



Tactical Application Police™
Ammunition Test Report and Application Guide

Hornady

Tactical Application Police T.A.P.

Ammunition Test Report and Application Guide

Hornady Manufacturing Company
JANUARY 2006

Thank you for your interest in the Hornady Manufacturing Company's line of Law Enforcement Tactical Ammunition. Every care has been taken to ensure that the information in this notebook is accurate and presented in the most straightforward manner possible. We plan to regularly update this notebook as more data becomes available or as the product line is expanded.

If you have any questions, require further information or technical assistance please feel free to contact us at 800-338-3220, ext. #0. Once again, thank you for your interest in our products. Additional copies \$15.00.

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Test Protocol

Test Protocol

Hornady TAP Ammunition Testing

Location: Hornady Manufacturing Ballistics Laboratory, Grand Island, Nebraska

Elevation: 1,800 feet ASL

Temperature: 74° F

Bullet Velocity: (Feet per second, fps). An Oehler model 35P with model 55 skyscreens were used for velocity measurements. Bullet velocity was measured at a distance of 21 feet from the muzzle. Ammunition Standard Deviation (fps) is given for each gun/load combination. Down range velocities shown in the ballistic tables are calculated with an exterior ballistics computer program.

Trajectory Tables: Trajectory was calculated using a computer code. As a general rule, zeros were selected to keep the maximum height of the trajectory (maximum ordinate) 3.0" or less. A (-) sign indicates the trajectory of the bullet is below the line of sight. A (+) sign indicates the trajectory of the bullet is above the line of sight. All trajectories were calculated for 80° Fahrenheit and 29.90 inches of mercury atmospheric pressure.

For 24" barreled .223 and 20" and longer barreled .308 rifles, it was assumed that they would be used as precision rifles with click adjustable telescopes. Basic "come-ups," in minute of angle (MOA) from a 100 yard zero, are provided out to a distance of 300 yards as a guide for the Police or Military marksman. A (-) sign indicates the marksman must dial the scope down from the 100 yard zero.

Maximum Performance Distance: This is based on bullet-retained velocity at distance and the associated expansion, fragmentation, and penetration performance at that velocity. The distance given indicates the point out to which the terminal performance will closely match that as shown in the test results. Beyond this distance, the terminal performance will slowly decrease as velocity decreases, causing less expansion, fragmentation and greater penetration. This was determined by evaluating the results of lower velocity shorter barreled weapons coupled with exterior ballistic calculations. We have assumed that tactical engagements beyond 300 yards will not be attempted and show no maximum effective range for the .308 loads.

10% Ballistic Gelatin tests: All ballistic gelatin was prepared in accordance with the procedure outlined by Dr. Martin Fackler and Mr. John Malinowski in their article, Ordnance Gelatin for Ballistic Studies, The Journal of Forensic and Pathology 9(3): 218-219 1998. All gelatin was in blocks measuring 6" x 10" x 12" and was stored at 40° F until just prior to testing. Each block of gelatin used was calibrated with a BB fired at a velocity of 585 to 610 fps with a depth of penetration of 3.1 to 3.9 inches. The gelatin was placed 30 feet from the muzzle of the test weapon.

Test Protocol

Hornady T.A.P. Ammunition Testing

Sheetrock Wall Penetration tests: Bullets were fired through 2 layers of 5/8" sheetrock spaced 3.5" apart. The muzzle velocity was measured as well as the exit velocity from the wall and the penetration into gelatin, 24" from the sheetrock. The sheetrock test panel was 28 feet from the muzzle of the test weapon. This test was performed solely on .22-caliber T.A.P. ammunition and only for the 16" barreled AR-15.

Glass penetration/Deflection tests: Bullets were fired through .205" automotive safety glass at an angle of 30 degrees from the vertical. Two tests were done with each bullet. 1.) In the first test the glass was placed 28 feet from the muzzle, the bullet captured in ballistic gelatin 18" beyond the glass. 2.) In the second test the glass was placed 28 feet from the muzzle with an aiming point 48.5 feet beyond the glass, deflection was measured from the aiming point.

Body Armor tests: Threat level IIIA Kevlar ballistic vest material was placed over the blocks of ballistic gelatin and fired through to measure the vests' effect on bullet performance. The vest and gelatin were placed 30 feet from the muzzle of the weapon. These tests were only done with the Bushmaster AR-15 with a 16" barrel.

Note: The data provided in this report is intended as a guide for ammunition selection. It is not meant to be a definitive report but rather a tool to be used for making informed choices. Actual bullet trajectory and terminal performance may vary depending on the velocity of the bullet in your weapon, atmospheric conditions, type of materials encountered and the anatomical structures contacted.

Gelatin Test Trajectory Data

Gelatin Tests/Trajectory Data

Product summary and General Performance Characteristics

Hornady T.A.P. Ammunition

.223 Remington/5.56 mm NATO

Summary: Hornady .223 TAP loads are unique offering to Law Enforcement. They offer dramatically better terminal performance than any handgun cartridge, yet they do not demonstrate over penetration in ballistic gelatin testing. All four rounds defeat level IIIA ballistic body armor with little effect on the bullets' performance. The 75 grain bullet showed significantly better performance on glass than the lighter bullets, showing less deflection and better penetration after penetrating glass.

40 grain TAP, Polymer tipped spitzer boat tail, part #83256, and ballistic coefficient =. 200:

This bullet offers high velocity even in shorter barreled weapons with reliable functioning in the AR-15 weapon system. It also offers rapid expansion, high fragmentation, and little retained weight. This round is intended primarily for situations where it has a limited penetration, extreme fragmentation, and reduced ricochet potential are desired.

55 grain TAP, Polymer tipped spitzer flat base, part # 83276, ballistic coefficient =. 255:

This bullet offers high velocity even in shorter weapons. It also offers rapid expansion, high fragmentation and low retained weight. The bullet will begin to fragment in a sheetrock wall but still has significant retained velocity, weight, and penetration in ballistic gelatin.

60 grain TAP, polymer tipped spitzer flat base, part #83286, ballistic coefficient =. 265:

This bullet offers high velocity in medium length, 14.5" or longer. The bullet offers performance similar to the 55 grain TAP with slightly lower velocity, 10 to 15% greater penetration and slightly more retained weight. This bullet weight is the heaviest acceptable for 1-12" twist weapons.

75 grain TAP, boat tail hollow point, part #80265, ballistic coefficient =. 390:

This match quality bullet is the Hornady Company's heaviest T.A.P. offering in .223 caliber. It demonstrates rapid expansion and a fragmenting bullet for both the precision rifle and the carbine. This bullet demonstrates deeper penetration than the 55 and 60-grain bullets yet penetrates less than most police handgun service rounds. It penetrates glass with minimal deflection; due to its retained weight. The bullet shows minimal break up on sheetrock, retaining most its weight and penetration.

Gelatin Tests/Trajectory Data

Product summary and General Performance Characteristics

Hornady TAP Ammunition

.308 Winchester/7.62 mm NATO

Summary: The .308 TAP ammunition was specifically developed for the police marksman who prefers the increased bullet weight and barricade penetration of the .308 cartridge. This ammunition offers match accuracy, rapid expansion, fragmentation and glass penetration with minimal deflection and bullet breakup. These performance characteristics along with limited penetration as demonstrated by ballistic gelatin testing are not normally expected or experienced in traditional .308 match grade ammunition. All three bullets will defeat Level IIIA ballistic body armor.

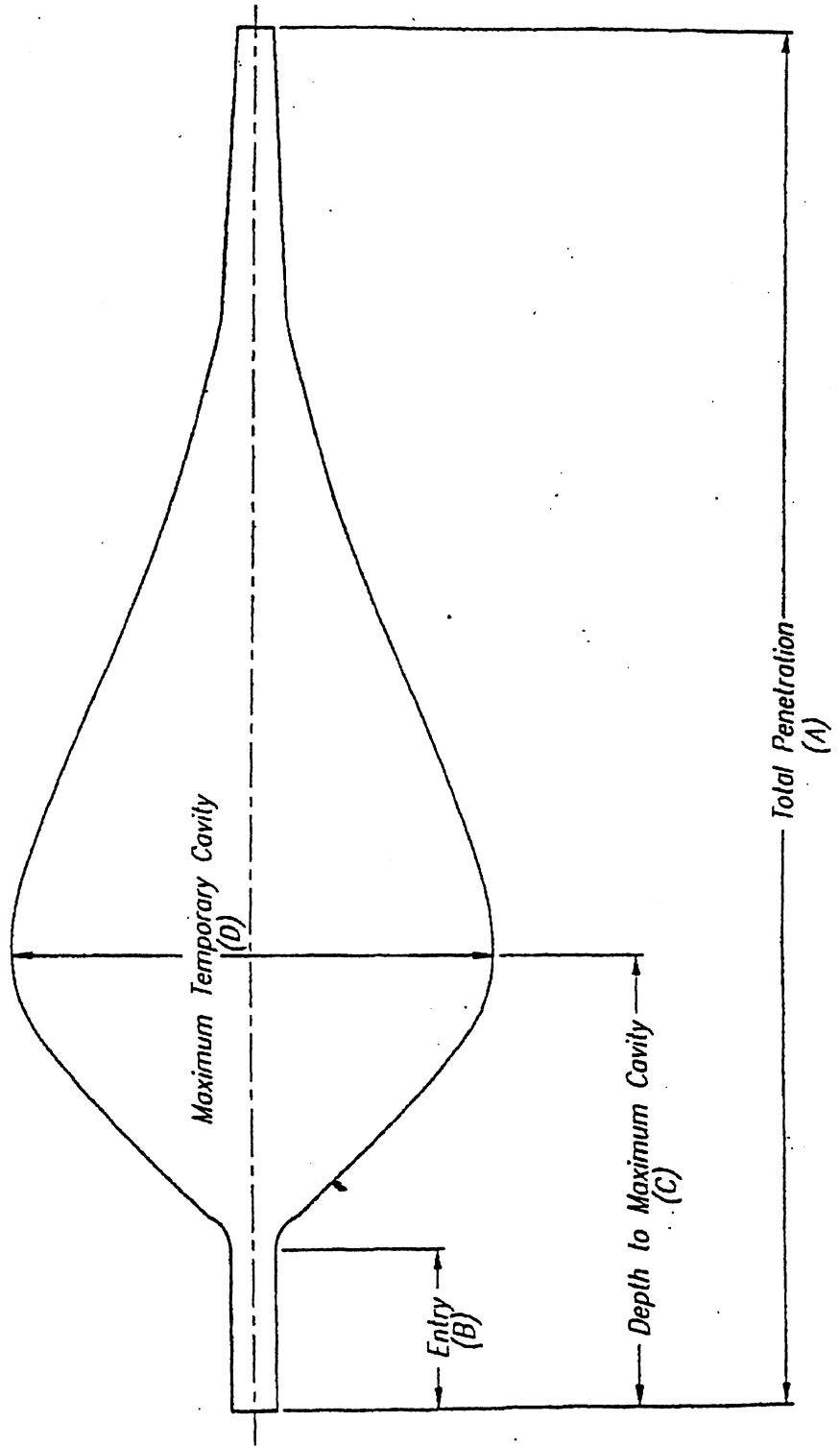
110 grain TAP, polymer tipped spitzer flat based bullet, part #83256, ballistic coefficient =.305: This cartridge offers the police marksman an unique bullet that demonstrates rapid expansion, fragmentation and low retained weight. This bullet offers the best penetration in ballistic gelatin and lower felt recoil as compared to heavier TAP bullets. The 110 grain bullet demonstrates similar penetration to the .223 75 grain BTHP bullet with substantially more temporary cavitation and fragmentation.

155 grain TAP, polymer tipped spitzer boat tail bullet, part #80925, ballistic coefficient =.500: The 155 grain bullet TAP cartridge offers match accuracy with a high ballistic coefficient, providing superior long range performance. This bullet demonstrates expansion and fragmentation similar to the 110 grain bullet with a slight increase in penetration and retained bullet weight. This bullet penetrates glass with minimal deflection and retain it's expansion and fragmentation characteristics.

168 grain TAP, polymer tipped spitzer boat tail bullet, part #80965, ballistic coefficient =.515: The 168 grain bullet is a traditional match grade weight with the advantages of a polymer tipped bullets' terminal performance. This match grade bullet demonstrates an increase in penetration and retained weight over the 155 grain TAP bullet. It offers even better long range performance due to it's higher ballistic coefficient and weight.

Gelatin Wound Profile Nomenclature

Gelatin Wound Channel



.223 Remington

223 Remington
Gelatin Penetration Performance Test

Bullet: 55 gr TAP

Weapon: Bushmaster

Barrel: 14.5"

Twist Rate: 1-9"

	<u>Bare</u>	<u>Car Door</u>	<u>Fire Door</u>	<u>Safety Glass</u>	<u>Wallboard</u>
BB Calibration					
Velocity (fps)	578	591	591	591	578
Penetration	3.20"	3.25"	3.25"	3.25"	3.20"
Velocity (fps)	2901	2930	2904	2922	2956
Total Penetration	10.00"	6.00"	8.00"	4.75"	11.25"
Entry	0.00"	0.00"	0.00"	0.00"	0.00"
Depth to Max Cavity	3.75"	3.25"	2.50"	1.00"	3.50"
Max. Temporary Cavity	5.75"	4.75"	4.75"	3.25"	5.00"
Retained Weight (grains)	22.3	0	9.6	11.8	25.3
Percent Fragmentation	59%	100%	83%	79%	54%
Deflection	N/A	N/A	N/A	??	N/A
Maximum Performance Range	240 yds	240 yds	240 yds	240 yds	240 yds

Notes

.223 Remington Ammunition Trajectory Performance (inches)

Muzzle Velocity	2940
Zero (yds.)	200
50	+0.1
100	+1.4
150	+1.5
200	0.0
250	-3.2
300	-8.5

223 Remington
Gelatin Penetration Performance Test

Bullet: 60 gr TAP

Weapon: Bushmaster

Barrel: 14.5"

Twist Rate: 1-9"

	<u>Bare</u>	<u>Car Door</u>	<u>Fire Door</u>	<u>Safety Glass</u>	<u>Wallboard</u>
BB Calibration					
Velocity (fps)	587	604	583	583	604
Penetration	3.50"	3.60"	3.75"	3.75"	3.60"
Velocity (fps)	2807	2794	2800	2789	2815
Total Penetration	11.25"	10.00"	9.00"	5.75"	7.00"
Entry	0.00"	0.00"	0.00"	0.00"	0.00"
Depth to Max Cavity	3.75"	3.00"	2.00"	2.75"	2.75"
Max. Temporary Cavity	5.25"	4.00"	2.50"	2.75"	5.75"
Retained Weight (grains)	21.8	23.2	19.8	8.6	0
Percent Fragmentation	64%	61%	67%	86%	100%
Deflection	N/A	N/A	N/A	??	N/A
Maximum Performance Range	215 yds	215 yds	215 yds	215 yds	215 yds

Notes

.223 Remington Ammunition Trajectory Performance (inches)

Muzzle Velocity	2818
Zero (yds.)	200
50	+0.3
100	+1.7
150	+1.6
200	0.0
250	-3.5
300	-9.2

223 Remington

Gelatin Penetration Performance Test

Bullet: 75 gr BTHP TAP

Weapon: Bushmaster

Barrel: 14.5"

Twist Rate: 1-9"

	<u>Bare</u>	<u>Car Door</u>	<u>Fire Door</u>	<u>Safety Glass</u>	<u>Wallboard</u>
BB Calibration					
Velocity (fps)	588	600	582	582	588
Penetration	3.10"	3.40"	3.25"	3.25"	3.10"
Velocity (fps)	2585	2545	2541	2515	2560
Total Penetration	14.0"	9.75"	7.25"	7.25"	9.50"
Entry	1.50"	0.00"	0.00"	0.00"	0.00"
Depth to Max Cavity	5.00"	3.40"	3.50"	1.75"	3.25"
Max. Temporary Cavity	5.25"	6.00"	5.50"	5.25"	6.10"
Retained Weight (grains)	24.4	43.9	27.8	9.2	22.1
Percent Fragmentation	67%	41%	63%	88%	71%
Deflection	N/A	N/A	N/A	??	N/A
Maximum Performance Range	125 yds	125 yds	125 yds	125 yds	125 yds

Notes

.223 Remington Ammunition Trajectory Performance (inches)

Muzzle Velocity	2565
Zero (yds.)	200
50	+0.5
100	+2.0
150	+1.9
200	0.0
250	-3.8
300	-9.6

Test Protocol

Hornady .223 62 grain Barrier Ammunition Testing

Location: Hornady Manufacturing Ballistics Laboratory, Grand Island, Nebraska
Elevation: 1,800 feet ASL
Temperature: 70 deg F

Bullet Velocity: (Feet per second, fps) An Oehler model 35P chronograph with Oehler model 55 skyscreens was used to measure velocities. Bullet velocity was measured at a distance of 21 feet from the muzzle of the gun.

