, which will provide protection from 9 mm submachine guns and 44 Magnum handguns using the test rounds, and types III and IV, which will protect against high-powered rifles, are normally considered to be special purpose armor most appropriate for use during tactical operations. See appendix A.

2.1 Type I (22 LR; 38 Special)

This armor protects against 22 Long Rifle High Velocity lead bullets, with nominal masses of 2.6 g (40 gr) impacting at a velocity of 320 m (1050 ft) per second or less, and 38 Special round nose lead bullets, with nominal masses of 10.2 g (158 gr) impacting at a velocity of 259 m (850 ft) per second or less. It also provides protection against most handgun rounds in calibers 25 and 32.

2.2 Type II-A (Lower Velocity 357 Magnum; 9 mm)

This armor protects against 357 Magnum jacketed soft point bullets, with nominal masses of 10.2 g (158 gr) impacting at a velocity of 381 m (1250 ft) per second or less, and 9 mm full metal jacketed bullets, with nominal masses of 8.0 g (124 gr) impacting at a velocity of 332 m (1090 ft) per second or less. It also provides protection against threats such as 45 Auto., 38 Special +P and some other factory loads in caliber 357 Magnum and 9 mm, as well as the threats mentioned in section 2.1.

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[1] The ballistic threat posed by a bullet depends, among other things, on its composition, shape, caliber, mass, angle of incidence, and impact velocity. Because of the wide variety of cartridges available in a given caliber, and because of the existence of hand loads, armors that will defeat a standard test round may not defeat other loadings in the same caliber. For example, an armor that prevents penetration by a 357 Magnum test round may or may not defeat a 357 Magnum round with higher velocity. In general, an armor that defeats a given lead bullet may not resist penetration by other rounds of the same caliber of different construction or configuration. The test ammunition specified in this standard represent common threats to law enforcement officers.

2.3 Type II (Higher Velocity 357 Magnum; 9 mm)

This armor protects against 357 Magnum jacketed soft point bullets, with nominal masses of 10.2 g (158 gr) impacting at a velocity of 425 m (1395 ft) per second or less, and 9 mm full jacketed bullets, with nominal masses of 8.0 g (124 gr) impacting at a velocity of 358 m (1175 ft) per second or less. It also provides protection against most other factory loads in caliber 357 Magnum and 9 mm, as well as the threats mentioned in sections 2.1 and 2.2.

2.4 Type III-A (44 Magnum; Submachine Gun 9 mm)

This armor protects against 44 Magnum, lead semi-wadcutter bullets with gas checks, nominal masses of 15.55 g (240 gr) and impacting at a velocity of 426 m (1400 ft) per second or less, and 9 mm full metal jacketed bullets, with nominal masses of 8.0 g (124 gr) impacting at a velocity of 426 m (1400 ft) per second or less. It also provides protection against most handgun threats, as well as the threats mentioned in sections 2.1 through 2.3.

2.5 Type III (High-Powered Rifle)

This armor protects against 7.62 mm full metal jacketed bullets (U.S. military designation M80), with nominal masses of 9.7 g (150 gr) impacting at a velocity of 838 m (2750 ft) per second or less. It also provides protection against threats such as 223 Remington (5.56 mm FMJ), 30 Carbine FMJ, and 12 gauge rifled slug, as well as the threats mentioned in sections 2.1 through 2.4.

2.6 Type IV (Armor-Piercing Rifle)

This armor protects against 30 caliber armor-piercing bullets (U.S. military designation APM2), with nominal masses of 10.8 g (166 gr) impacting at a velocity of 868 m (2850 ft) per second or less. It also provides at least single hit protection against the threats mentioned in sections 2.1 through 2.5.

2.7 Special Type

A purchaser having a special requirement for a level of protection other than one of the above standard threat levels should specify the exact test rounds and minimum impact velocities to be used, and indicate that this standard shall govern in all other respects.

3. DEFINITIONS

3.1 Angle of Incidence

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

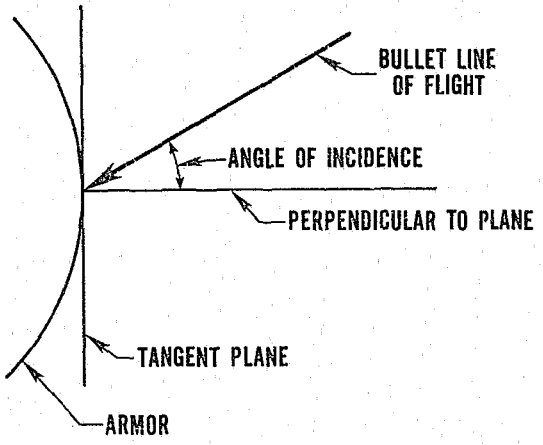


FIGURE 1. *Angle of incidence.*

3.2 Backing Material

A block of nonhardening, oil-base modeling clay placed in contact with the back of the armor test specimen during ballistic testing.

