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Test Procedure for Handgun Accuracy

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U.S. DEPARTMENT OF COMMERCE
Technology Administration
National Institute of Standards
and Technology
Electronics and Electrical Engineering Laboratory
Office of Law Enforcement Standards
Gaithersburg, MD 20899

Prepared for
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Office of Justice Programs
U.S. Department of Justice
Washington, DC 20531

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FOREWORD

The Office of Law Enforcement Standards (OLES) of the National Institute of Standards and Technology (formerly the National Bureau of Standards) furnishes technical support to the National Institute of Justice (NIJ) program to strengthen law enforcement and criminal justice in the United States. OLES's function is to conduct research that will assist law enforcement and criminal justice agencies in the selection and procurement of quality equipment.

OLES is: (1) Subjecting existing equipment to laboratory testing and evaluation and (2) conducting research leading to the development of several series of documents, including national voluntary equipment standards, user guides, and technical reports.

This document covers research on law enforcement equipment conducted by OLES under the sponsorship of NIJ. Additional reports as well as other documents are being issued under the OLES program in the areas of protective equipment, communications equipment, security systems, weapons, emergency equipment, investigative aids, vehicles, and clothing.

Technical comments and suggestions concerning this document are invited from all interested parties. They may be addressed to the Office of Law Enforcement Standards, National Institute of Standards and Technology, Gaithersburg, MD, 20899.

Lawrence K. Eliason, Director
Office of Law Enforcement Standards

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

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

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

TEST PROCEDURE FOR HANDGUN ACCURACY

Nicholas J. Calvano and Daniel E. Frank*
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A test procedure has been designed to determine the accuracy of handguns. The test procedure utilizes a collimated light beam as a means of establishing a fixed reference line to which the handgun sights are aligned. The aim point of the handgun once aligned is the center of the target, which is positioned on the reference line. The handgun accuracy is determined as the distance of the 10-shot bullet group from the aim point, expressed as the average value of the X and Y coordinates of the 10 shots.

Key words: aim point error; handgun accuracy; test procedure.

1. PURPOSE

This test procedure was developed to enable the measurement of the accuracy of handguns used by law enforcement officers. The test procedure is intended for use in measuring the accuracy[1] of revolvers and autoloading pistols that employ Patridge-type sights (or modifications thereof) with either fixed or adjustable rear sights.

2. SCOPE

The scope of this test procedure is limited to the measurement of handgun accuracy as defined in section 3. No attempt is made to establish limits for either handgun accuracy or the group size of multiple shots against the target.

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*Office of Law Enforcement Standards, Electronics and Electrical Engineering Laboratory.

[1]The accuracy of a handgun is ammunition specific; i.e., the results of the test will vary with different types of ammunition.

3. DEFINITIONS

3.1 Accuracy

Accuracy is the distance from the center of a shot group to the aim point on the test target. The center of the shot group is determined by calculating the average value of the X and Y coordinates of 10 shots relative to the aim point.

3.2 Aim Point

For the purposes of this test procedure the aim point is defined as a point on the target that coincides with the intersection of the reference line (see sec. 3.4) with the target.

3.3 Group Size

The group size is the diameter of the smallest circle that can be circumscribed around the outer edges of the 10 shots that impact the target.

3.4 Reference Line

The reference line is the line that extends from the handgun to the target established by the intersection of a vertical plane through the center of the front and rear sights with the plane of the top edges of the front and rear sights.

4. TEST EQUIPMENT

4.1 Ballistic Test Range

The ballistic test range shall provide a minimum firing distance of 7.6 m (25 ft), be equipped with a suitable bullet trap, provide a rigid mounting platform for the gun mount and a means of properly positioning the target.

4.2 Gun Mount

The gun mount shall restrain the handgun in a fixed firing position and provide adjustments for pitch and translation in increments of 0.025 mm (0.001 in) or less.

4.3 Light Source

The light source must produce a collimated beam of sufficient intensity to produce a distinct shadow of handgun sights at a minimum distance of 10 m (33 ft). The light source shall be equipped with a mask or diaphragm to provide a circular beam approximately 2 cm (3/4 in) in diameter.