10% Ballistic Gelatin tests: All ballistic gelatin was prepared in accordance with the procedure outlined by Dr. Martin Fackler and Mr> John Malinowski in their article, Ordinance Gelatin for Ballistic Studies, The Journal of Forensic and Pathology 9(3): pgs. 218-219, 1998. All gelatin was in blocks that measured 6" x 10" x 12" and was stored at 40 deg F until just prior to testing. Each block of gelatin used was calibrated with a BB fired at a velocity of 585 to 610 fps with a depth of penetration of 3.1 to 3.9 inches. The gelatin was placed 30 feet from the muzzle of the gun.

10% Gelatin, Sheet Metal: In these tests the projectiles are fired through two sheets of steel representing a car door and then impact gelatin. The gelatin is placed 18 inches behind two pieces of 20-gauge, hot rolled galvanized steel with the steel sheets placed 3 inches apart. The first sheet of steel was located 30 feet from the muzzle of the gun.

10% Gelatin, Automobile Safety Glass: In these tests the projectile is fired through 1 piece of one-quarter inch laminated automobile safety glass set at an angle of 45 degrees from vertical and 15 degrees from the line of flight of the bullet. The glass is placed 30 feet from the muzzle of the gun. The gelatin is placed 18 inches behind the glass. Additional tests were done firing through the glass at an aim point 10 feet away and the deflection of the bullet measured. In the table that follows the deflection is shown as the expected deflection from the point of aim per foot of travel behind the glass.

10% Gelatin and Fire Door: In these tests the projectile is fired at a simulated 3 hour fire door. The door consists of 1.65" of corrugated cardboard, with the honeycomb along the line flight, sandwiched between two layers of 18 gage cold rolled steel. The door simulant is placed 30 feet from the muzzle of the gun. The Gelatin is placed 18 inches behind the target.

223 Remington
Gelatin Penetration Performance Test

Bullet: 62 gr Barrier

Weapon: Bushmaster

Barrel: 14.5"

Twist Rate: 1-9"

	<u>Bare</u>	<u>Car Door</u>	<u>Fire Door</u>	<u>Safety Glass</u>	<u>Wallboard</u>
BB Calibration					
Velocity (fps)	582	596	583	583	596
Penetration	3.75"	3.25"	3.75"	3.75"	3.25"
Velocity (fps)	2,676	2,700	2,684	2,693	2,647
Total Penetration	16.50"	15.00"	12.00"	6.00"	13.00"
Entry	0.25"	0.00"	0.00"	0.00"	0.00"
Depth to Max Cavity	4.75"	4.25"	3.00"	3.25"	3.00"
Max. Temporary Cavity	5.25"	5.50"	5.25"	4.50"	5.75"
Retained Weight (grains)	35.9	45.9	35.6	21.5	35.9
Percent Fragmentation	42%	26%	43%	65%	42%
Deflection	N/A	N/A	N/A	??	N/A
Maximum Performance Range	225 yds	225 yds	225 yds	225 yds	225 yds

Notes

.223 Remington Ammunition Trajectory Performance (inches)

Muzzle Velocity	2,700
Zero (yds.)	200
50	+0.4
100	+1.9
150	+1.9
200	0.0
250	-3.9
300	-10.3

223 Remington
Gelatin Penetration Performance Test

Bullet: 62 gr Barrier

Weapon: Bushmaster

Barrel: 16.0"

Twist Rate: 1-9"

	<u>Bare</u>	<u>Car Door</u>	<u>Fire Door</u>	<u>Safety Glass</u>	<u>Wallboard</u>
BB Calibration					
Velocity (fps)	589	585	582	586	585
Penetration	3.50"	3.50"	3.50"	3.75"	3.50"
Velocity (fps)	2,759	2,729	2,751	2,761	2,731
Total Penetration	15.5"	11.5"	9.75"	6.0"	12.0"
Entry	0.25"	0"	0"	0"	0"
Depth to Max Cavity	3.75"	5.00"	4.50"	2.75"	3.75"
Max. Temporary Cavity	5.50"	6.25"	5.25"	5.75"	5.75"
Retained Weight (grains)	35.2	46.6	35.6"	11.4	38.5
Percent Fragmentation	43%	25%	43%	82%	38%
Deflection	N/A	N/A	N/A	??	N/A
Maximum Performance Range	225 yds	225 yds	225 yds	225 yds	225 yds

Notes

.223 Remington Ammunition Trajectory Performance (inches)

Muzzle Velocity	2,740
Zero (yds.)	200
50	+0.4
100	+1.8
150	+1.8
200	0.0
250	-3.8
300	-9.9

223 Remington
Gelatin Penetration Performance Test

Bullet: 62 gr Barrier

Weapon: Bushmaster

Barrel: 20.0"

Twist Rate: 1-9"

	<u>Bare</u>	<u>Car Door</u>	<u>Fire Door</u>	<u>Safety Glass</u>	<u>Wallboard</u>
BB Calibration					
Velocity (fps)	589	579	584	584	579
Penetration	3.50"	3.75"	3.75"	3.75"	3.75"
Velocity (fps)	2,874	2,854	2,864	2,868	2,877
Total Penetration	10.5"	11.5"	6.50"	7.25"	11.25"
Entry	0"	0"	0"	0"	0"
Depth to Max Cavity	4.75"	3.50"	3.00"	3.25"	4.00"
Max. Temporary Cavity	5.25"	5.25"	5.25"	4.25"	6.50"
Retained Weight (grains)	34.6	38.6	25.6	10.0	34.0
Percent Fragmentation	44%	38%	59%	84%	45%
Deflection	N/A	N/A	N/A	??	N/A
Maximum Performance Range	275 yds	275 yds	275 yds	275 yds	275 yds

Notes

.223 Remington Ammunition Trajectory Performance (inches)

Muzzle Velocity	2,885
Zero (yds.)	200
50	+0.2
100	+1.5
150	+1.5
200	0.0
250	-3.3
300	-8.7

62 Grain Barrier Ammunition Trajectory Performance

Weapon	Muzzle Velocity	Zero (yds)	50	100	150	200	250	300
14.5" Bushmaster	2,680	200	0.4	+1.9	+1.9	0.0	-3.9	-10.2
16" Bushmaster	2,735	200	0.3	+1.9	+1.7	0.0	-3.7	-9.7
20" Colt AR 15 A2	2,900	200	0.0	+1.4	+1.5	0.0	-3.2	-8.4

Exterior Ballistics Calculator

Version 4.01 BETA VERSION

Centerfire Rifle Flat Trajectory

I. CARTRIDGE DATA

Cartridge Name: 223 62 gr BARRIER 14.5" Bbl
Bullet Type: BARRIER
Bullet Weight: 62 grains
Ballistic Coefficient: 0.270000 (Given)
Given Velocity: 2,680 fps
Range for Velocity: Muzzle
Drag Factor: G1

II. ENVIRONMENTAL DATA

Temperature: 59° F
Atmospheric pressure: 29.53 inches of Hg

III. FIREARM DATA

Sight height: 2.5 inches above centerline of bore.
Sighting-in range: 200 yards

IV. PREDICTED PERFORMANCE

<u>Range (yards)</u>	<u>Remaining Velocity (feet/sec)</u>	<u>Remaining Energy (lb-feet)</u>	<u>Time of Flight (seconds)</u>	<u>Drop (inches)</u>	<u>Mid-Range Trajectory (inches)</u>	<u>Trajectory (inches)</u>	<u>Deflection 10-mph Wind (inches)</u>
Muzzle	2,680	989	0.0000	0.00	0.0	-2.5	0.0
50	2,516	871	0.0577	0.63	0.2	0.4	0.3
100	2,357	765	0.1194	2.63	0.7	1.9	1.3
150	2,204	669	0.1852	6.19	1.7	1.8	3.0
200	2,057	583	0.2556	11.55	3.1	0.0	5.6
250	1,916	505	0.3312	18.97	5.3	-3.9	9.0
300	1,781	437	0.4124	28.75	8.2	-10.2	13.5

Exterior Ballistics Calculator

Version 4.01 BETA VERSION

Centerfire Rifle Flat Trajectory

I. CARTRIDGE DATA

Cartridge Name: 223 62 gr BARRIER 16" Bbl
Bullet Type: BARRIER
Bullet Weight: 62 grains
Ballistic Coefficient: 0.270000 (Given)
Given Velocity: 2,735 fps
Range for Velocity: Muzzle
Drag Factor: G1

II. ENVIRONMENTAL DATA

Temperature: 59° F
Atmospheric pressure: 29.53 inches of Hg

III. FIREARM DATA

Sight height: 2.5 inches above centerline of bore.
Sighting-in range: 200 yards

IV. PREDICTED PERFORMANCE

<u>Range</u> <u>(yards)</u>	<u>Remaining</u> <u>Velocity</u> <u>(feet/sec)</u>	<u>Remaining</u> <u>Energy</u> <u>(lb-feet)</u>	<u>Time of</u> <u>Flight</u> <u>(seconds)</u>	<u>Drop</u> <u>(inches)</u>	<u>Mid-Range</u> <u>Trajectory</u> <u>(inches)</u>	<u>Trajectory</u> <u>(inches)</u>	<u>Deflection</u> <u>10-mph Wind</u> <u>(inches)</u>
Muzzle	2,735	1,030	0.0000	0.00	0.0	-2.5	0.0
50	2,569	908	0.0566	0.60	0.2	0.3	0.3
100	2,408	798	0.1169	2.52	0.7	1.8	1.3
150	2,254	699	0.1813	5.94	1.6	1.7	2.9
200	2,105	610	0.2502	11.08	3.0	0.0	5.4
250	1,961	530	0.3240	18.18	5.1	-3.7	8.8
300	1,824	458	0.4033	27.54	7.8	-9.7	13.1

Exterior Ballistics Calculator

Version 4.01 BETA VERSION

Centerfire Rifle Flat Trajectory

I. CARTRIDGE DATA

Cartridge Name: 223 62 gr BARRIER 20" Bbl
Bullet Type: BARRIER
Bullet Weight: 62 grains
Ballistic Coefficient: 0.270000 (Given)
Given Velocity: 2,900 fps
Range for Velocity: Muzzle
Drag Factor: G1

II. ENVIRONMENTAL DATA

Temperature: 59° F
Atmospheric pressure: 29.53 inches of Hg

III. FIREARM DATA

Sight height: 2.5 inches above centerline of bore.
Sighting-in range: 200 yards

IV. PREDICTED PERFORMANCE

<u>Range</u> <u>(yards)</u>	<u>Remaining</u> <u>Velocity</u> <u>(feet/sec)</u>	<u>Remaining</u> <u>Energy</u> <u>(lb-feet)</u>	<u>Time of</u> <u>Flight</u> <u>(seconds)</u>	<u>Drop</u> <u>(inches)</u>	<u>Mid-Range</u> <u>Trajectory</u> <u>(inches)</u>	<u>Trajectory</u> <u>(inches)</u>	<u>Deflection</u> <u>10-mph Wind</u> <u>(inches)</u>
Muzzle	2,900	1,158	0.0000	0.00	0.0	-2.5	0.0
50	2,727	1,024	0.0533	0.53	0.1	0.0	0.3
100	2,561	903	0.1101	2.23	0.6	1.4	1.2
150	2,401	794	0.1706	5.26	1.4	1.5	2.7
200	2,247	695	0.2352	9.80	2.7	0.0	5.0
250	2,098	606	0.3042	16.06	4.5	-3.2	8.0
300	1,955	526	0.3783	24.30	6.9	-8.4	12.0

Updated 5.56 mm/.223 Ammunition Test Results

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AUTHORS: Dr. Roberts maintains a private dental practice in Palo Alto, California and is on the staff at Stanford University Medical Center. He is currently a Lieutenant Commander in the U.S. Navy Reserve, performing wound ballistic research and combat casualty care training. He has served as a Reserve Police Officer in the San Francisco Bay Area. He is also a Technical Advisor to the Association of Firearms and Tool Mark Examiners, the professional organization of criminal investigators and laboratory technicians who testify in court regarding scientific evidence in firearms related crimes. Officer Lazzarini has served for 23 years with the City of Santa Clara Police Department in a variety of roles, including patrol and SWAT. He is currently assigned as a full time law enforcement weapons and tactics training officer at the department's shooting range.

ABSTRACT: 10% ordnance gelatin is used as a tissue simulant to assess terminal performance of 5.56 mm/.223 ammunition.

KEYWORDS: wound ballistics, 10% ordnance gelatin, law enforcement 5.56 mm/.223 ammunition

Updated 5.56 mm/.223 Ammunition Test Results

Gary K. Roberts, D.D.S. and Officer Don Lazzarini

This paper updates 5.56 mm/.223 ammunition test results.

MATERIALS AND METHODS

Testing was performed at the California Highway Patrol Academy Weapons Training Department Indoor Firing Range using the protocol described previously.¹ Testing was also performed at the Santa Clara Police Department Indoor Firing Range using the same protocol, except using Vyse ordnance gelatin made into 50 x 37 x 26 cm blocks. All shots were made with Colt AR15 rifles.

RESULTS

Table 1 shows the bullet type, lot #, type of barrel, five round averages of velocity, penetration depth, recovered diameter, recovered length, and recovered weight for each ammunition type, along with the gelatin calibration for the test series of shots fired into bare gelatin. New data is highlighted. Table 2 shows the same information for shots fired through replicas of standard construction interior walls placed 10 cm in front of the edge of the gelatin blocks and fabricated using two pieces of 1/2" thick dry wall cut in 12" x 24" segments and mounted four inches apart using 2 x 4" fir studs and 1.5" dry wall screws. Representative wound profiles, as devised by Fackler, are shown in the appendix.