3.3 Certification of Compliance

Manufacturer's affidavit (certification) that a production unit of body armor meets or exceeds (complies with) all of the requirements of this standard (sec. 4) for the labeled protection classification (sec. 2).

3.4 Deformation

The maximum momentary displacement of the back surface of the armor test specimen caused by a fair hit that does not penetrate the armor when the armor is in initial contact with the backing material.

3.5 Fair Hit

A bullet that impacts the armor at an angle of incidence no greater than $\pm 5°$ from the intended angle of incidence, no closer to the edge of the armor part than 7.6 cm (3 in) and no closer to a prior hit than 5 cm (2 in), at an impact velocity no more than 50 ft (15 m) per second greater than the minimum required test velocity.

3.6 Full Metal Jacketed Bullet (FMJ)

A bullet made of lead completely covered, except for the base, with copper alloy (approximately 90 copper-10 zinc).

3.7 Jacketed Soft Point (JSP)

A bullet made of lead completely covered, except for the point, with copper alloy (approximately 90 copper-10 zinc).

3.8 Lead Bullet

A bullet made of lead, which may be alloyed with hardening agents.

3.9 Penetration

Complete perforation of an armor test sample by a test bullet or by a fragment of the bullet or armor, as evidenced by the presence of that bullet or a fragment in the backing material, or by a hole which passes through the backing material.

3.10 Semi-Wadcutter

A bullet shape characterized by a flat nose and a tapered section leading to a cylindrical bullet body with a sharp break where the taper meets the body.

3.11 Strike Face

The surface of an armor designated by the manufacturer as the surface that should face the ballistic threat.

3.12 Wear Face

The surface of an armor designated by the manufacturer as the surface that should be worn toward the body.

4. REQUIREMENTS

4.1 Acceptance Criteria

An armor style satisfies the requirements of this standard if all four sample items (see sec. 5.1) meet the workmanship (see sec. 4.3) and labeling (see sec. 4.4) requirements and when tested in accordance with section 5.5, each part of the armor (torso front, back, side, groin and coccyx) meets the penetration and deformation requirements (see sec. 4.5) both wet and dry.

4.2 Test Sequence

Tests shall be conducted in the order presented in sections 5.3 through 5.5 of this standard.

4.3 Workmanship

Each armor shall be free from wrinkles, blisters, cracks or fabric tears, crazing, chipped or sharp corners and other evidences of inferior workmanship.

4.4 Labeling

Each set of ballistic-resistant armor shall be clearly and durably marked (labeled) in a readable type size in accordance with the requirements set forth below.

4.4.1 Ballistic Panels

Every ballistic panel shall have a label. The label shall be applied (attached) to either exterior surface of the panel. The label shall contain the following information:

a) name, logo or other identification of the manufacturer
b) the rated level of protection, according to section 2 of this standard, and referenced to this edition of the standard (i.e., type II in accordance with NIJ Standard-0101.03)
c) size (if custom fitted, provision for the name of the individual for whom it is made)
d) lot number
e) date of issue line
f) a model or style designation that uniquely identifies the panel for purchasing purposes (panels designed to fit the male and female torso shall have separate model/style designations)
g) 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
h) serial number
i) care instructions for the ballistic material in accordance with 16 CFR 423[2]
j) for type I through type III-A armor, a warning in type at least 1.5 times 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 rifle fire and, if applicable, that the armor is not intended to protect the wearer from sharp edged or pointed instruments. (Note: Printing color changes are acceptable but cannot be substituted for the type size requirement herein.)
k) certification of compliance with NIJ Standard-0101.03.

4.4.2 Armor Carriers with Nonremovable Ballistic Panels

Armor with ballistic panels that are nonremovable shall, in addition to the label required for the ballistic element, have a label on the carrier that is in conformance with the requirements for the ballistic panels (sec. 4.4.1) unless the armor is so constructed that the ballistic panel label is not covered by the carrier.

4.4.3 Armor Carriers with Removable Ballistic Panels

Armor carriers with removable ballistic panels shall have label(s) on either exterior surface of the carrier. If the carrier is one piece (i.e., all parts are sewn together into one garment) one (1) label in conformance with

[2] Part 423, Care Labeling of Textile Wearing Apparel and Certain Piece Goods, as amended effective January 2, 1984; Federal Trade Commission Regulation Rule.

the requirements of this section is sufficient. If the front and the back of the carrier are separable, the front and back parts shall each be labeled. The label shall contain the following information:

a) name, logo or other identification of the manufacturer
b) a statement telling the user to look at the ballistic panels to determine the protection provided
c) size (if custom fitted, provision for the name of the individual for whom it is made)
d) date of issue line
e) a model or style designation that uniquely identifies the garment for purchasing purposes (armor designed to fit the male and female torso shall have separate model/style designations)
f) care instructions for the armor carrier in accordance with 16 CFR 423[2]
g) certification of compliance with NIJ Standard-0101.03.

