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Technology Assessment Program

Ballistic Resistant Protective Materials

NIJ Standard 0108.01

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This standard was formulated by the Law Enforcement Standards Laboratory (LESL) of the National Bureau of Standards under the direction of Daniel E. Frank, Manager, Protective Equipment Program and Lawrence K. Eliason, Chief of LESL. The technical research was performed by Nicholas J. Calvano of the Automated Production Technology Division. The standard has been reviewed and approved by the Technology Assessment Program Advisory Council and adopted by the International Association of Chiefs of Police (IACP) as an IACP standard.

FOREWORD

This document, NIJ standard-0108.01, Ballistic Resistant Protective Materials, 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 can 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.

NIJ standards are subjected to continuing review. Technical comments and recommended revisions are welcome. Please send suggestions to the Program Manager for Standards, National Institute of Justice, U.S. Department of Justice, 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: Chief, Law Enforcement Standards Laboratory, National Bureau of Standards, Gaithersburg, MD 20899.

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NIJ STANDARD
FOR
BALLISTIC RESISTANT
PROTECTIVE MATERIALS

CONTENTS

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 x 0.03048000 = m/s
ft x 0.3048 = m
ft•lbf x 1.355818 =J
gr x 0.06479891 = g
in x 2.54 = cm
kWh x 3,6000,000 = J
lb x 0.4535924 = kg
lbf x 4.448222 = N
lbf/ft x 14.59390 = N/m
lbf•in x 0.1129848 = N•m
lbf/in^2 x 6894.757 = Pa
mph x 1.609344 = km/h
qt x 0.9463529 = L

Temperature: (T °F-32) x 5/9 = T °C
Temperature: (T °C x 9/5)+32 = T °F

NIJ STANDARD
FOR
BALLISTIC RESISTANT
PROTECTIVE MATERIALS

1. PURPOSE

The purpose of this standard is to establish minimum performance requirements and methods of test for ballistic resistant protective materials. This standard supersedes NIJ Standard-0108.00, Ballistic Resistant Protective Materials, dated December 1981. This revision adds threat level III-A and establishes threat level classifications that are consistent with other NIJ standards for ballistic protection.

2. SCOPE AND CLASSIFICATION

2.1 Scope

This standard is applicable to all ballistic resistant materials (armor) intended to provide protection against gunfire, with the exception of police body armor and ballistic helmets, which are the topic of individual NIJ performance standards [1,2][1]. Many different types of armor are now available that range in ballistic resistance from those designed to protect against small-caliber handguns to those designed to protect against high-powered rifles. Ballistic resistant materials are used to fabricate portable ballistic shields, such as a ballistic clipboard for use by a police officer; to provide ballistic protection for fixed structures such as critical control rooms or guard stations; and to provide ballistic protection for the occupants of vehicles. The ballistic resistant materials used to fabricate armor include metals, ceramics, transparent glazing, fabric, and fabric-reinforced plastics; they are used separately or in combination, depending upon the intended threat protection.

The ballistic threat posed by a bullet depends, among other things, on its composition, shape, caliber, mass, 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 a higher velocity. Similarly, for identical striking velocities, nondeforming or armor-piercing rounds pose a significantly greater penetration threat than an equivalent lead core round of the same caliber. The test ammunitions specified in this standard represent common threats to the law enforcement community.

2.2 Classification

Ballistic resistant protective materials covered by this standard are classified into five types, by level of performance.

2.2.1 Type 1 (22 LR; 38 Special)

[1] Numbers in brackets refer to the references in appendix A.

This armor protects against the standard test rounds as defined in section 5.2.1. It also provides protection against lesser threats such as 12 gauge No. 4 lead shot and most handgun rounds in calibers 25 and 32.

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

This armor protects against the standard test rounds as defined in section 5.2.2. It also provides protection against lesser threats such as 12 gauge 00 buckshot, 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 2.2.1.

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

This armor protects against the standard test rounds as defined in section 5.2.3. It also provides protection against most other factory loads in caliber 357 Magnum and 9 mm, as well as threats mentioned in section 2.2.1 and 2.2.2.