Table 1: Bare Gelatin

LOAD	LOT #	BARREL	VEL f/s	PEN cm	PEN"	MAX TC cm	RD "	RL"	RW gr	FRAG	GEL CAL
Fed 26 gr Ltd Range Frang P556L	2949663439	16" 1/7	3152	19.8	7.8	9.0	0.23	0.27	9.1	65.0%	9.0 cm @ 581 f/s
Simunitions 36 gr Frang Greenshield	n/a	16" 1/7	3283	15.5	6.1	7.0	n/a	n/a	n/a	100.0%	10.0 cm @ 582 f/s
Fed 40 gr JHP 223D	29A-0411	16" 1/7	3369	16.9	6.7	9.0	0.28	0.06	5.2	86.9%	9.5 cm @ 582 f/s
Glaser 45 gr Safety Slug	BG1102	16" 1/7	3094	19.5	7.7	9.0	n/a	n/a	n/a	100.0%	9.8 cm @ 576 f/s
Win 50 gr JSP SBST223	MD61	16" 1/7	3163	31.4	12.4	11.0	0.22	0.15	12.4	75.2%	9.8 cm @ 576 f/s
Win 53 gr JHP X223RH	9EC32	16" 1/7	2961	20.4	8.0	10.0	0.32	0.12	14.6	72.5%	9.5 cm @ 582 f/s
Fed 55 gr JHP 223C	33C-9487	16" 1/7	2949	24.3	9.6	9.5	0.40	0.15	23.2	57.9%	9.5 cm @ 582 f/s
Fed 55 gr JHP-BT P223E	330115V058	16" 1/7	2940	24.5	9.6	10.0	0.35	0.20	26.5	51.9%	9.5 cm @ 595 f/s
Fed 55 gr JSP Tactical LE223T	290115V090	16" 1/7	2854	42.6	16.8	8.5	0.46	0.31	53.7	2.4%	9.8 cm @ 576 f/s
Horn 55 gr Varmint Express BT 8327	9901374	16" 1/7	2970	18.0	7.1	11.0	0.38	0.15	17.4	68.4%	9.5 cm @ 576 f/s
Rem 55 gr JSP R223R1	P25NR2609	16" 1/7	2813	27.0	10.6	9.5	0.34	0.17	24.9	54.8%	9.5 cm @ 582 f/s
Win 55 gr FMJ X223R1	24EEC	16" 1/7	2886	36.4	14.3	11.5	0.21	0.77	45.7	17.0%	9.5 cm @ 582 f/s
Win 55 gr JSP X223R	4BN50	16" 1/7	2833	23.7	9.3	9.0	0.35	0.16	21.6	60.8%	9.5 cm @ 582 f/s
Black Hills 60 gr JSP	502033072	16" 1/7	2710	30.1	11.9	8.5	0.38	0.22	30.0	50.0%	10.5 cm @ 588 f/s
Rem 60 gr JHP Match R223R4	N300C1109	16" 1/7	2937	29.3	11.5	9.0	0.34	0.14	19.8	67.1%	10.5 cm @ 588 f/s
Powell River 61 gr JHP Tungsten	Win Head Stamp	16" 1/7	2820	32.0	12.6	10.0	n/a	n/a	n/a	100.0%	9.5 cm @ 576 f/s
Powell River 61 gr JHP Tungsten	Win Head Stamp	10.5" 1/9	2439	32.0	12.6	8.0	n/a	n/a	n/a	100.0%	9.5 cm @ 576 f/s
Win 62 gr FMJ RA556M855	12FF22	16" 1/7	2927	37.3	14.7	11.5	0.33	0.62	42.6	31.3%	10.5 cm @ 588 f/s
Win 64 gr JSP X223R2 (cannelure)	9DD1	16" 1/7	2867	24.1	9.5	8.0	0.40	0.18	27.5	57.0%	9.0 cm @ 581 f/s
Win 64 gr JSP X223R2 (smooth)	MC62	16" 1/7	2542	37.5	14.8	8.0	0.44	0.24	35.4	44.7%	9.8 cm @ 576 f/s
Win 64 gr JSP Q3246 (knurled)	LK21	16" 1/7	2722	35.0	13.8	9.0	0.48	0.31	47.8	25.3%	9.8 cm @ 576 f/s
Black Hills 68 gr JHP	504041253	16" 1/7	2615	30.8	12.1	9.0	0.39	0.23	31.5	53.6%	9.0 cm @ 581 f/s
Fed 69 gr JHP-BT Match 223M	29B-0445	16" 1/7	2646	37.4	14.7	10.0	0.40	0.19	27.5	60.2%	10.5 cm @ 588 f/s
Win 69 gr JHP-BT Match S223M	31LE61	16" 1/7	2758	30.1	11.9	8.5	0.36	0.16	17.5	74.6%	9.8 cm @ 576 f/s
Fed 70 gr JHP VLD	n/a	16" 1/7	2829	25.4	10.0	13.0	0.33	0.16	21.4	69.5%	8.8 cm @ 579 f/s
Black Hills 73 gr JHP Moly Match	99-9-1203032389	16" 1/7	2516	30.5	12.0	10.0	0.50	0.20	28.2	61.4%	9.5 cm @ 576 f/s
Black Hills 75 gr JHP Match	120103121	16" 1/7	2580	33.9	13.3	14.0	0.47	0.28	41.9	44.1%	9.5 cm @ 594 f/s
Black Hills 75 gr JHP Moly Match	1220142047	16" 1/7	2521	31.0	12.2	14.0	0.43	0.35	38.5	48.6%	9.5 cm @ 594 f/s
Hornady 75 gr TAP BT 80265	12258978801	16" 1/7	2564	33.7	13.3	12.0	0.46	0.42	39.0	48.0%	9.5 cm @ 576 f/s
Hornady 75 gr TAP BT 80265	12258978801	10.5" 1/9	2227	36.0	14.2	9.0	0.22	0.52	33.3	55.6%	9.5 cm @ 576 f/s
Hornady 75 gr TAP BT 80265	990317	10.5" 1/9	2229	40.3	15.9	12.0	0.27	0.51	32.2	57.0%	9.0 cm @ 561 f/s
Powell River 87 gr JHP Tungsten	Win Head Stamp	16" 1/7	2027	28.0	11.0	10.0	n/a	n/a	n/a	100.0%	9.5 cm @ 576 f/s
Powell River 87 gr JHP Tungsten	Win Head Stamp	24" 1/9	2193	29.0	11.4	10.0	n/a	n/a	n/a	100.0%	9.5 cm @ 576 f/s
Powell River 87 gr JHP Tungsten	BH Head Stamp	16" 1/7	2399	28.4	11.2	13.0	n/a	n/a	n/a	100.0%	9.0 cm @ 561 f/s

Table 2: Interior Wall Replica

LOAD	LOT#	BARREL	VEL f/s	PEN cm	PEN"	MAX TC cm	RD "	RL"	RW gr	FRAG	GEL CAL
Fed 55 gr JSP Tactical LE223T	290115V090	16" 1/7	2905	36.7	14.4	8.5	0.41	0.36	48.5	11.8%	11.0 cm @ 584 f/s
Win 55 gr FMJ X223R1	24EEC	16" 1/7	2898	41.0	16.1	11.5	0.22	0.50	46.5	15.5%	11.0 cm @ 584 f/s
Black Hills 60 gr JSP	502033072	16" 1/7	2660	30.5	12.0	7.0	0.38	0.18	26.5	55.8%	11.0 cm @ 584 f/s
Win 62 gr FMJ RA556M855	12FF22	16" 1/7	2962	29.3	11.5	10.0	0.20	0.36	13.4	78.4%	11.0 cm @ 584 f/s
Win 64 gr JSP Q3246 (knurled)	LK21	16" 1/7	2763	32.3	12.7	8.0	0.48	0.31	47.8	25.3%	9.5 cm @ 594 f/s
Black Hills 68 gr JHP	504041253	16" 1/7	2939	27.0	10.6	8.0	0.49	0.27	36.8	45.9%	9.5 cm @ 594 f/s
Fed 69 gr JHP-BT Match 223M	29B-0445	16" 1/7	2637	30.3	11.9	10.0	0.39	0.32	40.2	41.7%	9.5 cm @ 594 f/s
Win 69 gr JHP-BT Match S223M	31LE61	16" 1/7	2758	30.1	11.9	7.0	0.34	0.16	14.1	79.5%	9.5 cm @ 594 f/s
Black Hills 75 gr JHP Match	120103121	16" 1/7	2595	33.0	13.0	14.0	0.44	0.37	46.2	38.4%	9.5 cm @ 594 f/s
Hornady 75 gr TAP BT 80265	12258978801	16" 1/7	2564	30.9	12.2	12.0	0.42	0.40	39.6	47.2%	9.5 cm @ 576 f/s

DISCUSSION

As discussed previously, the ideal bullet for law enforcement and military special operations use is that which offers the greatest potential for physiologically incapacitating an aggressor.²

Acceptable performing 5.56 mm/.223 ammunition choices are noted below:

- 1 in 9" or faster twist barrels**
- Black Hills 60 gr JSP
 - Winchester M-855 62 gr FMJ (FMJ RA556M855)
 - Federal 62 gr Tac JSP (LE223T2)
 - Winchester 64 gr JSP (Q3246)
 - Black Hills 68 gr JHP
 - Federal 69 gr JHP (223GM)
 - Winchester 69 gr JHP (S223M)
 - Black Hills 73 gr JHP
 - Black Hills 75 gr JHP
 - Hornady 75 gr TAP (80265)

- 1 in 12" twist barrels**
- M-193 55 gr FMJ
 - Federal 55 gr Tac JSP (LE223T1)

For 1 in 9" or faster twist barrels, the Hornady 75 gr TAP load appears to reliably provide the greatest potential to physiologically incapacitate an aggressor of all currently available 5.56 mm/.223 loads. In addition, the Hornady 75 gr TAP is the first .223 bullet which the authors have tested which exhibits adequate terminal performance when fired out of barrel lengths shorter than 14.5 inches.

5.56 mm/.223 weapons with a 1 in 12" twist rate are generally limited to bullet weights of 55 grains or less. At this time, only two ammunition choices are available, neither of which is ideal for CQB or entry use.

The Tungsten core JHP bullets appear to exhibit a unique fragmentation mechanism which results in a dust like cloud of bullet material spreading away from the main wound track. The resulting permanent crush cavity is quite large and the bullet is completely fragmented. This behavior has not been seen previously. With increased penetration depths, this may eventually prove to offer a significant increase in incapacitation potential for 5.56 mm/.223 caliber rifles.

CONCLUSION

At this time, the Hornady 75 gr TAP appears to be the 5.56 mm/.223 ammunition with the best potential to reliably incapacitate an aggressor.

REFERENCES

1. Roberts GK: "Comparison of the Terminal Performance of 9mm Parabellum, .40 S&W, and .45 ACP Jacketed Hollow Point Bullets Intended for Law Enforcement and Military Special Operations Applications, Using 10% Ordnance Gelatin as a Tissue Simulant". *Wound Ballistics Review*. 1 (4):32-37, 1994.
2. Roberts GK: "The Wounding Effects of 5.56mm/.223 Law Enforcement General Purpose Shoulder Fired Carbines Compared With 12 ga. Shotguns and Pistol Caliber Weapons using 10% Ordnance Gelatin as a Tissue Simulant.". *Wound Ballistics Review*. 3(4):16-28, 1998.