4.5 Ballistic Penetration and Deformation

One complete armor (each part) shall be tested for resistance to ballistic penetration and ballistic deformation in accordance with section 5.5 after wet conditioning in accordance with section 5.2.10. A second complete armor shall be tested in accordance with section 5.5 in the dry condition. Penetration by any fair hit, deformation to a depth greater than 44 mm (1.73 in), or penetration by a bullet at a velocity lower than the minimum required impact velocity in either test, shall constitute failure. A bullet that impacts too close to the edge or to a prior hit and/or at too high a velocity, but does not penetrate, shall be considered a fair hit for penetration purposes. A bullet that impacts at too high a velocity, but is otherwise a fair hit that produces a backface signature less than 44 mm (1.73 in) deep, shall be considered a fair hit for the determination of deformation. The detailed requirements are summarized in table 1.

At the option of the tester, a type I, II-A, II or III-A armor part which has successfully withstood six fair hits with one test ammunition may thereupon be tested with the second test ammunition. However, if failure occurs with the second test ammunition a retest shall be conducted. A second specimen of that armor part shall be tested with the second test ammunition and the results of that test shall govern.

Type I, II-A, II or III-A armor designed to include a removable insert for additional ballistic or blunt trauma protection over a localized area of the panel shall be tested without the insert.

5. TEST METHODS

5.1 Sampling

Four complete armors, selected at random and sized to fit a 117 cm (46 in) to 122 cm (48 in) chest circumference, shall constitute a test sample. (Note: The larger the size, the more likelihood that all ballistic testing will fit on just two complete armors.)

5.2 Test Equipment and Setup

It should be noted that hand-loaded ammunition may be required to achieve some of the bullet velocities required in the following sections. The test weapon may be a handgun, rifle, or test barrel chambered as appropriate for the test bullet required by the type of armor that is being tested.

5.2.1 Type I Test Weapons and Ammunition

5.2.1.1 22 LR

Test bullets shall be 22 Long Rifle High Velocity lead, with nominal masses of 2.6 g (40 gr) and a minimum measured velocity of 320 m (1050 ft) per second.

5.2.1.2 38 Special

Test bullets shall be 38 Special round nose lead, with nominal masses of 10.2 g (158 gr) and a minimum measured velocity of 259 m (850 ft) per second.

TABLE 1. *Test Summary.*

Armor type	Test variables				Performance requirements		
	Test Round	Test ammunition	Nominal bullet mass	Minimum required bullet velocity	Required fair hits per armor part at 0° angle of incidence	Maximum depth of deformation	Required fair hits per armor part at 30° angle of incidence
I	1	38 Special RN Lead	10.2 g 158 gr	259 m/s (850 ft/s)	4	44 mm (1.73 in)	2
	2	22 LRHV Lead	2.6 g 40 gr	320 m/s (1050 ft/s)	4	44 (1.73 in)	2
II-A	1	357 Magnum JSP	10.2 g 158 gr	381 m/s (1250 ft/s)	4	44 mm (1.73 in)	2
	2	9 mm FMJ	8.0 g 124 gr	332 m/s (1090 ft/s)	4	44 mm (1.73 in)	2
II	1	357 Magnum JSP	10.2 158 gr	425 m/s (1395 ft/s)	4	44 mm (1.73 in)	2
	2	9 mm FMJ	8.0 g 124 gr	358 m/s (1175 ft/s)	4	44 mm (1.73 in)	2
III-A	1	44 Magnum Lead SWC Gas Checked	15.55 g 240 gr	426 m/s (1400 ft/s)	4	44 mm (1.73 in)	2
	2	9 mm FMJ	8.0 g 124 gr	426 m/s (1400 ft/s)	4	44 mm (1.73 in)	2
III		7.62 mm (308 Winchester) FMJ	9.7 g 150 gr	838 m/s (2750 ft/s)	6	44 mm (1.73 in)	0
IV		30–06 AP	10.8 g 166 gr	868 m/s (2850 ft/s)	1	44 mm (1.73 in)	0
Special requirement (see sec. 2.2.7)*		*	*	*	*	44 mm (1.73 in)	*

* These items must be specified by the user. All of the items must be specified.