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

This armor protects against the standard test rounds as defined in section 5.2.4. It also provides protection against most handgun threats as well as the threats mentioned in sections 2.2.1 through 2.2.3.

2.2.5 Type III (High-Powered Rifle)

This armor protects against the standard test round as defined in section 5.2.5. It also provides protection against most lesser threats such as 223 Remington (5.56 mm FMJ), 30 Carbine FMJ, and 12 gauge rifle slug, as well as the threats mentioned in sections 2.2.1 through 2.2.4.

2.2.6 Type IV (Armor-Piercing Rifle)

This armor protects against the standard test round as defined in section 5.2.6. It also provides at least single hit protection against the threats mentioned in sections 2.2.1 through 2.2.5.

2.2.7 Special Type

A purchaser having a special requirement for a level of protection other than one of the above standards should specify the exact test rounds 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 (see fig. 1). Also known as angle of obliquity.

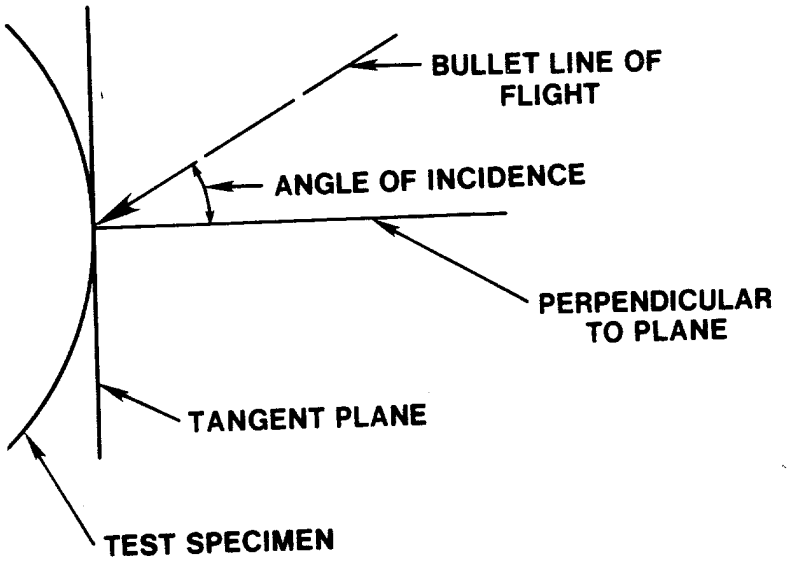


FIGURE 1. *Angle of incidence*

3.2 Fair Hit

A hit that impacts the ballistic resistant protective material at an angle of incidence no greater than 5°, and is at least 5 cm (2 in) from a prior hit or the edge of the test specimen and at an acceptable velocity as defined in this standard. A bullet that impacts too close to the edge or a prior hit and/or at too high a velocity, but does not penetrate, shall be considered a fair hit for the determination of nonpenetration..

3.3 Full Metal Jacketed (FMJ) Bullet

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

3.4 Jacketed Soft Point (JSP) Bullet

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

3.5 Lead Bullet

A bullet made of lead alloyed with hardening agents

3.6 Penetration

Perforation of a witness plate by any part of the test specimen or test bullet, as determined by passage of light when held up to a 60-W light bulb.

3.7 Strike Face

The surface of a ballistic resistant protective material designated by the manufacturer as the surface that should be exposed to (face) the weapon threat.

3.8 Semiwadcutter

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.

3.9 Witness Plate

A thin sheet of aluminum alloy placed behind a test specimen to determine the potential for an incapacitating injury.

4. REQUIREMENTS

4.1 Acceptance Criteria

A ballistic material satisfies the requirements of this standard if the sample item (see sec. 5.1) meets the requirements of sections 4.2 through 4.4.

4.2 Workmanship

Ballistic resistant protective materials shall be free from dents, blisters, cracks, crazing, chipped or sharp corners, and other evidence of inferior workmanship.

4.3 Labeling

The Sample item and each full size panel of ballistic resistance material shall be permanently and legibly labeled and shall include the following information.

a) Name, designation, or logo of the manufacturer
b) Type of material, according to section 2 of this standard
c) Month and year of manufacture
d) Lot number
e) Strike face, if any
f) Certification of compliance with this edition of this standard

Items c and d may be incorporated into a single number, e.g., a serial number.