A small halogen bulb in a housing with a collimating lens is a suitable light source. See appendix A.

The light source mount shall provide adjustments for height, translation and pitch, and once aligned retain the source in a fixed position throughout the test.

4.4 Shadow Screen

The shadow screen shall consist of a translucent material, such as ground glass, in a suitable fixed mount, that permits viewing of the shadow of the handgun sights, projected onto the screen by the light source, through the screen.

The shadow screen shall incorporate a circle and crosshairs as described in section 4.5.

4.5 Target

The target consists of standard graph paper ruled 4 x 4 to the centimeter (10x10 to the inch). A circle, approximately 16 mm (1/16 in) less in diameter than the diameter of the collimated beam from the light source is scribed about the center of the graph paper with horizontal and vertical lines through the center point extending across the circle.

5. TEST PROCEDURE

Place the handgun under test in the gun mount and set up the light source at the opposite end of the test range, 7.6 m (25 ft) from the muzzle of the handgun as shown in figure 1. The rear sight of handguns with adjustable sights shall be adjusted to the midpoint

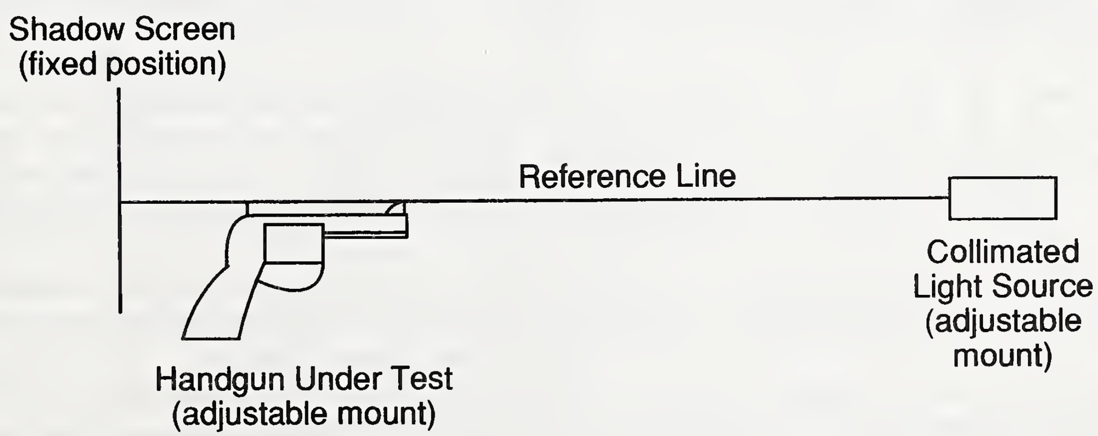

Figure 1. *Equipment setup for aligning handgun with reference line.*

of elevation of azimuth excursions and maintained so throughout the test that follows. Aiming through the weapon sights, adjust the light source to achieve approximate alignment with the reference line. Position the shadow screen behind the handgun and turn the light source on. With the ambient lights off (if necessary) adjust the light source and shadow screen until the circle on the shadow screen is centered on the collimated light beam when viewed through the screen. Adjust the handgun until the shadows of the sights are aligned as shown in figure 2; i.e., the top edge of both the front and rear sights just touch the horizontal crosshair on the screen and both sights are centered on the vertical crosshair. It may be necessary to readjust both the light source and the handgun alignment several times to fully align the sights with the reference line.

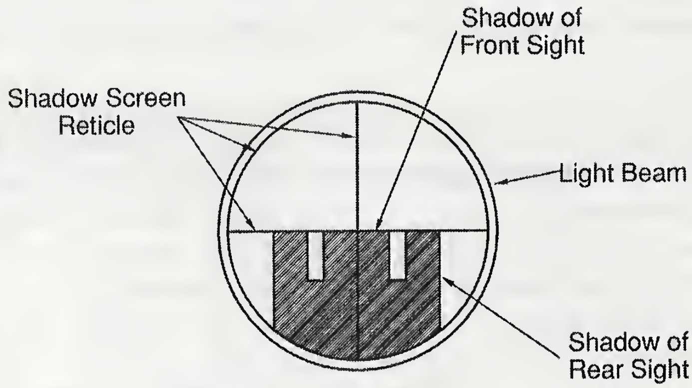

Figure 2. *Shadow image when handgun sights are aligned with reference line.*

Once the initial alignment of the source and shadow screen has been achieved, neither is to be disturbed for the duration of the test.