Notes: Armor parts covering the torso front and torso back, with or without side coverage, shall each be impacted with the indicated number of fair hits. Armor parts covering the groin and coccyx shall each be impacted with three fair hits at 0° angle of incidence. The deformation due to the first fair hit shall be measured to determine compliance. No fair hit bullet or one impacting at a velocity lower than the minimum required bullet velocity shall penetrate the armor.

Abbreviations:
AP – Armor Piercing
FMJ – Full Metal Jacketed
JSP – Jacketed Soft Point
LRHV – Long Rifle High Velocity
RN – Round Nose
SWC – Semi-Wadcutter

5.2.2 Type II-A Test Bullets

5.2.2.1 Lower Velocity 357 Magnum

Test bullets shall be 357 Magnum jacketed soft point, with nominal masses of 10.2 g (158 gr) and a minimum measured velocity of 381 m (1250 ft) per second.

5.2.2.2 Lower Velocity 9 mm

Test bullets shall be 9 mm full metal jacketed, with nominal masses of 8.0 g (124 gr) and a minimum measured velocity of 332 m (1090 ft) per second.

5.2.3 Type II Test Bullets

5.2.3.1 Higher Velocity 357 Magnum

Test bullets shall be 357 Magnum jacketed soft point, with nominal masses of 10.2 g (158 gr) and a minimum measured velocity of 425 m (1395 ft) per second.

5.2.3.2 Higher Velocity 9 mm

Test bullets shall be 9 mm full metal jacketed, with nominal masses of 8.0 g (124 gr) and a minimum measured velocity of 358 m (1175 ft) per second.

5.2.4 Type III-A Test Bullets

5.2.4.1 44 Magnum

Test bullets shall be 44 Magnum, lead semi-wadcutter with gas checks, nominal masses of 15.55 g (240 gr), and a minimum measured velocity of 426 m (1400 ft) per second.

5.2.4.2 Submachine Gun 9 mm

Test bullets shall be 9 mm full metal jacketed, with nominal masses of 8.0 g (124 gr) and a minimum measured velocity of 426 m (1400 ft) per second.

5.2.5 Type III Test Bullets

Test bullets shall be 7.62 mm full metal jacketed (U.S. military designation M80), with nominal masses of 9.7 g (150 gr) and a minimum measured velocity of 838 m (2750 ft) per second.

5.2.6 Type IV Test Bullets

Test bullets shall be 30 caliber armor-piercing (U.S. military designation APM2), with nominal masses of 10.8 g (166 gr) and a minimum measured velocity of 868 m (2850 ft) per second.

5.2.7 Special Type Test Bullets

The cartridge type, bullet construction, bullet caliber, bullet mass, and bullet minimum striking velocity must all be specified by the user.

5.2.8 Chronograph

The chronograph shall have a precision of 1 μs and an accuracy of 2 μs. Its triggering devices shall be of either the photoelectric or conductive screen type.

5.2.9 Armor Backing Material

The backing material shall be in the form of a single block at least 10.2 cm (4 in) thick and of sufficient length and width [approximately 61 × 61 cm (24 × 24 in)] to completely back the armor part to be tested.

The armor backing material shall be conditioned for at least 3 h at a temperature between 15 and 30 °C (59 and 95 °F), and shall be worked thoroughly to eliminate any voids. Its consistency shall be such that a depression of 25 ± 3 mm (1 ± 0.1 in) in depth is obtained when a 1 kg ± 10 gm (2.2 lb ± 0.35 oz) cylindrical steel mass, 44.5 ± 0.5 mm (1.75 ± 0.02 in) in diameter and having a hemispherical striking end, is dropped from a height of 2 m ± 2 cm (6.5 ± 0.07 in) onto one of its square faces. Three drop tests shall be made, and the center of each impact site shall be at least 76 mm (3 in) from a previous impact site and from any edge. A guide tube or other means may be used as required to assure that the striking end of the cylindrical mass impacts the backing material squarely. The backing material may be maintained at any temperature in the above range that will give it the required consistency when conducting the tests described in section 5.5.

A backing material found to be suitable is Roma Plastilina No. 1 modeling clay, available from Sculpture House, Inc., 38 East 30th St., New York, NY 10016, and other artist supply centers.[3]

[3] The use of brand names in this standard does not constitute endorsement by the National Bureau of Standards, the National Institute of Justice, or any other agency of the Federal Government, nor does it imply that the product is best suited for its intended application.

5.2.10 Wet Armor Conditioning

The complete armor shall be conditioned by subjecting both sides of each armor part to a water spray under the following conditions:

The spray nozzles shall be of such size and so spaced that 10 ± 2 L (2.5 ± 0.5 gal) of water per hour falls uniformly distributed on each 0.1 m^2 (1 ft^2) of spray booth floor area. Orient the nozzles so that when the droplets strike the armor surface they fall from gravitational force.