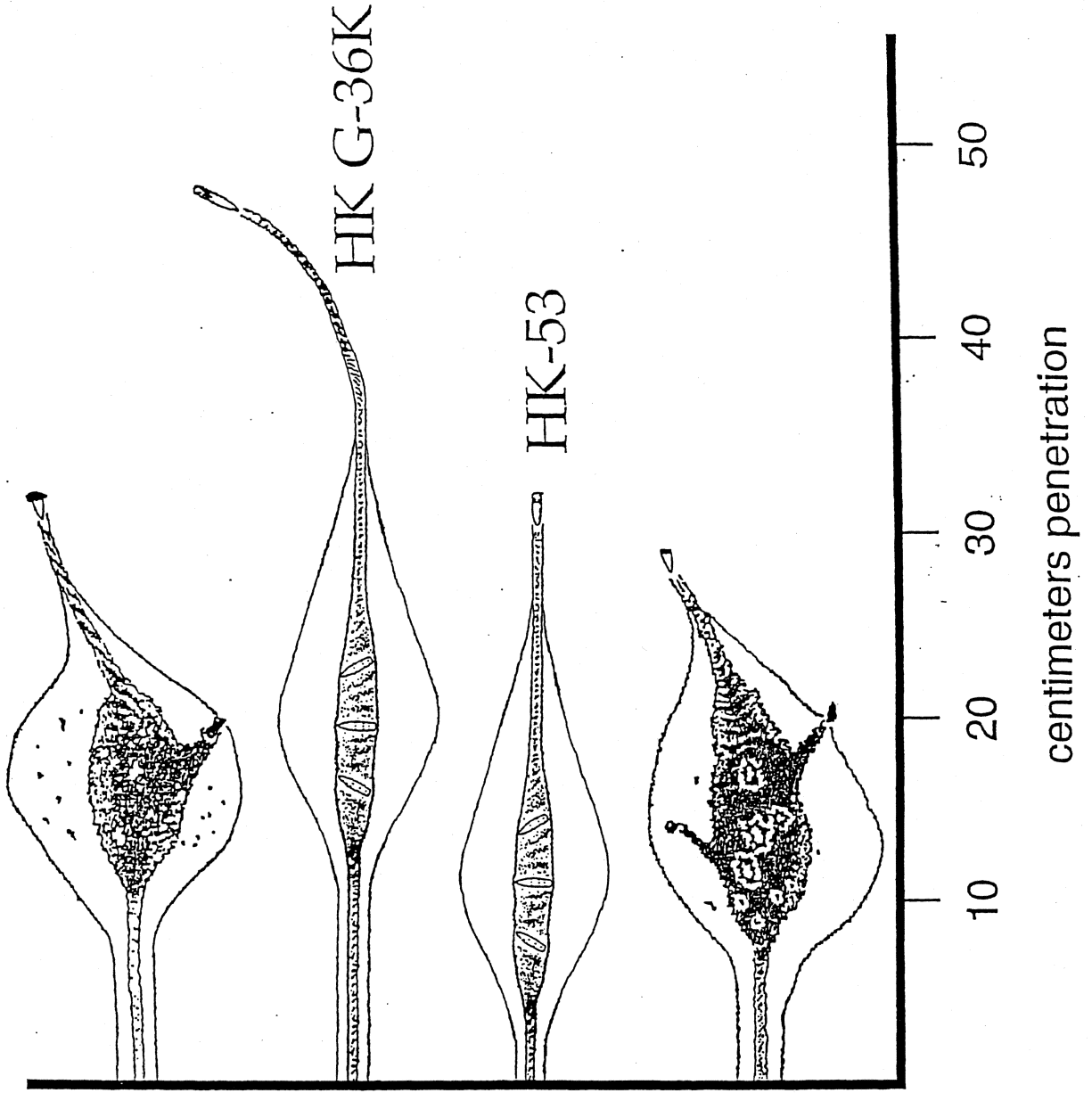
Typical 5.56 mm FMJ Wound Profiles

5.56 mm M193 55 gr FMJ
at 2900 f/s

5.56 mm M193 55 gr FMJ
at 2650 f/s

5.56 mm M193 55 gr FMJ
at 2380 f/s

5.56 mm M855 62 gr FMJ
at 2925 f/s



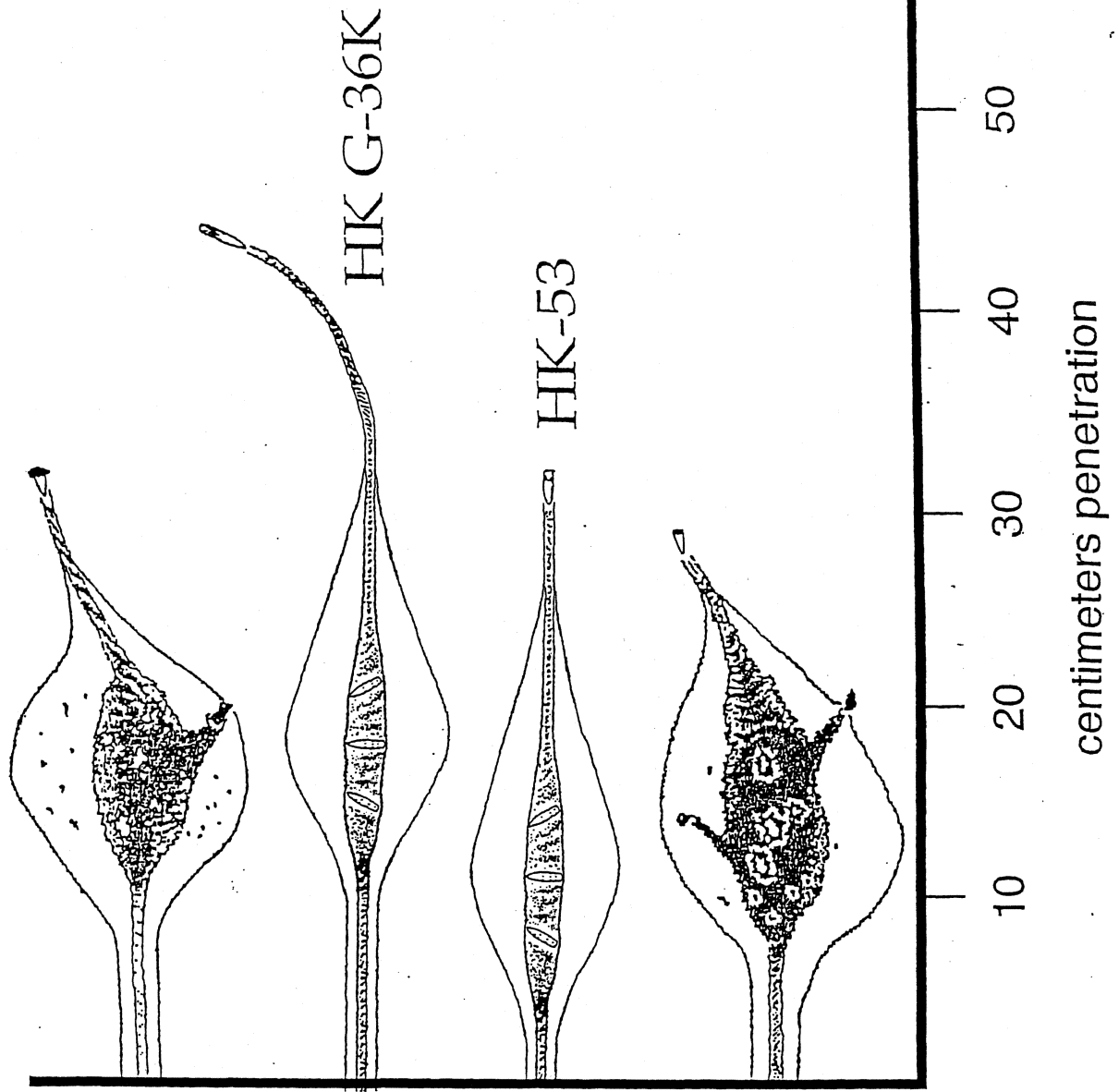
Typical 5.56 mm FMJ Wound Profiles

5.56 mm M193 55 gr FMJ
at 2900 f/s

5.56 mm M193 55 gr FMJ
at 2650 f/s

5.56 mm M193 55 gr FMJ
at 2380 f/s

5.56 mm M855 62 gr FMJ
at 2925 f/s



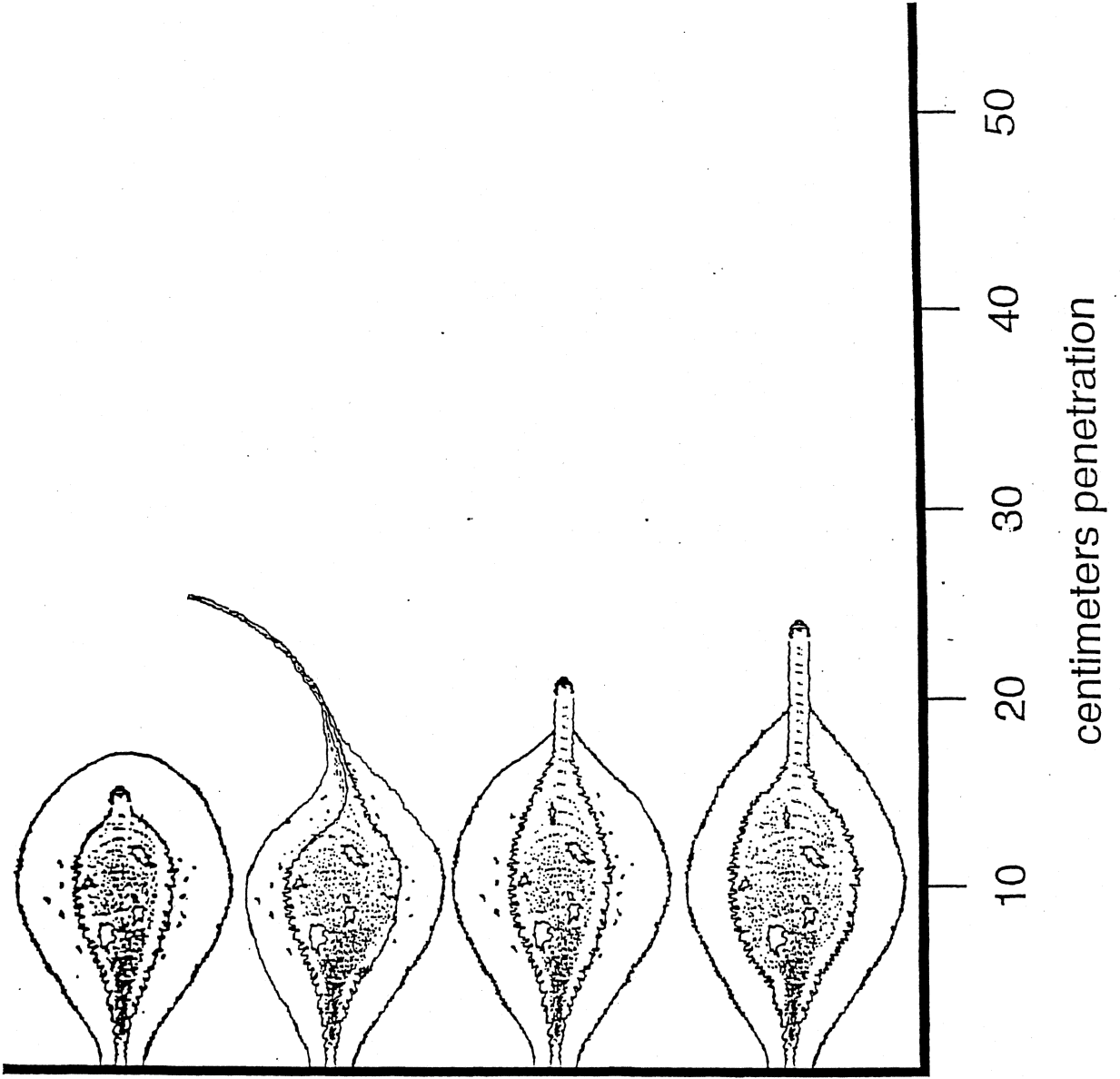
Typical .223 JHP/JSP Wound Profiles

.223 Fed 40 gr JHP at 3350 f/s

.223 Win 50 gr JSP at 3150 f/s

.223 Fed 55 gr JHP at 2950 f/s

.223 Rem 55 gr JSP at 2800 f/s



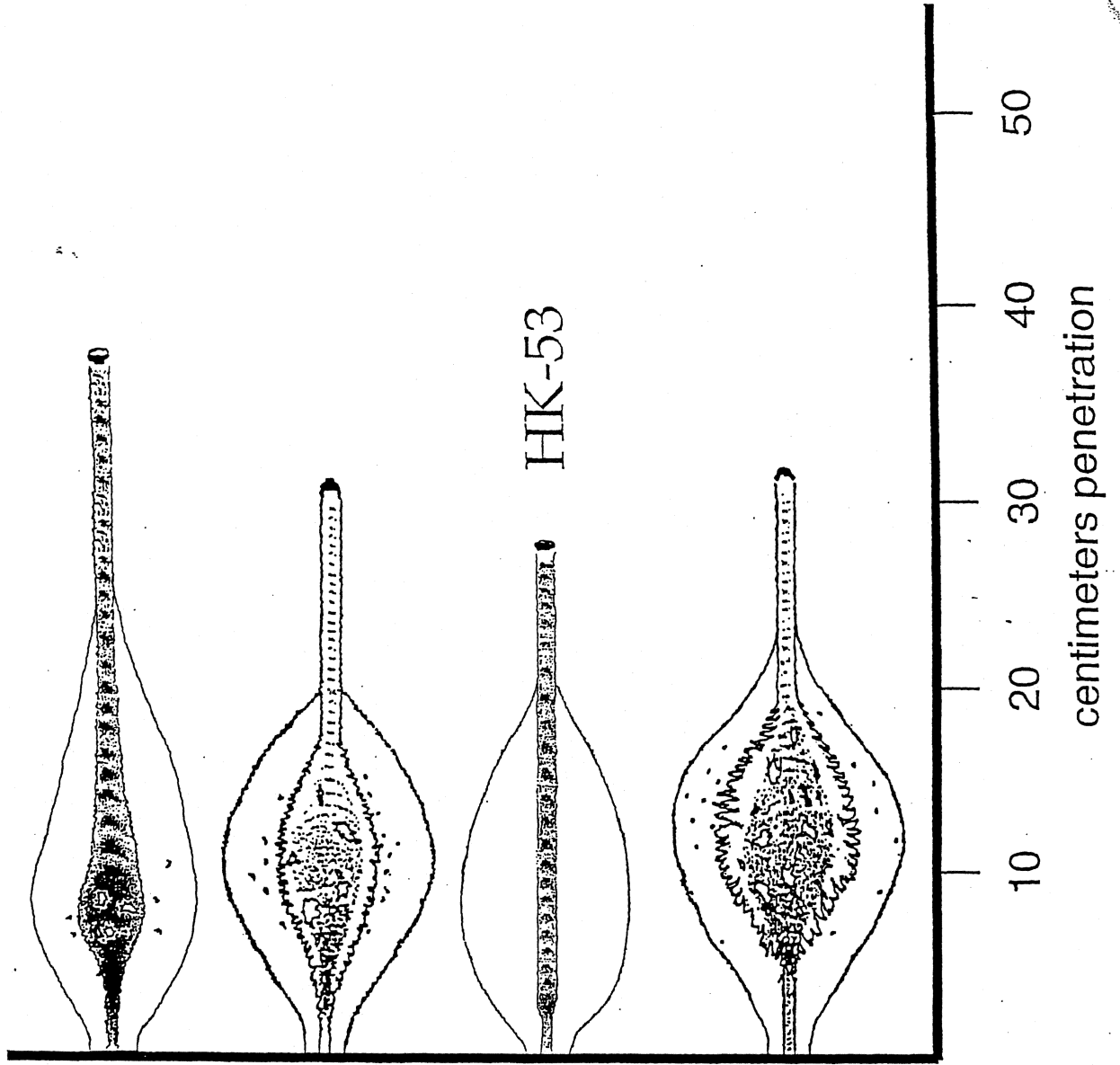
Typical .223 JHP/JSP Wound Profiles

23 Fed 55 gr JSP-Tac at 2875 f/s

.223 Win 64 gr JSP at 2700 f/s

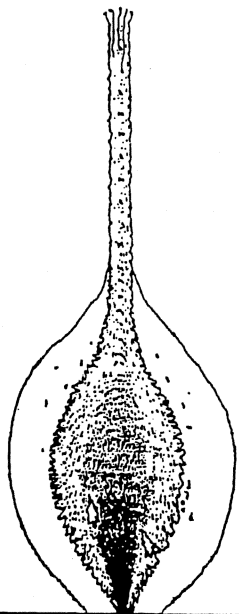
.223 Win 64 gr JSP at 2300 f/s

.223 Fed 69 gr JHP-BT at 2700 f/s

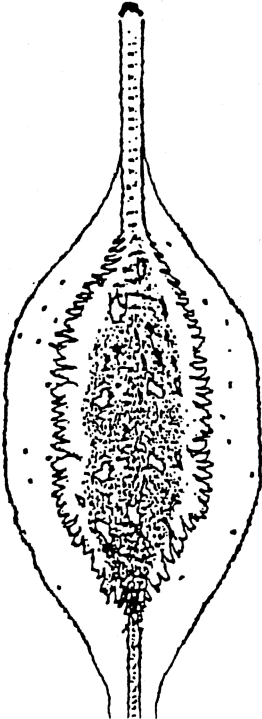


New .223 JHP Wound Profiles

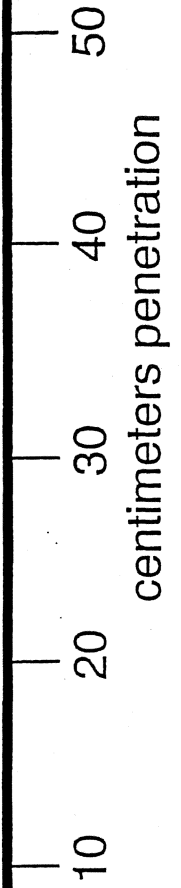
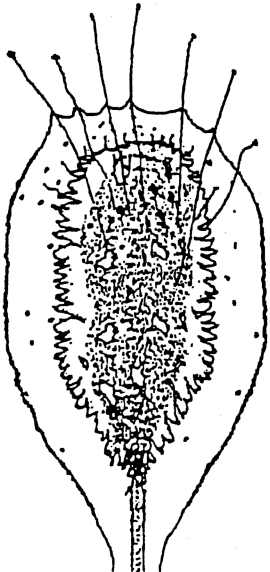
.223 61 gr JHP Tungsten
at 2820 f/s



.223 75 gr TAP
at 2564 f/s



.223 87 gr JHP Tungsten
at 2399 f/s



5.56 NATO

HORNADY 5.56 X 45 mm NATO SPECIFICATION AMMUNITION

O Ammunition conforms to 5.56 M855 ammunition and propellant specifications for case mouth and port pressure in an M4A1 system.

O Ammunition uses a crimped in mil-spec No 41 primer. Primer push forces meet or exceed M855 specification.

O Ammunition is loaded with the proven Hornady 75 gr BTHP bullet. The bullet is cannelured and both bullet push and pull forces meet or exceed M855 specification. Bullet has a unique ogive shape to facilitate reliable feeding.

O Ammunition retains Hornady's proven match accuracy, with a factory specification in a 20" 1-7" twist 5.56 test barrel of less than 1 moa.