Mount the target 1.5 m (5 ft) in front of the light source and adjust its position horizontally and vertically until the circle is centered within the circumference of the collimated beam. Position a bullet trap in front of the light source behind the target as shown in figure 3. Turn on the firing range lights (if off) and fire a bullet at the target.

Remove the target and measure and record the X and Y distances of the center of the bullet hole from the center of the target. Remove the bullet trap and examine the shadows of the sights to verify that they are still centered as shown in figure 2. Adjust handgun alignment if necessary, replace the target and bullet trap as described above and fire the second shot. Repeat the entire procedure until a total of 10 shots have been fired and the X and Y coordinates have been measured and recorded for each test round. The use of a new target for each shot facilitates the measurement of the X and Y coordinates when the impact points are close together.

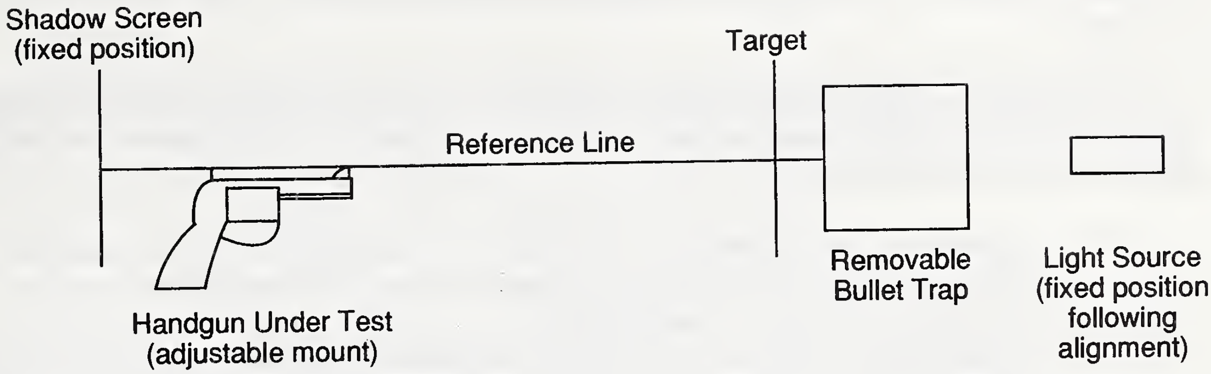

Figure 3. *Equipment setup for firing.*

Calculate the average X and Y coordinate of all 10 rounds and report those values, to the nearest 2.5 mm (0.1 in), as the accuracy of the handgun. In reporting the coordinates, X values to the right of the vertical center line are positive and those to the left negative. Likewise, Y coordinates above the horizontal center line are positive and those below negative.

6. DISCUSSION

The exact trajectory of a bullet fired from a handgun is determined by the characteristics of the handgun itself and the ammunition that is used. Those wishing to determine the accuracy of handguns should therefore conduct the tests using the ammunition that will be issued for use with the weapon.

For practical purposes, no two individuals aim a handgun by aligning the sights with the desired point of impact in exactly the same manner. When an individual is first issued a handgun, he or she will "sight-it-in," prior to qualification firing or use while on duty. Small errors in handgun accuracy can often be compensated for by a simple adjustment of the manner in which an individual aligns the front and rear sights when aiming the handgun.

The test procedure described in this report is used to determine the accuracy of a handgun over a range of 6.1 m (20 ft). The accuracy (distance from aim point) is directly proportional to the distance between the handgun muzzle and the impact point. At a distance of 7.6 m (25 ft), the coordinates of the shot group would be increased by a factor of 7.6/6.1 (25/20) or 1.25 times that measured on the 6.1 m (20 ft) range used in this test procedure.