4.4 Ballistic Resistance

The ballistic resistance of each test specimen of ballistic resistant protective material shall be determined in accordance with section 5.3. The test weapon and ammunition used during this test shall be those specified in table 1 in accordance with the type (threat level rating) specified by the manufacturer (sec. 4.3). Any penetration of the witness plate shall constitute failure.

The ballistic resistance test variables and test requirements are presented in table 1.

Table 1. *Test Summary*

Test Variables				Performance Requirements		
Armor Type	Test Ammunition	Nominal Bullet Mass	Suggested Barrel Length	Required Bullet Velocity	Required Hits Per Armor Specimen	Permitted Penetrations
I	22 LRHV Lead	2.6 g 40 gr	15 to 16.5 cm 6 to 6.5 in	320 ± 12 m/s 1050 ± 40 ft/s	5	0
	38 Special RN Lead	10.2 g 158 gr	15 to 16.5 cm 6 to 6.5 in	259 ± 15 m/s 850 ± 50 ft/s	5	0
II-A	357 Magnum JSP	10.2 g 158 gr	10 to 12 cm 4 to 4.75 in	381 ± 15 m/s 1250 ± 50 ft/s	5	0
	9 mm FMJ	8.0 g 124 gr	10 to 12 cm 4 to 4.75 in	332 ± 12 m/s 1090 ± 40 ft/s	5	0
II	357 Magnum JSP	10.2 g 158 gr	15 to 16.5 cm 6 to 6.5 in	425 ± 15 m/s 1395 ± 50 ft/s	5	0
	9 mm FMJ	8.0 g 124 gr	10 to 12 cm 4 to 4.75 in	358 ± 12 m/s 1175 ± 40 ft/s	5	0
III-A	44 Magnum Lead SWC Gas Checked	15.55 g 240 gr	14 to 16 cm 5.5 to 6.25 in	426 ± 15 m/s 1400 ± 50 ft/s	5	0
					5	0
	9 mm FMJ	8.0 g 124 gr	24 to 26 cm 9.5 to 10.25 in	426 ± 15 m/s 1400 ± 50 ft/s		
III	7.62 mm 308 Winchester FMJ	9.7 g 150 gr	56 cm 22 in	838 ± 15 m/s 2750 ± 50 ft/s	5	0
IV	30-06 AP	10.8 g 166 gr	56 cm 22 in	868 ± 15 m/s 2850 ± 50 ft/s	1	0
Special Requirement (see sec. 2.2.7)*	*	*	*	*	*	*

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

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

5. TEST METHODS

5.1 Sampling

The test specimen shall be a current production sample of the ballistic resistant material at least 30.5x30.5 cm (12x12 in).

5.2 Test Equipment

It should be noted that hand-loaded ammunition may be required to achieve some of the bullet velocities required in the following sections.

5.2.1 Type I Test Weapons and Ammunition

5.2.1.1 22 LR

The test weapon may be a 22-caliber handgun or test barrel. The use of a handgun with a 10 to 12 cm (6 to 6.5 in) barrel is suggested. Test bullets shall be 22 Long Rifle High Velocity lead, with nominal masses of 2.6 g (40 gr) and measured velocities of 320 ± 12 m (1050 ± 40 ft) per second.

5.2.1.2 38 Special

The test weapon may be a 38 Special handgun or test barrel. The use of a handgun with a 15 to 16.5 cm (6 to 6.5 in) barrel is suggested. Test bullets shall be 38 Special round-nose lead, with nominal masses of 2.6 g (158 gr) and measured velocities of 259 ± 15 m (850 ± 50 ft) per second.

5.2.2 Type II-A Test Weapons and Ammunition

5.2.2.1 Lower Velocity 357 Magnum

The test weapon may be a 357 Magnum handgun or test barrel. The use of a handgun with a 10 to 12 cm (4 to 4.75 in) barrel is suggested. Test bullets shall be 357 Magnum jacketed soft point, with nominal masses of 10.2 g (158 gr) and measured velocities of 381 ± 15 m (1250 ± 50 ft) per second.