PERFORMANCE

14.5" Bbl, Colt M4A1

Muzzle Velocity: 2,660 fps

Range: (yds)	<u>50</u>	<u>100</u>	<u>200</u>	<u>300</u>
Bullet Path: (in)	.40	1.80	0.0	-9.1
Velocity: (fps)	2,535	2,413	2,180	1,960
Energy: (ft-lbs)	1,070	970	791	640

16.0" Bbl, Bushmaster, 5.56 NATO chambered

Muzzle Velocity: 2,720 fps

Range: (yds)	<u>50</u>	<u>100</u>	<u>200</u>	<u>300</u>
Bullet Path: (in)	.20	1.70	0.0	-8.7
Velocity: (fps)	2593	2470	2234	2011
Energy: (ft-lbs)	1,120	1,016	831	673

CAUTION: THIS AMMUNITION IS MEANT ONLY FOR WEAPONS CHAMBERED IN 5.56 x 45mm NATO

20.0" Bbl, Bushmaster, 5.56 NATO chambered

Muzzle Velocity: 2,825 fps

Range: (yds)	<u>50</u>	<u>100</u>	<u>200</u>	<u>300</u>
Bullet Path: (in)	.10	1.40	0.0	-7.9
Velocity: (fps)	2695	2569	2328	2099
Energy: (ft-lbs)	1,210	1,099	902	734

CAUTION: THIS AMMUNITION IS MEANT ONLY FOR WEAPONS CHAMBERED IN 5.56 x 45mm NATO

5.56 X 45mm NATO
Gelatin Penetration Performance Test

Bullet: 75 gr BTHP T2

Weapon: Bushmaster

Barrel: 14.5"

Twist Rate: 1-9"

	<u>Bare</u>	<u>Car Door</u>	<u>Fire Door</u>	<u>Safety Glass</u>	<u>Wallboard</u>
BB Calibration					
Velocity (fps)	591	580	580	583	583
Penetration	3.25"	3.50"	3.50"	3.75"	3.75"
Velocity (fps)	2,667	2,681	2,665	2,643	2,624
Total Penetration	13.5"	8.5"	6.50"	7.50"	7.50"
Entry	1.25"	0"	0"	0"	0"
Depth to Max Cavity	5.0"	2.5"	2.0"	2.75"	2.25"
Max. Temporary Cavity	5.50"	7.00"	6.50"	4.50"	6.25"
Retained Weight (grains)	32.8	26.6	23.8	16.4	24.2
Percent Fragmentation	56%	65%	68%	78%	68%
Deflection	N/A	N/A	N/A	??	N/A
Maximum Performance Range	225 yds	225 yds	225 yds	225 yds	225 yds

Notes

.223 Remington Ammunition Trajectory Performance (inches)

Muzzle Velocity	2,710
Zero (yds.)	200
50	+0.3
100	+1.7
150	+1.6
200	0.0
250	-3.4
300	-8.7

5.56 X 45mm NATO
Gelatin Penetration Performance Test

Bullet: 75 gr BTHP T2

Weapon: Bushmaster

Barrel: 16"

Twist Rate: 1-9"

	<u>Bare</u>	<u>Car Door</u>	<u>Fire Door</u>	<u>Safety Glass</u>	<u>Wallboard</u>
BB Calibration					
Velocity (fps)	576	576	599	576	599
Penetration	3.50"	3.75"	3.75"	3.75"	3.75"
Velocity (fps)	2,665	2,682	2,695	2,711	2,688
Total Penetration	13.5"	12.0"	8.75"	6.5"	6.0"
Entry	1.25"	0"	0"	0"	0"
Depth to Max Cavity	4.5"	3.25"	2.25"	3.0"	3.25"
Max. Temporary Cavity	6.50"	6.0"	5.50"	4.5"	6.25"
Retained Weight (grains)	25.1	14.1	27.4	21.7	23.8
Percent Fragmentation	67%	81%	63%	71%	68%
Deflection	N/A	N/A	N/A	??	N/A
Maximum Performance Range	225 yds	225 yds	225 yds	225 yds	225 yds

Notes

.223 Remington Ammunition Trajectory Performance (inches)

Muzzle Velocity	2,740
Zero (yds.)	200
50	+0.2
100	+1.6
150	+1.6
200	0.0
250	-3.3
300	-8.5

5.56 X 45mm NATO
Gelatin Penetration Performance Test

Bullet: 75 gr BTHP T2

Weapon: Bushmaster

Barrel: 20"

Twist Rate: 1-9"

	<u>Bare</u>	<u>Car Door</u>	<u>Fire Door</u>	<u>Safety Glass</u>	<u>Wallboard</u>
BB Calibration					
Velocity (fps)	576	584	584	576	576
Penetration	3.50"	3.75"	3.75"	3.75"	3.75"
Velocity (fps)	2,809	2,809	2,797	2,804	2,799
Total Penetration	14.0"	5.0"	6.0"	6.5"	8.0"
Entry	0.5"	0"	0"	0"	0"
Depth to Max Cavity	5.0"	2.0"	2.5"	2.5"	2.5"
Max. Temporary Cavity	7.0"	5.5"	5.5"	5.5"	5.75"
Retained Weight (grains)	23.4	23.2	21.5	29.5	17.9
Percent Fragmentation	69%	69%	71%	61%	76%
Deflection	N/A	N/A	N/A	??	N/A
Maximum Performance Range	300 yds	300 yds	300 yds	300 yds	300 yds

Notes

.223 Remington Ammunition Trajectory Performance (inches)

Muzzle Velocity	2815
Zero (yds.)	200
50	+0.1
100	+1.5
150	+1.5
200	0.0
250	-3.1
300	-7.9

6.8 SPC

6.8 SPC Gelatin Performance

Gelatin Penetration Performance Test

Bullet: 110 grain tipped TAP

Weapon: PRI

Barrel: 12.5"

Twist Rate: 1-10"

	<u>Bare</u>	<u>Car Door</u>	<u>Fire Door</u>	<u>Safety Glass</u>	<u>Wallboard</u>
BB Calibration					
Velocity (fps)	586	581	586	583	585
Penetration	3.75"	3.75"	3.75"	3.25"	3.10"
Velocity (fps)	2,466	2,440	2,448	2,400	2,354
Total Penetration	15.0"	16.5"	13.0"	8.5"	18.5"
Entry	.25"	0"	0"	0"	0"
Depth to Max Cavity	4.25"	3.0"	2.0"	3.0"	6.0"
Max. Temporary Cavity	5.75"	6.25"	6.25"	5.50"	5.75"
Retained Weight (grains)	59.8 gr	65.6 gr	63.2 gr	47.2 gr	51.3 gr
Percent Fragmentation	46%	40%	42%	57%	53%
Maximum Performance Range	250 yds	250 yds	250 yds	250 yds	250 yds
Deflection	N/A	N/A	N/A	??	N/A

Notes

6.8 SPC Ammunition Trajectory Performance (inches)

Muzzle Velocity	2,435
Zero (yds.)	200
50	+0.8
100	+2.4
150	+2.2
200	0.0
250	-4.4
300	-11.1

6.8 SPC Gelatin Performance

Gelatin Penetration Performance Test

Bullet: 110 grain tipped TAP

Weapon: DPMS

Barrel: 16"

Twist Rate: 1-10"

	<u>Bare</u>	<u>Car Door</u>	<u>Fire Door</u>	<u>Safety Glass</u>	<u>Wallboard</u>
BB Calibration					
Velocity (fps)	579	580	580	583	579
Penetration	3.50"	3.50"	3.50"	3.25"	3.50"
Velocity (fps)	2,537	2,530	2,524	2,562	2,500
Total Penetration	14.5"	12.0"	10.25"	6.25	12.0"
Entry	0"	0"	0 "	0"	0"
Depth to Max Cavity	5.5"	3.25"	3.00"	3.00"	4.00"
Max. Temporary Cavity	6.5"	6.00"	6.75"	5.50"	7.25"
Retained Weight (grains)	66.8	50.3	48.7	36.9	68.9
Percent Fragmentation	39%	54%	56%	67%	37%
Maximum Performance Range	300 yds	300 yds	300 yds	300 yds	300 yds
Deflection	N/A	N/A	N/A	??	N/A

Notes

6.8 SPC Ammunition Trajectory Performance (inches)

Muzzle Velocity	2,570
Zero (yds.)	200
50	+0.5
100	+2.0
150	+1.9
200	0.0
250	-3.8
300	-9.8

6.8 SPC Gelatin Performance

Gelatin Penetration Performance Test

Bullet: 110 grain BTHP TAP

Weapon: PRI

Barrel: 12.5"

Twist Rate: 1-10"

	<u>Bare</u>	<u>Car Door</u>	<u>Fire Door</u>	<u>Safety Glass</u>	<u>Wallboard</u>
BB Calibration					
Velocity (fps)	601	601	602	606	595
Penetration	3.25"	3.25"	3.13"	3.25"	3.50"
Velocity (fps)	2,337	2,329	2,357	2,405	2,344
Total Penetration	15.75"	17.50"	17.75"	9.00"	19.00"
Entry	1.00"	0.00"	0.00"	0.00"	0.00"
Depth to Max Cavity	4.25"	4.00"	5.25"	4.75"	4.50"
Max. Temporary Cavity	6.00"	4.75"	5.50"	4.50"	4.75"
Retained Weight (grains)	89.1 gr	109.8 gr	109.6 gr	21.0 gr	95.9 gr
Percent Fragmentation	19%	0.2%	0.4%	81%	12.8%
Maximum Performance Range	200 yds	250 yds	250 yds	250 yds	250 yds
Deflection	N/A	N/A	N/A	??	N/A

Notes

6.8 SPC Ammunition Trajectory Performance (inches)

Muzzle Velocity	2,370
Zero (yds.)	200
50	+1.0
100	+2.7
150	+2.4
200	0.0
250	-4.1
300	-12.2

6.8 SPC Gelatin Performance

Gelatin Penetration Performance Test

Bullet: 110 grain BTHP TAP

Weapon: DPMS

Barrel: 16"

Twist Rate: 1-10"

	<u>Bare</u>	<u>Car Door</u>	<u>Fire Door</u>	<u>Safety Glass</u>	<u>Wallboard</u>
BB Calibration					
Velocity (fps)	597	590	595	605	590
Penetration	3.25"	3.50"	3.50"	3.25"	3.50"
Velocity (fps)	2,484	2,507	2,505	2,529	2,497
Total Penetration	15.50"	22.5"	14.50"	8.50"	13.75"
Entry	0.50"	0.50"	0.75"	0.00"	0.75"
Depth to Max Cavity	4.00"	4.00"	4.00"	4.00"	4.75"
Max. Temporary Cavity	4.75"	5.00"	5.50"	4.00"	5.25"
Retained Weight (grains)	89.9 gr	109.8 gr	80.7 gr	47.2 gr	59.8 gr
Percent Fragmentation	18%	0.2%	17.5%	57.1%	45.6%
Maximum Performance Range	300 yds	300 yds	300 yds	300 yds	300 yds
Deflection	N/A	N/A	N/A	??	N/A

Notes

6.8 SPC Ammunition Trajectory Performance (inches)

Muzzle Velocity	2,520
Zero (yds.)	200
50	+0.6
100	+2.1
150	+2.0
200	0.0
250	-4.0
300	-10.4

6.8 SPC Gelatin Performance

Gelatin Penetration Performance Test

Bullet: 110 grain BTHP TAP

Weapon: PRI

Barrel: 12.5"

Twist Rate: 1-10"

	<u>7.62x39 steel case ammo with corncob filler, canvas mad pouch and fabric robe simulant against gelatin</u>
BB Calibration	
Velocity (fps)	601
Penetration	3.25
Velocity (fps)	2,376
Total Penetration	14.5"
Entry	0.0
Depth to Max Cavity	3.75"
Max. Temporary Cavity	4.25"
Retained Weight (grains)	65.7
Percent Fragmentation	40%
Maximum Performance Range	250 yds
Deflection	N/A

Notes

6.8 SPC Ammunition Trajectory Performance (inches)

Muzzle Velocity	2,370
Zero (yds.)	200
50	+1.0
100	+2.7
150	+2.4
200	0.0
250	-4.1
300	-12.2

.308 Win/ 7.62 NATO

.308 Winchester/7.62mm NATO

Weapon: Springfield Armory M1A Scout

Barrel: 18"

Twist Rate: 1-11"

Ammunition

	110 grain	155 grain	168 grain
Bullet Weight:	110 grain	155 grain	168 grain
Muzzle Velocity (fps):	3050	2623	2485
Standard Deviation:	20	4	15

Gelatin Performance

	110 grain	155 grain	168 grain
BB Penetration (inches/fps)	3.56"/586	3.44"/586	3.50"/598
A. Total Penetration:	9.75"	14"	17"
<u>B.</u> Entry:	.5"	.5"	1"
C. Depth to Max. Cavity:	4"	4.5"	6.88"
D. Max. Temporary Cavity:	6.50"	7.25"	5.25"
E. Retained Weight (grains):	20.3 gr.	118.4 gr.	138.7 gr.
F. Percent Fragmentation:	82%	24%	18%

Trajectory in inches

Height of the sight above the bore (off set): 1.38"

Bullet	Muzzle Velocity:	Zero (yds)	50	100	150	200	250	300
110 grain	3050 fps	250 yards	+1.2	+2.8	+3.2	+2.3	0	-3.9
155 grain	2623 fps	200 yards	+1.1	+2.2	+1.9	0	-3.5	-8.9
168 grain	2485 fps	200 yards	+1.3	+2.5	+2.1	0	-4	-9.9

.308 Winchester/7.62mm NATO

Weapon: Steyr SSG

Barrel: 20"

Twist Rate: 1-12"

Ammunition

	110 grain	155 grain	168 grain
Bullet Weight:			
Muzzle Velocity (fps):	3031	2639	2546
Standard Deviation:	29	16	10

Gelatin Performance

	110 grain	155 grain	168 grain
BB Penetration (inches/fps)	3.38"/589	3.38"/591	3.50"/588
A. Total Penetration:	10.5"	14.5"	18"
<u>B.</u> Entry:	.25"	.5"	1"
C. Depth to Max. Cavity:	3.38"	4.38"	6"
D. Max. Temporary Cavity:	7.50"	8"	7.5"
E. Retained Weight (grains):	19.8 gr.	103 gr.	105 gr.
F. Percent Fragmentation:	82%	33%	38%

Trajectory, come-ups are from 100 yard zero in MOA to nearest .25 MOA

Height of the sight above the bore (off set): 1.38"

Bullet	Muzzle Velocity:	25	50	100	150	200	250	300
110 grain	3031 fps	-2.5	-.25	0	+.75	+1.75	+2.75	+4.25
155 grain	2639 fps	-2.25	-0	0	+1.0	+2.25	+3.5	+5.0
168 grain	2546 fps	-2.0	0	0	+1.0	+2.25	+3.75	+5.5

.308 Winchester/7.62mm NATO

Weapon: Savage

Barrel: 24"

Twist Rate: 1-10"

Ammunition

Bullet Weight:	110 grain	155 grain	168 grain
Muzzle Velocity (fps):	3176	2796	2680
Standard Deviation:	32	21	10

Gelatin Performance

No ballistic gelatin tests conducted see page 20 for the Winchester M70 with a 25.25" barrel

Trajectory, come-ups are from 100 yard zero in MOA to nearest .25 MOA

Height of the sight above the bore (off set): 1.38"