The change in sight alignment (horizontal or vertical movement of the front sight relative to the rear sight) required to center the shot group on the reference point (aim point) is calculated as follows:

1) Divide the distance between the muzzle of the handgun and the target [6.1 m (20 ft) or 610 cm (240 in) in this test procedure] by the distance between the front and rear sights of the handgun.
2) Divide either the X or Y accuracy coordinate obtained in the test by the number obtained above to determine the required movement of the front sight relative to the back sight to move the center of the shot group to the aim point.

For example, if the sights on a handgun are 15.2 cm (6 in) apart, the range of 6.1 m (20 ft) used in this test, or 610 cm (240 in), divided by the sight distance 15.2 cm (6 in) is 40. If the Y accuracy coordinate is 6.35 cm (−2.5 in), the top edge of the front sight must move down 1.6 mm (1/16 in) (2.5 in/40 = 0.0625 in = 1/16 in) relative to the top edge of the rear sight to center the Y coordinate of the shot group on the aim point used in this test. This can be accomplished by raising the rear sight 1.6 mm (1/16 in), or removing 1.6 mm (1/16 in) from the top edge of the front sight.

Similarly, an X accuracy coordinate of +6.35 cm (+2.5) or -6.35 cm (−2.5) in would require that the front sight move 1.6 mm (1/16 in) to the left or right, respectively, relative to the notch in the rear sight to move the center of the X coordinate of the shot group to the aim point. Again, this can be accomplished by moving the rear sight laterally, or altering the front sight.

While the purpose of this test procedure is solely to determine handgun accuracy, it is obvious that one can also measure the group size that the handgun produces. This is most easily accomplished with a circle template, recording the group size as the diameter of the smallest circle that includes all of the individual shots on the target.

APPENDIX A — LIGHT SOURCE

A sketch of the light source used to develop this test procedure is shown in figure A1. It consists of an aluminum tube [2.2 cm (7/8 in) inside diameter] with a 6-diopter lens in one end and a light bulb mounted on a Teflon[2] cylinder in the other. The Teflon cylinder is machined to provide a smooth friction fit so that the light bulb filament-to-lens distance can be adjusted by moving the Teflon cylinder within the tube.

A 2 cm (3/4 in) aperture centered on the major axis of the tube is attached to the tube approximately 6 mm (1/4 in) in front of the lens. The leads from two C batteries in series extend through a hole aligned with the major axis of the cylinder and are soldered directly to the bulb (MAG Instruments Co., LM3A001)[2].

This unit provides suitably collimated light to project a sharp image of the sights of a handgun with a filament-to-lens distance of approximately 16.5 cm (6 1/2 in).

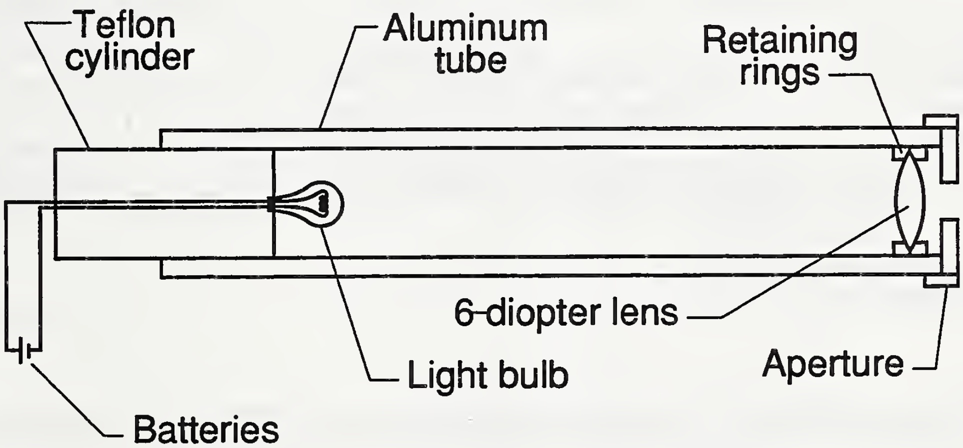

Figure A1. *Light Source.*

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[2]The use of trade names in this report does not constitute endorsement by the National Institute of Standards and Technology, or the National Institute of Justice, nor does it mean that the item is necessarily best suited for the intended application.

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aim point error; handgun accuracy; test procedure

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