Each surface of each armor part shall be sprayed for 3 min. Spray the strike face last. Ballistic testing shall begin immediately after the armor is removed from the spray. The armor must be completely tested within 30 min of the moment the armor is removed from the spray; if the testing has not been completed in the time permitted, the test data shall be discarded and wet testing must begin again with new armor.

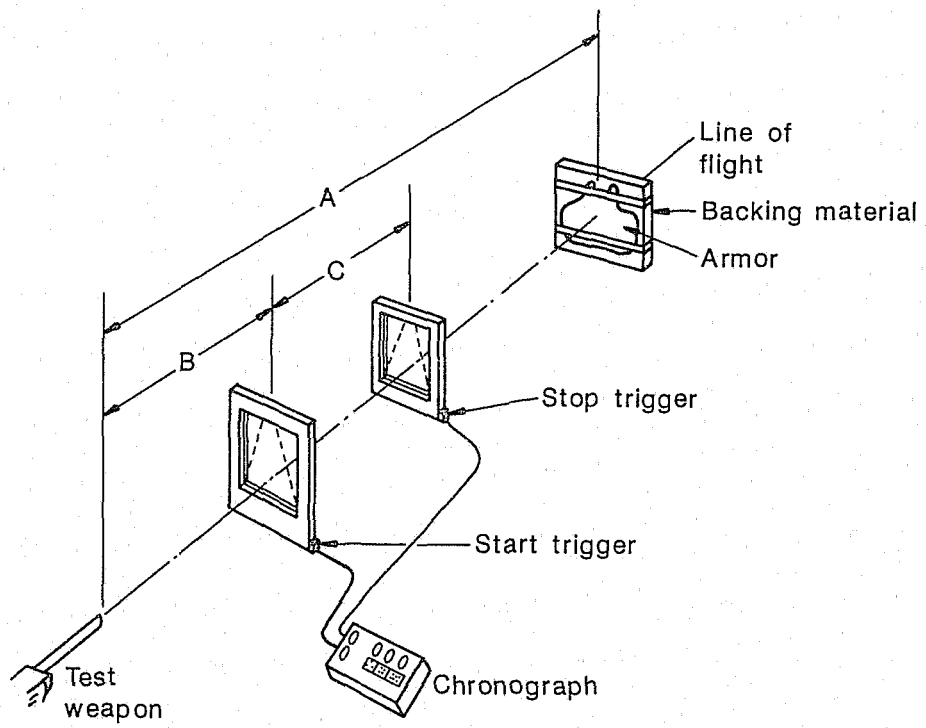
5.2.11 Test Preparation

Set up the test equipment as shown in figure 2. Use a test barrel or weapon appropriate for the ammunition required to test the armor (table 1) and firmly clamp it in place with the barrel horizontal.

Allow all electronic equipment to warm up until stability is achieved. During testing, maintain the ambient temperature at 20–28 °C (68–82 °F) and the relative humidity at 30 to 70 percent.

Condition the armor backing material and test it for consistency in accordance with section 5.2.9. Reshape and smooth the backing material to its defined dimensions, and maintain it at the temperature required to maintain the required consistency.

Place the chronograph start trigger screen a minimum of 2 m (6.6 ft), from the muzzle of the test weapon and the stop trigger screen a suitable distance from it [approximately 1/2 to 1.5 m (1.6 to 4.9 ft)]. Arrange the screens so that they define planes perpendicular to the line of flight of the bullet. Measure the distance between the triggering planes with an accuracy of 1 mm (0.04 in).



A – 5 m for type I, II–A, II, and III–A armors;
15 m for type III and IV armors.

B – 2 m minimum

C – Approximately 0.5 to 1.5 m

FIGURE 2. *Ballistic test setup.*

5.3 Workmanship Examination

Examine the complete armor. Note any evidence of inferior workmanship in accordance with the requirements of section 4.3.

5.4 Label Examination

Examine the complete armor and each part for conformance to the labeling requirement of section 4.4. Note any deviations from the requirements.