Bullet	Muzzle Velocity:	25	50	100	150	200	250	300
110 grain	3176 fps	-2.75	-.5	0	+.5	+1.5	+2.5	+3.5
155 grain	2796 fps	-2.5	-.25	0	+.75	+1.75	+3.0	+4.5
168 grain	2680 fps	-2.25	0	0	+1.0	+2.0	+3.5	+4.75

.308 Winchester/7.62mm NATO

Weapon: Winchester Model 70 Match Grade Custom Barrel

Barrel: 25.25"

Twist Rate: 1-12"

Ammunition

	110 grain	155 grain	168 grain
Bullet Weight:	110 grain	155 grain	168 grain
Muzzle Velocity (fps):	3179	2783	2675
Standard Deviation:	27	18	9

Gelatin Performance

BB Penetration (inches/fps)	3.44"/607	3.25"/592	3.44"/598
A. Total Penetration:	9.75"	14"	15.75"
<u>B.</u> Entry:	.25"	.5"	.5"
C. Depth to Max. Cavity:	4"	4.5"	5"
D. Max. Temporary Cavity:	7.25"	8"	5.5"
E. Retained Weight (grains):	19.9 gr.	90 gr.	91 gr.
F. Percent Fragmentation:	82%	41%	46%

Trajectory, come ups are from 100 yard zero in MOA to nearest .25 MOA

Height of the sight above the bore (off set): 1.38"

Bullet	Muzzle Velocity:	25	50	100	150	200	250	300
110 grain	3179 fps	-2.75	-.5	0	+.5	+1.5	+2.5	+3.5
155 grain	2783 fps	-2.5	-.25	0	+.75	+1.75	+3.0	+4.5
168 grain	2675 fps	-2.25	0	0	+1.0	+2.0	+3.5	+4.75

308 Win 165 Barrier Performance
Gelatin Penetration Performance Test

Bullet: 165 gr Barrier

Weapon: Savage Tactical

Barrel: 24"

Twist Rate: 1-12"

	<u>Bare</u>	<u>Car Door</u>	<u>Fire Door</u>	<u>Safety Glass</u>	<u>Wallboard</u>
BB Ca libration					
Velocity (fps)	590	595	602	601	610
Penetration	3.75"	3.50"	3.60"	3.50"	3.75"
Velocity (fps)	2,658	2,650	2,634	2,679	2,686
Total Penetration	18.50"	23.00"	24.50"	28.5"	19.25"
Entry	0.50"	0.00"	0.00"	0.00"	0.00"
Depth to Max Cavity	5.50"	5.25"	4.50"	6.00"	6.00"
Max. Temporary Cavity	5.75"	6.00"	5.25"	6.75"	6.25"
Retained Weight (grains)	152.8	154.0	144.7	117.3	136.0
Percent Fragmentation	7%	6.7%	12.3%	29.9%	17.6%
Deflection	N/A	N/A	N/A	N/A	N/A
Maximum Performance Range	250 yds	250 yds	250 yds	250 yds	250 yds

Notes

308 Winchester 165 Barrier Ammunition Trajectory Performance (inches)
(H.O.S.: 1.38")

Muzzle Velocity	2,675
Zero (yds.)	100
25	-0.5
50	0.0
100	0.0
150	-1.4
200	-4.3
250	-8.9
300	-15.2

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American Sniper Ammunition What It Is and What It Should Be

Incredibly as this book is being written, neither the U. S. military snipers nor the vast majority of police snipers are using appropriate sniper ammunition. By appropriate we mean ammunition properly designed for their specific sniper mission.

Since Vietnam, U. S. military snipers have been using one variety or another of 7.62mm NATO match ammunition with non-expanding bullets of 168 to 173 grains. Probably 95% or better of the American law enforcement snipers also use similar match ammunition usually with a 168 grain non-expanding hollow point. Since such ammunition is quite accurate and sniper ammunition needs to be accurate, it was a logical place to start.

Because match ammunition was already in the system when the requirement for sniper rifles and ammunition for use in Vietnam was identified, it was expedient to use it for that purpose. However, our involvement in Vietnam ended nearly thirty years ago. Incredibly, to this day the U. S. military seems to have put little if any thought into adopting an appropriate round specifically designed for military sniper mission requirements. This is particularly unfathomable in light of the fact that the Soviet Union, which supplied weapons and ammunition to many of our enemies and potential enemies, did develop just such a sniper round decades ago.

What is wrong with our military match ammunition for sniping? Actually at least two things. As stated in the Forward to

this book, all good sniper ammunition is accurate but not all accurate ammunition is good sniper ammunition.

A basic part of the military sniper mission is shooting from concealment. It is ridiculous to train our snipers to use camouflage to keep their position from being detected and then issue them bright and shiny ammunition that can compromise them. The last thing a sniper needs is ammunition that is so bright and shiny that it will give away his position by flashing or glint when it is being loaded into the rifle or being ejected from it. Certainly in many cases the sniper can take actions to help prevent this from happening but he should not even have to worry about it. Unfortunately our military match ammunition is bright and shiny.

Military sniper ammunition should be dull and non-reflective in texture and dark in color. This is easily accomplished in a wide variety of ways. There are many coating processes that would work well. Optionally the case and bullet can be darkened chemically, which has the advantage of not changing dimensions to a measurable degree.

Author Karwan can personally attest to the effectiveness of the dull dark Soviet style tactical ammunition in preventing detection from his experiences in Vietnam facing enemies using such ammunition. The only time he or anyone else he served with ever spotted an enemy shooter by the reflection of his ammunition was when the enemy was using weapons with shiny brass ammunition like captured M16s or M1 Carbines. Indeed, we would support the position that all military small arms ammunition should be dull and dark colored not just sniper ammunition. However, if that is not

practical at least military sniper ammunition should be made that way.

Also, there is a strong contingent in the military sniper community that is against the use of semiautomatic sniper rifles. One of their major criticisms of semiautomatics is that reflection from the automatically ejected cartridge case can give away the sniper's position. In most cases the sniper can camouflage the ejection of his rounds anyway. However, even when he can't, it is only a problem if shiny match ammunition is used instead of proper dull and dark colored sniper ammunition.

The second deficiency in using match ammunition for military sniping is that it has a standard configuration jacketed ball bullet with a lead core. For several reasons what should be used instead is a match grade armor piercing (AP) bullet.

First, with regard to accuracy, such bullets can be made so as to be every bit as accurate as a conventional match bullet. Such a bullet is just as effective against soft targets as match ball but an AP bullet is far more effective against important materiel targets like radios, radar dishes, fuel tanks, aircraft skins, ad infinitum.

Finally, an AP bullet will defeat various types of cover that will stop match ball. This can include light skinned vehicles, light armor, masonry walls, thick timber either in a standing tree or as part of a bunker, heavy bullet resistant glass, and much more. This trait allows the military sniper to get kills he would otherwise fail to get. In other words a highly accurate armor piercing sniper round has several significant advantages over match ball and no tactical disadvantages.

Few modern U. S. military snipers know that for all the reasons given above, during WWII the primary U. S. military sniper round, particularly in the European Theater, was .30-06 M2 Armor Piercing. Indeed M2 AP was the primary rifle and machine gun round as well also for the same reasons. There is no reason why our current standard machine gun round should not be armor piercing either. Similarly, the favored sniper round for the British snipers in WWII was .303 Armor Piercing. This is just another example of hard won information that has been lost or forgotten.

For the last several decades the standard Soviet 7.62x54Rmm sniper round has been an extremely accurate specially designed sniper bullet with a steel penetrator forward core. Interestingly, this round is especially constructed with an air space in its nose that causes the bullet to tumble in soft targets like flesh. Thus this brilliantly designed bullet makes this round superior to ball ammunition against both hard and soft targets. There is nothing in the U. S. inventory that compares with the Soviet sniper bullet or round, but there should be.

There you have it. The standard military sniper cartridge should be a highly accurate armor piercing round with a dull dark finish. If it could be made to be more lethal against soft targets like the Soviet sniper round, it would be even better.

It would also be extremely helpful for some types of anti-materiel sniping to have available an armor piercing incendiary sniper round with exactly the same trajectory as the proposed AP sniper round.

Now let us turn to law enforcement sniper ammunition. While

the vast majority of police snipers use virtually the same type ammunition as our military, match ball, the problem is completely different. It is probably not all that critical that a law enforcement sniper have dull dark colored ammunition except when operating against terrorists which may have military training and a counter sniper capability. Consequently, we will not dwell on that aspect except to say it would not hurt for police to have dull dark sniper ammunition.

The main problem with law enforcement (LE) sniper ammunition is that the match bullet typically used, even when it has a hollow point, is not an expanding bullet and is far too prone to over penetrate. This also applies to special military hostage rescue and counter terrorist units.

Such over penetration is likely to lead to killing or injuring some of the very people that the police are there to serve, protect, and rescue. The standard .308 168 grain match bullet used by most law enforcement snipers will literally penetrate through a typical house from side to side. It never ceases to amaze us how many LE snipers think that the hollow point in the match bullet is for expansion. It is not and the bullet acts much like full metal jacket ball.

No sniper needs the death of an innocent on his hands and no agency needs the bad publicity and fiscal liability that comes with it. Superbly accurate sniper ammunition is readily available that will not over penetrate. Consequently, any agency or individual sniper that uses ammunition that does over penetrate and kills or wounds an innocent person because it does, has left themselves wide open

for a lawsuit that they will lose.

Law enforcement sniper ammunition should expand violently on contact with flesh with extremely limited penetration and maximum fragmentation of the bullet. The primary reason is to prevent over penetration that will injure or kill innocents. However, it also is superior in other ways.

The law enforcement sniper's primary job is to prevent someone from hurting or killing someone else. To this end the LE sniper applies lethal force with his sniper rifle to end the threat. When the target has a gun pointed at a hostage, a knife held to the throat of a hostage, or a finger on a bomb detonator, the shot must bring about instantaneous incapacitation so that the hostage or hostages are not killed or injured by the target's last death throws or efforts. This is why LE snipers put so much emphasis on brain shots. When the brain is hit by a high velocity projectile incapacitation is instantaneous.

Obviously, if the brain is hit with a match bullet or a fragmenting limited penetration bullet the results to the target are going to be the same, instant lights out. However, what if the brain is missed because the target moved or stood up just as the shot broke? What if the angle of the sniper or the position of the hostage prevents a brain shot? This is where the violently expanding bullet shines.

The best of these bullets, like those used in the superb Hornady Tactical Application Police (TAP) ammunition, cause such a violent and large temporary cavity that a hit almost anywhere on the head or neck will break the target's spine or severely damage the brain

even if the brain is missed. Either situation causes the required instant incapacitation.

Possibly even more significant is that a study conducted in North Carolina involving shooting large goats in the lungs with high velocity high energy frangible projectiles indicates that the large temporary cavity created by such a projectile can cause a severe blood pressure spike to the animal's brain causing instant incapacitation. In effect it is an artificially induced massive stroke. The test animals had special blood pressure monitoring probes surgically inserted into one of the animal's major neck arteries to the brain well prior to the shooting. When the projectile had a large and violent enough temporary cavity to cause a severe blood pressure spike, the animal was instantly incapacitated. The Hornady TAP rounds have energies and temporary cavity sizes well beyond those shown to cause instant incapacitation in the tests.

What this means is that by using this type of high energy violently expanding and fragmenting bullets the LE sniper can be confident that he can successfully deliver instant incapacitation even with an upper torso shot. Also, when shooting conditions do not allow a stable shooting platform a much larger target area than the brain can be engaged with confidence that instant incapacitation can still be achieved.

In .308 the Hornady TAP round with a 110 grain bullet is ideal for LE sniper use. It was extremely accurate in all rifles it was tested in, shooting sub-MOA in virtually everything tried, bolt action or semiauto, achieving 1/2 MOA in some. Yes, the conventional wisdom is that such a light bullet will not be as accurate as heavier bullets in

this chambering but this one is. A Knight SR-25 and two different M1A sniper rifles functioned semiautomatically perfectly with the round, so that is not a problem either.

The 110 grain TAP round launches its bullet out at 3200 fps. Ballistically this is the equivalent of two 55 grain 5.56mm (.223) wrapped up in one bullet. Thanks to its high velocity it has an extremely flat trajectory out to well beyond typical law enforcement sniper ranges. Indeed, properly zeroed this round can have a point blank zero that will allow a head shot all the way out to 250 yards with just one sight setting.

Because of its exceptionally high velocity, this load has a shorter time of flight than more conventional loads meaning that it needs less lead on moving targets. It also extends the range to which the forward edge of the target aiming point system works on moving targets.

In addition, because the bullet is so light the recoil of this load is remarkably low. This allows the shooter to see the impact of his shot in his scope, making for extremely fast shot recovery, and immediate follow up shots if the shooter is using a semiautomatic sniper rifle.

This 110 gr. TAP load will defeat a Level 2 or better protective vest with ease but not come out the other side of the person shot whether or not there is a vest panel in the rear. This is ideal performance for use against terrorists and criminals wearing protective vests. It is so explosive that it will not exit a human with a torso hit and at the maximum only small non-lethal pieces will exit on a head shot. If a block of ballistic gelatin, as used in handgun

bullet testing, is shot with this load at 100 yards, it practically blows up. This load is absolutely the single best .308 law enforcement sniper or tactical cartridge available today.

Author Karwan tested this load on an adult blacktail buck deer, purposely taking a shoulder shot to see if it might blow up on the surface of the shoulder blade. It penetrated the shoulder blade and underlying ribs nicely then fragmented in the chest cavity completely shredding the animal's lungs, heart, and liver. The animal died instantly literally dropping in his tracks without a drop of blood coming out of the bullet hole. He has considerable experience shooting deer with a wide variety of cartridges and loads and has never had such an instantaneous incapacitation on a deer which are far tougher than any human. While shooting just one animal is not conclusive, the point here is that the bullet performed exactly as was predicted by laboratory testing on gelatin and goats. The only reason not to use it would be if it was not accurate enough in an individual rifle.

To cover this contingency Hornady offers a similar load made with a 155 gr. bullet that is likely to shoot well in any .308 with a conventional rifling twist barrel. This load too is wonderfully accurate and has most of the same traits as its 110 gr. brother except that it has noticeably heavier recoil and muzzle jump and is slightly less explosive with a smaller less violent temporary wound cavity. However, experience shooting animals like hogs and gelatin indicates that it is unlikely to over penetrate a human torso.

The problem is that as this is being written most police snipers and agencies are incapable of "thinking outside of the box". Typically

they will say that a 110 gr. bullet is "too light" for sniping. It probably would be for sniping at 600 plus yards. However, out to three hundred yards it is flatter shooting and more effective than any heavier bullet .308 load we are aware of. We should point out that the average distance for law enforcement snipers to shoot at is around 75 yards and any shot beyond 200 yards is extremely rare.

Hornady has had such a problem getting this across to law enforcement snipers and their agencies that they were forced to bring out a 168 grain TAP load for the heavy bullet crowd who can not understand or will not except the advantages of the lighter bullets. This too is a highly frangible bullet but it is less explosive than the 110 and 155 gr. TAP and has more potential for some over penetration as well as considerably more recoil than the former.

For those agencies using .223 sniper and tactical rifles Hornady has several highly accurate and highly explosive TAP loads in this chambering as well.

The bottom line is that the law enforcement sniper ammunition should be a highly accurate, deliver extremely limited penetration, and have a highly frangible bullet. Agencies using other calibers like .243, .270, or .30-06 can turn to light bullet varmint type loads in these chamberings to approximate the Hornady TAP performance. Regardless, what they *should not* be using is ammunition with non-expanding match ball type bullets.