5.2.2.2 Lower Velocity 9 mm

The test weapon may be a 9 mm handgun or test barrel. The use of a handgun with a 10 to 12 cm (4 to 4.75 in) barrel is suggested. Test bullets shall be 9 mm full metal jacketed, with nominal masses of 8.0 g (124 gr) and measured velocities of 332 ± 12 m (1090 ± 40 ft) per second.

5.2.3 Type II Test Weapons and Ammunition

5.2.3.1 Higher Velocity 357 Magnum

The test weapon may be a 357 Magnum handgun or test barrel. The use of a handgun with a 15 to 16.5 cm (6 to 6.5 in) barrel is suggested. Test bullets shall be 357 Magnum jacketed soft point, with nominal masses of 10.2 g (158 gr) and measured velocities of 425 ± 15 m (1395 ± 50 ft) per second.

5.2.3.2 Higher Velocity 9 mm

The test weapon may be a 9 mm handgun or test barrel. The use of a handgun with a 10 to 12 cm (4 to 4.75 in) barrel is suggested. Test bullets shall be 9 mm full metal jacketed, with nominal masses of 8.0 g (124 gr) and measured velocities of 358 ± 12 m (1175 ± 40 ft) per second.

5.2.4 Type III-A Test Weapons and Ammunition

5.2.4.1 44 Magnum

The test weapon may be a 44 Magnum handgun or test barrel. The use of a handgun with a 14 to 16 cm (5.5 to 6.25 in) barrel is suggested. Test bullets shall be 44 Magnum, lead semiwadcutter with gas checks, nominal masses of 15.55 g (240 gr), and measured velocities of 426 ± 15 m (1400 ± 50 ft) per second.

5.2.4.2 Submachine Gun (SMG) 9 mm

The test weapon may be a 9 mm SMG or test barrel. The use of a test barrel with a 24 to 26 cm (9.5 to 10.25 in) barrel is suggested. Test bullets shall be 9 mm full metal jacketed, with nominal messes of 8.0 g (124 gr) and measured velocities of 426 ± 15 m (1400 ± 50 ft) per second.

5.2.5 Type III Test Weapon and Ammunition

The test weapon may be a rifle or a test barrel chambered for 7.62-mm (308 Winchester) ammunition. The use of a rifle with a barrel length of 56 cm (22 in) is suggested. 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 measured velocities of 838 ± 15 m (2850 ± 50 ft) per second.

5.2.6 Type IV Test Weapon and Ammunition

The test weapon may be a rifle or a test barrel chambered for 30–06 ammunition. The use of a rifle with a barrel length of 56 cm (22 in) is suggested. Test bullets shall be 30 caliber armor piercing (U.S. military designation APM2), with nominal masses of 10.8 g (166 gr) and measured velocities of 868 ± 15 m (2850 ± 50 ft) per second.

5.2.7 Special Type Test Weapon and Ammunition

The test weapon, cartridge type, bullet construction, bullet caliber, bullet mass, and bullet 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 Support Fixture

The test specimen shall be supported by a fixture that permits its position and attitude to be readily adjusted so that it is perpendicular to the line of flight of the bullet at the point of impact.

5.2.10 Witness Plate

The witness plate shall be a 0.5 mm (0.020 in) thick sheet of 2024-T3 or 2024-T4 aluminum alloy and shall be placed and rigidly affixed perpendicular to the line of flight of the bullet and 15 cm (6 in) beyond the armor under test.

5.3 Ballistic Resistance Test

Condition the test specimen at a temperature of 20 to 28°C (68 to 82°F) for at least 24 h prior to test.