5.5 Ballistic Tests

5.5.1 Penetration and Backface Signature Tests Types I, II-A, II, and III-A Armor

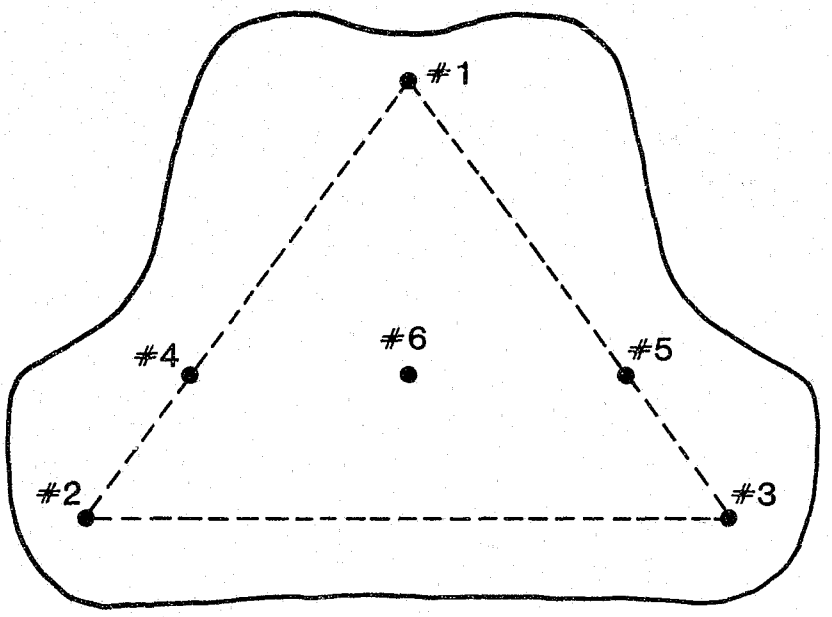
Select the required test bullet as appropriate for the armor type as specified in sections 5.2.1 through 5.2.4. Use test bullet number 1 as specified for the armor type in table 1. Fire a sufficient number of pretest rounds to have a reasonable assurance that the first test round fired at the armor will strike the armor with a velocity no more than 15 m/s (50 ft/s) above the minimum required test round velocity. Position a sheet of cardboard 5 m (16 ft) from the muzzle of the test weapon. Fire the last pretest round through the cardboard to determine the line of flight and point of impact of the bullet; alternatively, use an aiming light or other suitable means for positioning.

Remove all removable inserts. Precondition one complete armor in accordance with section 5.2.10. Place one of the square faces of the armor backing material in intimate contact with the back face of the armor specimen under test and secure it with tape, straps or other means which leave the strike face impact area exposed, but will not permit the armor to shift on the backing material when impacted. Place this assembly in back of the sheet of cardboard with the armor front face perpendicular to the line of flight of the bullet (0° angle of incidence) so that the desired point of impact touches the bullet hole in the cardboard made by the pretest round, then remove the cardboard.The desired points of impact for the six test hits required by this procedure are shown in figure 3.

Fire the first test round at the armor at location no. 1 in figure 3, using the chronograph to determine the bullet velocity. Examine the armor and the backing material to determine if the bullet made a fair hit and whether penetration occurred. If no penetration occurred and the bullet made a fair hit, measure and record the depth of the depression made in the armor backing material. The depth of the depression is the distance from the original undisturbed surface of the backing material to the lowest point of the depression. If the depth of the depression complies with the requirement of section 4.5, the armor meets the requirements of section 4.5. If the depth of depression is greater than permitted, and the velocity exceeds the minimum test velocity by more than 15 m/s (50 ft/s), the backing material shall be reconditioned, the armor smoothed and another attempt made to obtain a fair hit. This second attempt will be made to impact the same general area of the armor as the first shot but more than 2 in from the previous shot and more than 3 in from any edge of the armor. This process is repeated until a fair hit for backface signature is obtained, following which the depth of the depression shall be measured to determine compliance with the requirements of section 4.5.

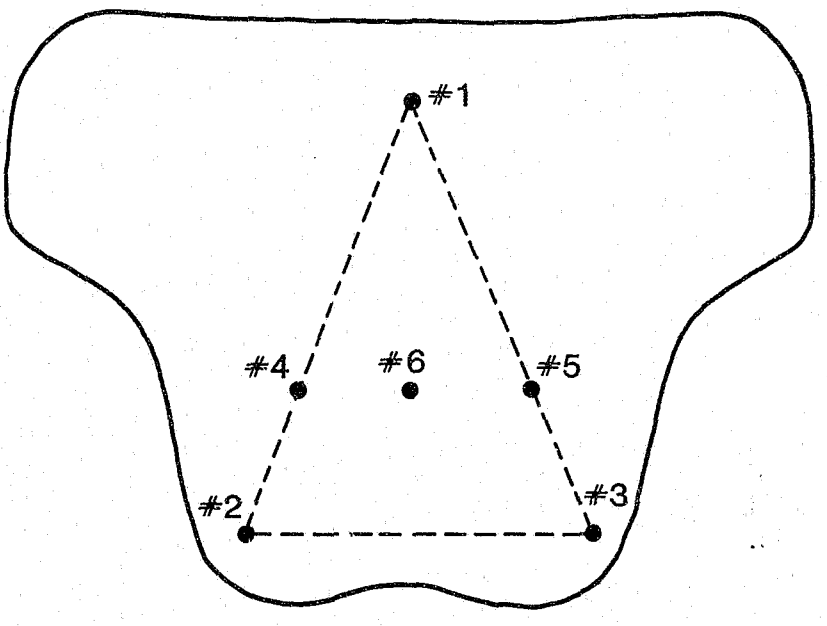
If no failure has occurred, replace the armor on the backing material in its original position without reconditioning the backing material (do not smooth the dent) and without removing the first test bullet if it is trapped in the armor. The velocity of the remaining rounds in the test sequence that follows shall meet the requirements shown in table 1, as appropriate for the test ammunition. When conducting the following firing sequence, inspect the armor following each test round to verify that the impact was a fair hit. If not, repeat the test at that general location on the armor until a fair hit is obtained before proceeding to the next test location.