300 Winchester Meg

300 Win Mag 178 TAP Performance
Gelatin Penetration Performance Test

Bullet: 178 gr AMAX

Weapon: Winchester M70

Barrel: 25"

Twist Rate: 1-10"

	<u>Bare</u>	<u>Car Door</u>	<u>Fire Door</u>	<u>Safety Glass</u>	<u>Wallboard</u>
BB Calibration					
Velocity (fps)	594	595	589	582	607
Penetration	3.50"	3.50"	3.25"	3.50"	3.50"
Velocity (fps)	2,969	2,981	2,978	2,998	2,964
Total Penetration	13.50"	15.00"	12.00"	10.5"	14.00"
Entry	0.00"	0.00"	0.00"	0.00"	0.00"
Depth to Max Cavity	4.00"	4.50"	3.50"	3.50"	4.50"
Max. Temporary Cavity	7.00"	8.00"	6.50"	7.00"	7.00"
Retained Weight (grains)	80.2	37.6	13.2	29.4	66.3
Percent Fragmentation	55%	78.9%	92.6%	83.5%	62.8%
Deflection	N/A	N/A	N/A	N/A	N/A
Maximum Performance Range	350	350	350	350	350

Notes

308 Winchester 178 TAP Ammunition Trajectory Performance (inches)
(H.O.S.: 1.38")

Muzzle Velocity	2,990
Zero (yds.)	200
100	+1.5
200	0.0
300	-6.6
400	-19.0
500	-38.2

Sheetrock Test

Sheetrock Test

.223 Remington/5.56mm NATO

Weapon: Bushmaster AR-15 A2

Barrel: 16"

Twist Rate: 1-9"

Ammunition

	40 grain	55 grain	60 grain	75 grain
Bullet Weight:				
Muzzle Velocity (fps):	3242	2997	(a)	(a)
Exit Velocity:	2398	2491		

Gelatin Performance

BB Penetration (inches/fps)	3.44"/607	3.44"/607
A. Total Penetration:	3.12"	5.75"
<u>B.</u> Entry:	0"	0"
C. Depth to Max. Cavity:	1.75"	3"
D. Max. Temporary Cavity:	2.5"	4.0"
E. Retained Weight (grains):	0 gr.	7.8 gr.
F. Percent Fragmentation:	100%	86%

(a) Testing not yet completed

Automotive Safety Glass Test

Automotive Glass Penetration Performance

.223 Remington/5.56mm NATO

Weapon: Bushmaster AR-15 A2

Barrel: 16"

Twist Rate: 1-9"

Ammunition

Bullet Weight:	40 grain	55 grain	60 grain	75 grain
Muzzle Velocity (fps):	(a)	(a)	2896	2616

Gelatin Performance

BB Penetration (inches/fps)	3.50"/608	3.50"/608
A. Total Penetration:	5"	8"
<u>B.</u> Entry:	0"	0"
C. Depth to Max. Cavity:	2.68"	3"
D. Max. Temporary Cavity:	3.75"	5"
E. Retained Weight (grains):	11.6gr.	0 gr.
F. Percent Fragmentation:	81%	100%
G. Deflection:	.11"	.05"
H. Total Deflection 48.5 feet:	5.3"	.24

Note: Deflection is measured in inches of bullet movement off the aiming point per foot of travel.

(a) Testing not yet completed.

Automotive Glass Penetration Performance

.308 Winchester/7.62mm NATO

Weapon: Winchester M70

Barrel: 25.25"

Twist Rate: 1-12"

Ammunition

Bullet Weight:	110 grain!	155 grain*	168 grain
Muzzle Velocity (fps):	(a)	2824	2680

Gelatin Performance

BB Penetration (inches/fps)	3.31"/589	3.31"/589
A. Total Penetration:	11"	10"
B. Entry:	0"	0"
C. Depth to Max. Cavity:	4.5"	4.5"
D. Max. Temporary Cavity:	7"	7"
E. Retained Weight (grains):	25 gr.	0 gr.
F. Percent Fragmentation:	84%	100%
G. Deflection:	.07"	.2"
H. Total Deflection 48.5 feet:	3.4"	9.7"

Note: Deflection is measured in inches of bullet movement off the aiming point per foot of travel.

(a) Testing not yet completed.

*168 AMAX round stats are very close to stats for the 155 AMAX with less deflection and more retained weight.

SUMMARY OF GLASS SHOOTING EXPERIENCE

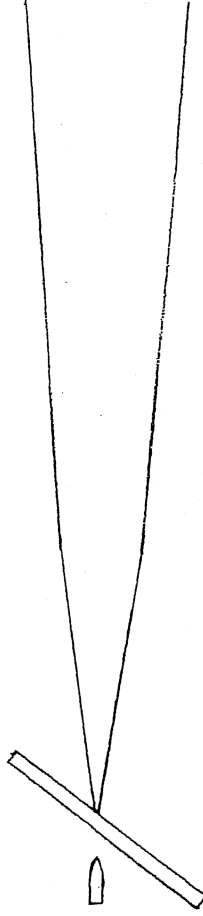
○ THERE ARE FEW ABSOLUTES.

○ BULLETS WITH CONVENTIONAL JACKETED DESIGN WILL ALMOST ALWAYS SHED THE JACKET AND TYPICALLY LOSE 40 - 50% OF THEIR LENGTH. (30 - 40% OF WEIGHT). BONDED BULLETS FRAGMENT LESS AND RETAIN MORE WEIGHT BUT PRESENT A SEVERE OVER PENETRATION THREAT.

- THICKER GLASS, LIGHTER BULLET OR LARGE ANGLE OF OBLIQUITY WILL BE WORSE. (LOSE 70 - 80% OF LENGTH, 60 - 70 % OF WEIGHT)

○ IF ANY SIGNIFICANT ANGLE OF OBLIQUITY EXISTS (15 DEG OR MORE), THE BULLET IS ALMOST ALWAYS YAWED AND DEFLECTED FROM THE FLIGHT PATH.

- BULLETS PATH CAN USUALLY BE FOUND WITHIN A CONE OF 1.0 TO 2.0 DEG HALF ANGLE ABOUT THE EXIT POINT IN THE GLASS. THIS RESULTS IN GROUPS GROWING .4 - .8 INCHES PER FOOT OF BULLET TRAVEL BEHIND THE GLASS. (THIS APPLIES FOR THE FIRST 3 TO 4 FEET BEHIND THE GLASS. AT FURTHER DISTANCE THE BULLET/FRAGMENTS USUALLY DIVERGE AT A LESSER ANGLE.



- BTHP DESIGNS TYPICALLY FALL IN THE TOP HALF OF THIS RANGE, SOFT POINT BULLETS USUALLY ARE IN THE 1.0 TO 1.5 DEG RANGE.

- FMJ BULLETS ARE TOTALLY UNPREDICTABLE, THEIR USE IS STRONGLY DISCOURAGED

- .22 CAL BULLETS FREQUENTLY HAVE DEFLECTION ANGLES 3 TO 4 TIMES A .30 CAL BULLET

SUMMARY (CONT'D)

- THE THICKER THE GLASS, HIGHER THE OBLIQUITY ANGLE OR THE LIGHTER THE BULLET THE GREATER THE DEFLECTION WILL BE
- A HEAVIER BULLET WILL TYPICALLY DEFLECT LESS
- BTHP DESIGNS HAVE POOR PERFORMANCE ON GLASS BECAUSE THEY DO NOT HAVE A SOLID NOSE. THEY WILL DEFLECT MORE, BE YAWED MORE AND BE DAMAGED MORE.
- THE SNIPER MUST ALSO CONSIDER THE PATH OF THE GLASS AND BULLET FRAGMENTS CLOUD BEHIND THE GLASS AND THE POTENTIAL FOR COLATERAL DAMAGE.

APPROXIMATE

GROUP SIZE GROWTH BEHIND GLASS PER FOOT OF TRAVEL
FOR 3 TO 4 FEET BEHIND GLASS
(ANGLES UP TO 45 DEGREES)

<u>BULLET</u>	<u>GLASS TYPE</u>	<u>GROUP SIZE GROWTH (IN)</u>
.22 CAL	SAFETY/SINGLE PANE RESIDENTIAL	1.24 - 2.00
.30 CAL	SAFTEY/SINGLE PANE RESIDENTIAL	.5
.30 CAL	DOUBLE PANE RESIDENTIAL	.5 - .75
.30 CAL	THICK TEMPERED GLASS	.75 - 1.00

* SOFT POINT BULLETS WILL BE IN THE LOWER PART OF THE RANGE, BTHP DESIGNS WILL BE IN THE UPPER PART OF THE RANGE. THIS IS TYPICAL PERFORMANCE UNDER LABORATORY CONDITIONS. YOU CANNOT GUARENTEE THAT BULLETS WILL PERFORM EXACTLY LIKE THIS ALL THE TIME!

SUMMARY (CONT'D)

○ THE DEBRIS CLOUD THAT FOLLOWS A BULLET EXITING GLASS CONTAINS THOUSANDS OF PIECES OF GLASS FROM GRAIN OF SAND SIZE TO SIGNIFICANT PIECES THE SIZE OF A .22 BULLET. IN ADDITION IT CONTAINS BULLET FRAGMENTS THAT CAN WEIGH UPWARDS OF 10 TO 20 GRAINS TRAVELING AT NEARLY THE SAME SPEED AS THE BULLET. THIS MUST BE CONSIDERED WHEN ATTEMPTING TO MAKE A SHOT IN A HOSTAGE SITUATION. COLLATERAL DAMAGE IS A SERIOUS THREAT.

○ THE DEBRIS CLOUD SPREADS OUT RAPIDLY IN THE FIRST 3 TO 4 FEET FROM THE POINT OF BULLET EXIT. THE GLASS FRAGMENTS HAVE LESS VELOCITY THAN THE BULLET FRAGMENTS AND RAPIDLY LOSE THEIR VELOCITY. HOWEVER, MANY OF THESE GLASS FRAGMENTS ARE CAPABLE OF BREAKING THE SKIN AND ACHIEVING SOME PENETRATION. MANY OF THE BULLET FRAGMENTS ARE CAPABLE OF PENETRATING INTO MUSCLE TISSUE.

IN THE FIRST 3 TO 4 FEET BEHIND THE GLASS THE DEBRIS CLOUD WILL SPREAD OUT AT A RATE OF ABOUT 3.5 INCHES PER FOOT BEHIND THE GLASS.

RECOMMENDATIONS

- AVOID SHOOTING THROUGH GLASS IF AT ALL POSSIBLE.**
- TAKE SHOTS AS CLOSE TO PERPENDICULAR TO THE GLASS SURFACE AS POSSIBLE**
- TRY TO HAVE TARGET AS CLOSE TO GLASS AS POSSIBLE**
- TRY TO AVOID SHOTS OF GREATER THAN 30 DEG OBLIQUITY. DO NOT TAKE SHOTS OF GREATER THAN 45 DEG OBLIQUITY**
- FOR ANY SHOT OF 15 TO 30 DEG OBLIQUITY DO NOT TAKE A SHOT AT A TARGET AT MORE THAN 5 TO 6 FEET FROM THE GLASS. FOR SHOTS OF 30 TO 45 DEGREES OBLIQUITY DO NOT TAKE SHOTS AT TARGETS OVER 3 FEET FROM THE GLASS.**
- FOR NEARLY PERPENDICULAR SHOTS THE TARGET CAN BE 8 TO 10 FEET FROM THE GLASS**
- SNIPERS AND COMMANDERS MUST BE AWARE OF THE RISK OF COLLATERAL DAMAGE FROM GLASS AND BULLET FRAGMENTS.**

Body Armor Gelatin Tests

Body Armor Gelatin Tests

223 Remington/5.56mm NATO

Weapon: Bushmaster AR-15 A2

Barrel: 16"

Twist Rate: 1-9"

Ammunition

	40 grain	55 grain	60 grain	75 grain
Bullet Weight:				
Muzzle Velocity (fps):	(a)	2930	2865	2477

Gelatin Performance

BB Penetration (inches/fps)		3.25"/596	3.25"/596	3.38"/602
A. Total Penetration:		5.68"	6.25"	11"
<u>B.</u> Entry:		0"	0"	.25"
C. Depth to Max. Cavity:		1.75"	1.75"	3.25"
D. Max. Temporary Cavity:		4.38"	3.68"	4.50"
E. Retained Weight (grains):		11.1 gr.	5 gr.	39.8 gr.
F. Percent Fragmentation:		80%	92%	47%

(a) Testing not yet completed.

TAP Pistol

Hornady Pistol TAP XTP CQ Ammunition

Hornady offers the Pistol TAP XTP CQ line of ammunition for Law Enforcement (LE) use. This ammunition is being offered to complement our existing line of TAP Rifle ammunition. The TAP Pistol line of ammunition is specifically designed to offer Law Enforcement the best possible performance in duty pistol ammunition. This ammunition has been designed with bullets that perform in the optimum range of penetration and expansion for LE applications, giving 12-15" of penetration in bare ordnance gelatin. The ammunition has also been designed with propellants that offer clean burning with a minimum of residue and minimum signature from flash. Below is a general description of each round and a brief description of its' performance.

9 x 19mm (9mm Luger):

124 gr XTP CQ: This round is the lightest weight bullet that offers a reasonable range of performance for the 9mm. The round offers what we consider the minimum acceptable non barrier performance but becomes rather marginal when firing through the standard barrier tests. It is loaded to a nominal velocity of 1,110 fps in a SAAMI standard test barrel.

147 gr XTP CQ: This round offers more flexibility than the 124 gr particularly on barriers. Because of the greater bullet weight it offers superior terminal performance to the 124 gr in penetration/expansion and associated lethality. It is loaded to a nominal 975 fps in a SAAMI standard test barrel.

40 S & W

155 gr XTP CQ: This round offers a lower recoil load for the 40 S & W and terminal performance far exceeding a 9mm. The round offers very good terminal performance on everything but a car door shooting situation. It is loaded to a nominal velocity of 1,180 fps in SAAMI standard test barrel.

180 gr XTP CQ: This round is the best performing round in the line and offers truly exceptional performance on all types of targets. The round offers exceptional accuracy accuracy and impressive terminal performance. It is loaded to a nominal velocity of 950 fps in a SAAMI standard test barrel.

.45 AUTO

200 gr XTP CQ: This round is offered as a reduced recoil load for the .45 Auto. It offers very good terminal performance on everything but car door type shooting situations. It will not defeat a car type target but offers very good terminal performance on all other types of targets. The round is loaded to a nominal velocity of 900 fps in a SAAMI standard test barrel.

230 gr XTP CQ: This round offers acceptable performance on most target types but tends to over penetrate somewhat on some of the barrier shooting scenarios. The round offers exceptional accuracy. It is loaded to a nominal velocity of 850 fps in a SAAMI standard test barrel.

Test Protocol

Hornady TAP Pistol Ammunition Testing

Location: Hornady Manufacturing Ballistics Laboratory, Grand Island, Nebraska

Elevation: 1,800 feet ASL

Temperature: 70 deg F

Bullet Velocity: (Feet per second, fps) An Oehler model 35P chronograph with Oehler model 55 skyscreens was used to measure velocities. Bullet velocity was measured at a distance of 21 feet from the muzzle of the gun. Ammunition Standard Deviation, in fps, is given for each gun/load combination.