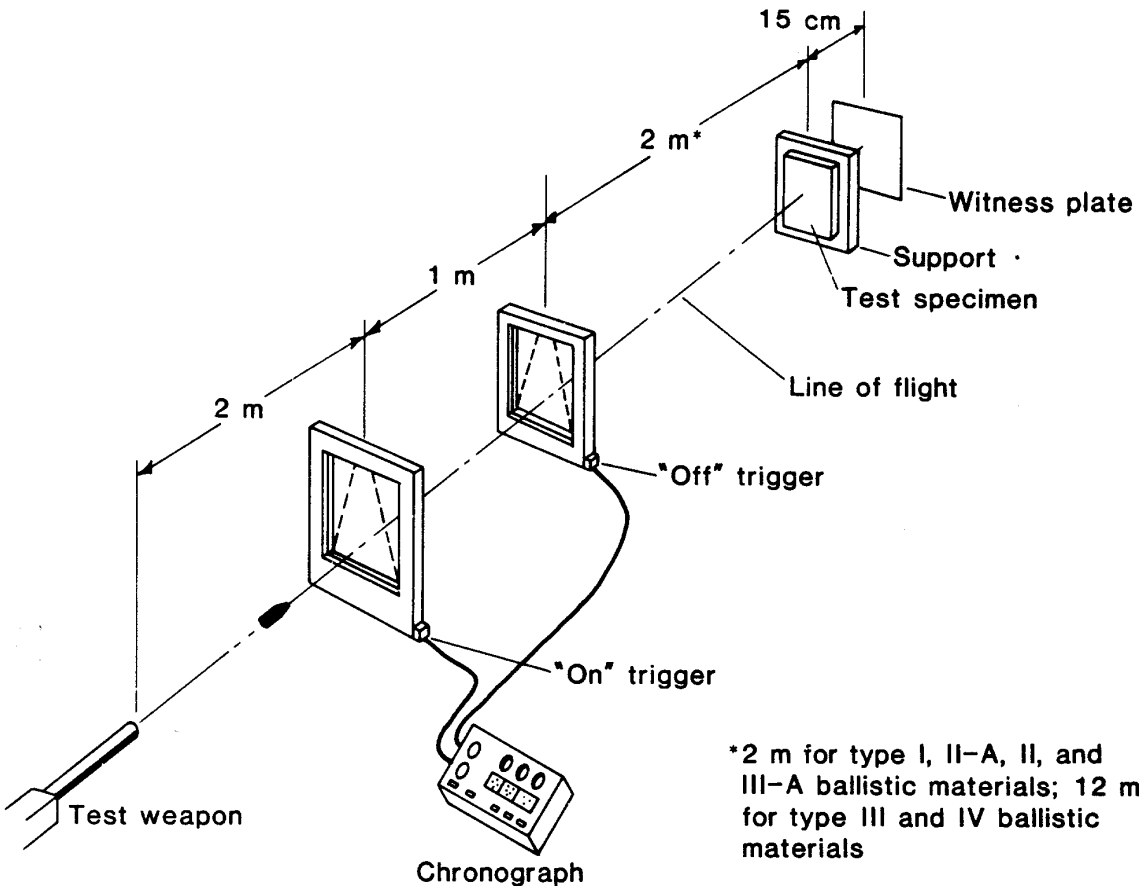
Place the triggering devices 2 and 3 m (6.6 and 9.8 ft), respectively from the muzzle of the test weapon as shown in fig. 2, and arrange them so that they define planes perpendicular to the line of flight of the bullet. Measure the distance between them with an accuracy of 1.0 mm (0.04 in). Use the time of flight and distance measurements to calculate the velocity of each test round.

After the specified test weapon has been supported, leveled, and positioned, fire one or more pretest rounds (as needed) through a witness plate to determine the point of impact.

Place the test specimen in the support fixture and position it 5 m (16 ft) from the muzzle of the test weapon. Then position an unperforated witness plate 15 cm (6 in) beyond the test specimen. Fire a test round and record the velocity of the bullet as measured by the chronograph. Examine the witness plate to determine penetration, and examine the specimen to see if the bullet made a fair hit.

If no penetration occurred, reposition the test specimen and repeat the procedure with additional test rounds until the test is completed. Space the hits as evenly as possible so that every portion of the test specimen is subject to test.

FIGURE 2. *Ballistic test setup*



APPENDIX A-REFERENCES

[1] Ballistic resistance of police body armor. NIJ Standard-0101.02. National Institute of Justice, U.S. Department of Justice, Washington, DC 20531.

[2] Ballistic helmets. NIJ Standard-0106.01. National Institute of Justice, U.S. Department of Justice, Washington, DC 20531; 1981 December.