Reposition the armor and backing material so that the test shot will impact the armor at location number 2 shown in figure 3. Fire the test round. Without disturbing the relationship between the armor and the backing material (do not remove any trapped bullets from the armor and do not smooth it), reposition the assembly so that the test round will impact the armor at location no. 3 shown in figure 3. Fire the test round. Without disturbing the relationship between the armor and the backing material, reposition the assembly so that the defined angle of incidence between the perpendicular to the armor and the line of flight of the test round is 30° and so that the bullet will be directed towards the center of the armor part and so the bullet will impact the armor at location no. 4 of figure 3. Fire the test round. Without disturbing the relationship between the armor and the backing material, reposition the assembly so that the angle of incidence for the test round is 30° and so that the bullet will be directed towards the center of the armor part and so the bullet will impact the armor at location no. 5 of figure 3. Fire the test round. Without disturbing the relationship between the



All shots at least 7.6 cm (3 in) from any edge and at least 5 cm (2 in) from another shot

A. Test ammunition shot series



All shots at least 7.6 cm (3 in) from any edge and at least 5 cm (2 in) from another shot

B. Optional second ammunition shot series

FIGURE 3. *Test pattern*

armor and the backing material, reposition the assembly so that the angle of incidence for the test round is 0° and so that the bullet will impact the armor at location no. 6 of figure 3. Examine the armor and backing material for penetrations.

For body armor sized and shaped for female officers, the bust cups shall be filled with backing material conditioned at the same time as the main body of the backing material and in the same manner; however, the drop test for consistency does not have to be performed. Further, impact locations 4 and/or 5 of the above test sequence shall be such that at least one of the 30° angle of incidence shots shall impact on a bust cup. If the bust cup contains one or more seams, the shot shall impact a seam.

Recondition the backing material. Repeat the test sequence described above using the test round number 2 from table 1 as required for the armor type that is being tested. If there is room on the armor part, it may be turned upside-down and the second test sequence may be performed. If there is no room on the armor part, repeat the above test sequence with a new armor part using the second ammunition type.

If no failure has occurred (see sec. 4.5), repeat the entire test procedure as described with both test rounds using dry armor.

5.5.2 Penetration and Backface Signature Tests Type III Armor

Position a sheet of cardboard 15 m (50 ft) from the muzzle of the test weapon. Fire a pretest round of the bullet specified in section 5.2.6 through the cardboard to locate the bullet impact point so that the armor can be correctly positioned; alternatively, use an aiming light or other suitable means.

Precondition one complete armor in accordance with section 5.2.10. Place one of the square faces of the armor backing material in intimate contact with the back face of the armor specimen under test and secure it with tape, straps or other means which leave the strike face impact area exposed. If the armor is rigid and contoured to fit a human torso, such that the back surface of the armor does not come in contact with the surface of the backing material, build up the front surface of the backing material to achieve contact with the back surface of the armor. The backing material used for this purpose shall be conditioned at the same time as the main body of the backing material and in the same manner; however, the drop test for consistency does not have to be performed on the built-up section. Place this assembly in back of the sheet of cardboard with the armor front face perpendicular to the line of flight of the bullet so that the center area of the armor is aligned with the bullet hole in the cardboard made by the pretest round, then remove the cardboard.

Fire a test round at the armor using the chronograph to determine the bullet velocity. Examine the armor and the backing material to determine if the bullet made a fair hit and whether penetration or spalling occurred.

If no failure has occurred, reposition the armor so as to space five additional impacts evenly over its surface at 0° obliquity for a total of six fair hits. Place each successive fair hit as far as possible from the center of each armor part. Reposition the backing material (as required) to avoid any overlap of depressions. If there are seams in the ballistic material, place the required number of fair hits so as to include at least one impact directly on a seam.

If no penetration has occurred, measure and record the depth of the depression made in the armor backing material for the two highest velocity fair hits. The depth of the depression is the distance from the original undisturbed surface of the backing material to the lowest point of the depression. Note whether the depth of the depression is in compliance with the requirements of section 4.5.

If no failure has occurred, repeat the entire test procedure as specified above using dry armor.

5.5.3 Penetration and Backface Signature Test Type IV Armor

Position a sheet of cardboard 15 m (50 ft) from the muzzle of the test weapon. Fire a pretest round of the bullet specified in section 5.2.7 through the cardboard to locate the bullet impact point so that the armor can be correctly positioned; alternatively, use an aiming light or other suitable means.

Precondition one complete armor in accordance with section 5.2.10. Place one of the square faces of the armor backing material in intimate contact with the back face of the armor specimen under test and secure it with tape, straps or other means which leave the strike face impact area exposed. If the armor is rigid and contoured to fit a human torso, such that the back surface of the armor does not come in contact with the surface of the backing material, build up the front surface of the backing material to achieve contact with the back surface of the armor. The backing material used for this purpose shall be conditioned at the same time as the main body of the backing material and in the same manner; however, the drop test for consistency does not have to be performed on the built-up section. Place this assembly in back of the sheet of cardboard with the armor front face perpendicular to the line of flight of the bullet so that the center area of the armor is

aligned with the bullet hole in the cardboard made by the pretest round, then remove the cardboard.

Fire a test round at the armor using the chronograph to determine the bullet velocity. Examine the armor and the backing material to determine if the bullet made a fair hit and whether penetration or spalling occurred.

If no penetration has occurred, measure and record the depth of the depression made in the armor backing material. The depth of the depression is the distance from the original undisturbed surface of the backing material to the lowest point of the depression. Note whether the depth of the penetration is in compliance with the requirements of section 4.5.

If no failure has occurred, repeat the entire test procedure as specified above using dry armor.

5.5.4 Penetration and Backface Signature Test (Special Type)

If the armor is principally made of fabric, use the test procedure of section 5.5.1.

If the armor is principally nonfabric, rigid, or "hard" (metal plates or ceramic with a small amount of fabric to act as a trauma shield or to catch backface fragments from the main ballistic resistance element) use the test procedure of section 5.5.2 or 5.5.3 depending upon the armor type.

APPENDIX A—BODY ARMOR SELECTION

Police administrators should make every effort to encourage their officers to wear body armor throughout each duty shift. Although designed primarily to provide protection against handgun assault, soft 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. If the officers cited in the fatality statistics in the Federal Bureau of Investigation report, "Law Enforcement Officers Killed and Assaulted," are representative of all police, it would appear that only about 20 percent of all officers routinely wear their armor. A large percentage of the officer fatalities could have been prevented if the officer had been wearing armor at the time of the assault.

Before purchasing body armor one should read NIJ Guide 100-87, "Selection and Application Guide to Police Body Armor," which discusses armor in depth.

The fundamental considerations are the threat to which officers are exposed and their own service weapons. A knowledge of the street weapons in the local area (confiscated weapons are a good indicator) is essential, for the armor should be selected to protect against the street threat, or service weapons, whichever is the greater threat. Throughout the last decade, one in five officers killed was shot with his or her own weapon. Full coverage of the torso is critical since fatalities among officers wearing armor resulting from bullets entering the side of an officer through the opening between front and rear panels are common.

Type I body armor, which was issued during the NIJ demonstration project, is the minimum level of protection that any officer should have, and is totally suitable for full-time wear. A number of departments desiring more than minimum protection wear type II-A armor, which has been found sufficiently comfortable for full-time wear where the threat warrants it, particularly for those departments that use lower velocity 357 Magnum service weapons. Type II armor, heavier and more bulky than type II-A, is worn full time by some departments, but may not be considered suitable for full-time use in hot, humid climates. Type III-A armor, which provides the highest level of protection available as soft body armor, is generally considered to be unsuitable for routine wear, however, individuals confronted with a terrorist threat may be willing to tolerate the weight and bulk of such armor while on duty. Type III and IV armor are clearly intended for use only in tactical situations when the threat warrants such protection.

It is absolutely essential that those who select body armor and each officer who wears it realize that there is no such thing as a *bulletproof* vest. The routine use of appropriate soft body armor *significantly* reduces the likelihood of fatal injury, but 100-percent protection in all circumstances is impossible. Body armor selection is to some extent a tradeoff between ballistic protection and wearability. The weight and comfort of soft body armor is inversely proportional to the level of ballistic protection that it provides.

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