10% Ballistic Gelatin tests: All ballistic gelatin was prepared in accordance with the procedure outlined by Dr. Martin Fackler and Mr. John Malinowski in their article, Ordinance Gelatin for Ballistic Studies, The Journal of Forensic and Pathology 9(3): pgs. 218-219, 1998. All gelatin was in blocks that measured 6" x 10" x 12" and was stored at 40 deg F until just prior to testing. Each block of gelatin used was calibrated with a BB fired at a velocity of 585 to 610 fps with a depth of penetration of 3.1 to 3.9 inches. The gelatin was placed 30 feet from the muzzle of the gun.

10% Gelatin and Heavy Clothing: In these tests the gelatin block was placed 30 feet from the muzzle of the gun. The gelatin was covered with materials representing heavy winter clothing. This material consisted of, starting from the surface of the gelatin outward, one layer of cotton t-shirt material (48 threads per inch), one layer of cotton shirt material (80 threads per inch), a 10-ounce down comforter in a cambric shell cover (200 threads per inch), and one layer of 13-ounce denim (50 threads per inch). Rounds were fired through the fabric and into the gelatin.

10% Gelatin, Sheet Metal and Light Clothing: In these tests the projectiles are fired through two sheets of steel representing a car door and then impact gelatin covered with light clothing. The gelatin is covered with light clothing consisting of one layer of cotton t-shirt material (48 threads per inch) and one layer of cotton shirt material (80 threads per inch). The gelatin is placed 18 inches behind two pieces of 20-gauge, hot rolled galvanized steel with the steel sheets placed 3 inches apart. The first sheet of steel was located 30 feet from the muzzle of the gun.

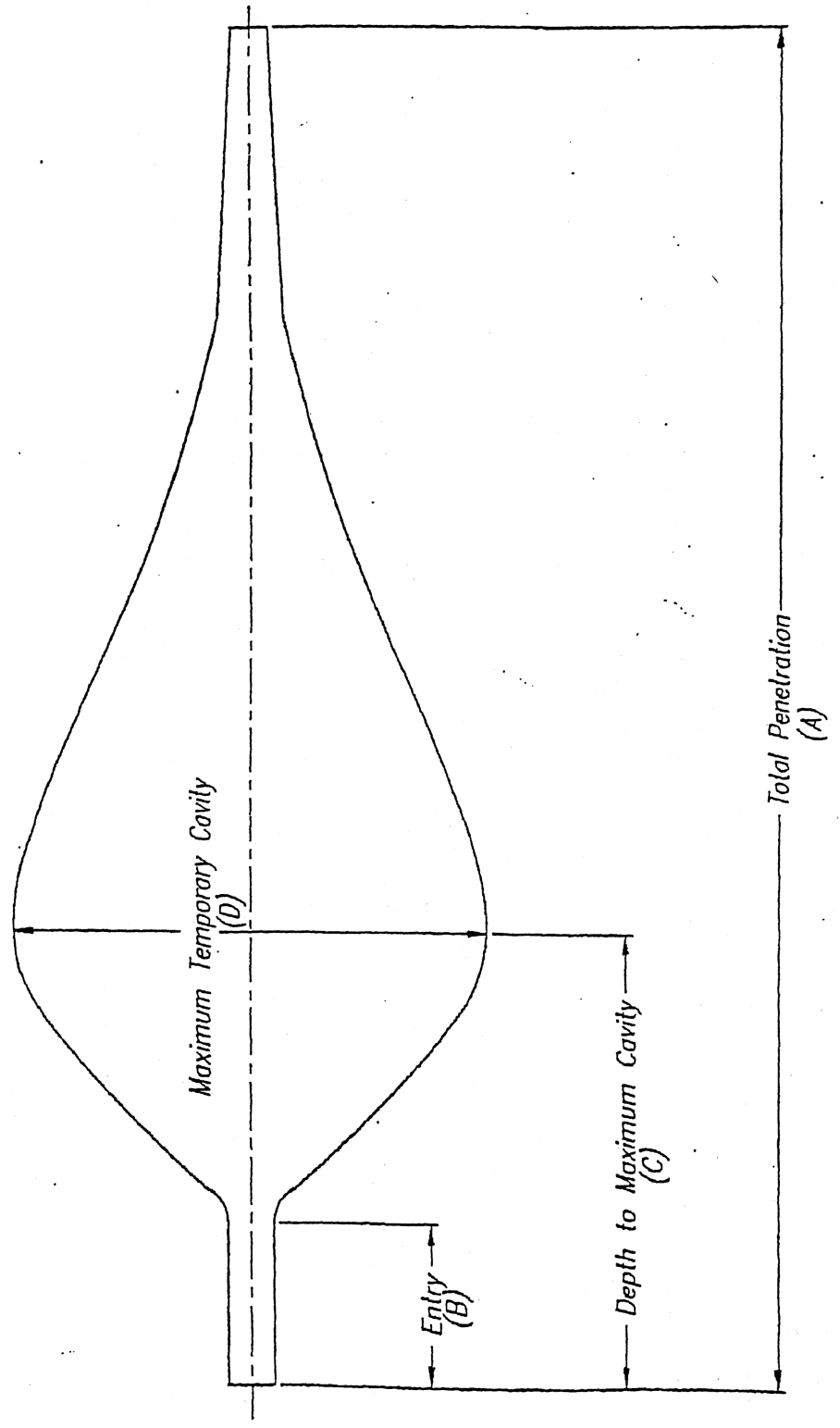
10% Gelatin, Sheetrock and Light Clothing: In these tests the projectile is fired through two pieces of half inch gypsum sheetrock set 3.5" apart, with the first sheet being 30 feet from the muzzle of the gun. The gelatin is placed 18" behind the back piece of sheetrock and covered with the above described light clothing.

10% Gelatin, Automobile Safety Glass and Light Clothing: In these tests the projectile is fired through 1 piece of one-quarter inch laminated automobile safety glass set at an angle of 45 degrees from vertical and 15 degrees from the line of flight of the bullet. The glass is placed 30 feet from the muzzle of the gun. The gelatin is placed 18 inches behind the glass and covered with light clothing.

TAP Pistol XTP CQ Handgun Test Velocities

<u>Ammunition</u>	<u>Firearm</u>	<u>Velocity fps (21')</u>	<u>Std Dev (fps)</u>
9mm 124	Beretta 92 FS	1,038	13
	Glock 19	1,044	5
	Sig P226	1,019	14
	S&W SW9F	1,064	7
9mm 147	Beretta 92 FS	985	21
	Glock 19	1,000	7
	Sig P226	981	12
	S&W SW9F	1,034	16
40 S&W 155	Glock 22	1,152	14
	S&W 4006	1,113	16
40 S&W 180	Glock 22	973	14
	S&W 4006	947	13
.45 Auto 200	Ruger P90	824	13
	Sig P220	833	11
	Colt 1911	843	16
.45 Auto 230	Ruger P90	804	12
	Sig P220	807	14
	Colt 1911	821	14

Gelatin Wound Channel



Bare Gelatin Performance Test

Ammunition:	9mm 124	9mm 147	40 S&W 155	40 S&W 180	.45 Auto 200	.45 Auto 230
Weapon:	Glock 19	Glock 19	Glock 22	Glock 22	Sig P220	Sig P220
BB Calibration:						
Velocity:	594	594	594	594	581	581
Penetration:	3.5"	3.5"	3.5"	3.5"	3.5"	3.5"
Velocity:	1,028	996	1,124	963	824	821
Total Penetration:	13"	15.25"	12.75"	13"	13.25"	13"
Entry:	.5"	.5"	.5"	.5"	.5"	.5"
Depth to Max. Cavity:	2.5"	2.25"	3"	3"	2.25"	3"
Max. Temporary Cavity:	1.75"	2"	2.62"	3"	2"	2.25"
Max. bullet expansion (in):	.610"	.520"	.605"	.735"	.665"	.670"
Retained weight (grains):	123.8	138.5	142.5	178.6	200	230

Notes:

Heavy Clothing Gelatin Performance Test

Ammunition:	9mm 124	9mm 147	40 S&W 155	40 S&W 180	.45 Auto 200	.45 Auto 230
Weapon:	Glock 19	Glock 19	Glock 22	Glock 22	Sig P220	Sig P220
BB Calibration:						
Velocity:	586	586	591	581	597	597
Penetration:	3.2"	3.2"	3.9"	3.9"	3.9"	3.9"
Velocity:	1,057	1005	1,096	951	817	815
Total Penetration:	18.75"	17.5 "	14.5"	15.5"	15.75"	19.25"
Entry:	.5"	.5"	.5"	.5"	1"	.5"
Depth to Max. Cavity:	2.6"	3.75"	2.75"	3"	2.5"	5.5"
Max. Temporary Cavity:	1.5"	1.75"	2"	2.5"	2"	2"
Max. bullet expansion (in):	.490"	.530"	.635"	.640"	.620"	.600"
Retained weight (grains):	123.6	146.9	154.7	180	200	230

Notes:

Sheet Metal Gelatin Performance Test

Ammunition: 9mm 124 Glock 19 9mm 147 Glock 19 40 S&W 155 Glock 22 40 S&W 180 Glock 22 .45 Auto 200 Sig P220 .45 Auto 230

Weapon: Glock 19 Glock 19 Glock 19 Glock 22 Glock 22 Glock 22 Glock 22 Glock 22 Sig P220 Sig P220

BB Calibration:

Velocity:

Penetration:

597
3.9"

593
3.9"

594
3.9"

594
3.9"

594
3.9"

Velocity:

1,029

1,124

957

817

Total Penetration:

18.25"

16.25"

21.5"

16.75"

15"

Entry:

.75"

.5"

.75"

.5"

.25"

Depth to Max. Cavity:

2.5"

2.5"

3"

1.5"

1.5"

Max. Temporary Cavity:

1.5"

1.25"

1.5"

1.5"

1.5"

Max. bullet expansion (in):

.440"

.510"

.460"

.550"

.570"

Retained weight (grains):

123.1

114.9

154

177.6

229.3

Notes:

Jacket separation

Did not defeat sheet metal

Sheet Rock Gelatin Performance Test

Ammunition:	9mm 124	9mm 147	40 S&W 155	40 S&W 180	.45 Auto 200	.45 Auto 230
Weapon:	Glock 19	Glock 19	Glock 22	Glock 22	Sig P220	Sig P220
BB Calibration:						
Velocity:	581	581	581	581	589	581
Penetration:	3.5"	3.5"	3.5"	3.5"	3.6	3.5"
Velocity:	1,051	992	1,064	977	824	827
Total Penetration:	14.75"	18.00"	13"	15.25"	15.25"	21.5"
Entry:	.5"	.5"	.5"	.5"	.5"	1.0"
Depth to Max. Cavity:	1.25"	4"	2.5"	3.5"	2"	3"
Max. Temporary Cavity:	1.75"	2"	2"	2"	1.75"	1.25"
Max. bullet expansion (in):	.510"	.460"	.610"	.600"	.555"	N/A
Retained weight (grains):	123.6	146.6	155	180	200	230

Notes:

Did not expand

Auto Glass Gelatin Performance Test

Ammunition:	9mm 124	9mm 147	40 S&W 155	40 S&W 180	.45 Auto 200	.45 Auto 230
Weapon:	Glock 19	Glock 19	Glock 22	Glock 22	Sig P220	Sig P220
BB Calibration:						
Velocity:	591	591	591	591	588	513
Penetration:	3.7"	3.7"	3.7"	3.7"	3.8	3.8"
Velocity:	1,034	985	1,095	959	823	813
Total Penetration:	10.5"	12"	14.25"	12"	10.5"	13.75"
Entry:	1"	.5"	0"	0"	0"	.5"
Depth to Max. Cavity:	2.5"	1.5"	2.25"	1.5"	2"	2"
Max. Temporary Cavity:	1.5"	1.5"	2.25"	1.5"	1.5"	1.25"
Max. bullet expansion (in):	.595"	.570"	.540"	.575"	.625"	.665
Retained weight (grains):	86.1(1)	98.8(1)	105.2(1)	125.8(1)	148.2(1)	179.7

Notes: (1) Jacket separated from the lead core.

TAP Buckshot

HORNADY MANUFACTURING ADDS TO THE TAP LINE OF AMMUNITION.

TAP 12 Gauge 00 Buckshot "Custom" Item #8626

This load is designed to work in pump action shotguns and has reduced recoil. This reduced recoil load encourages better marksmanship and faster follow up shots. Three to four-inch patterns at 15 yards is typical.

TAP BUCK SHOT "CUSTOM" (BLUE HULL)

12 Gauge

2 3/4

Shot Size 00

Pellet Count 8

	Muzzle	10yds	20yds	30yds	40yds
Velocity (fps)	1050	1008	954	901	851
Energy (ft. lbs.)	959.5	884.3	791.5	706.0	630.2

TAP 12 Gauge 00 Buckshot "Light Magnum" Item #8627

This load was designed to reliably function in all semi auto shotguns as well as pump action shotguns. Three to four-inch patterns at 15 yards is typical.

TAP BUCK SHOT "LIGHT MAGNUM" (RED HULL)

12 Gauge

2 3/4

Shot Size 00

Pellet Count 8

	Muzzle	10yds	20yds	30yds	40yds
Velocity (fps)	1370	1295	1206	1124	1049
Energy (ft. lbs.)	1633.4	1459.5	1265.8	1098.5	958.1

Hornady Manufacturing has color coded hulls for both loads. The "Custom" load will have a blue hull (Blue for Cool) and the "Light Magnum" will have a red hull (Red for Hot). This line of ammunition is intended for Law Enforcement sales ONLY.

For further information please contact Hornady Manufacturing P O Box 1848 Grand Island NE 68802 or call 800-338-3220.

Exterior Ballistics Calculator

Version 4.01 BETA VERSION

Shotshell Flat Trajectory

I. CARTRIDGE DATA

Shell Identification: 12 Gau 2 3/4" Blue Load
Shot Weight: 0.8960 ounces
Shot Material: Lead - 2% Sb
Shot Density: 0.40220 lb/in³
Shot Diameter: 0.320 in.
Approximate Pellet Count: 8
Ballistic Coefficient: 0.060900 (Calculated)
Velocity over 3' @ 3': 1,090 fps
Drag Factor: G99

II. ENVIRONMENTAL DATA

Temperature: 70° F
Atmospheric pressure: 30.00 inches of Hg
Properties of air basis: SAAMI data and functions

III. CALCULATED LOAD PARAMETERS

Pellets Per Ounce: 9
Pellet Sectional Density: 0.06739 lb/sq. in.:

IV. PREDICTED PERFORMANCE

Range (yards)	Remaining Velocity (feet/sec)	Pellet Energy (lb-feet)	Payload Energy (lb-ft)	Pellet Momentum (lb-ft/sec)	Pellet Energy Density (lb-ft/in ²)	Flight Time (sec)	Drop (inches)	Wind Drift 10 mph Wind (inches)
1	1,090	127.41	1034.0	7.5217	1584.2	0.0000	0.0	0.0
5	1,072	123.18	999.7	7.3959	1531.7	0.0111	0.0	0.0
10	1,044	116.91	948.7	7.2050	1453.6	0.0253	-0.1	0.1
15	1,015	110.43	896.1	7.0025	1373.1	0.0398	-0.3	0.2
20	985	104.11	844.9	6.7993	1294.5	0.0548	-0.6	0.4
25	956	98.10	796.1	6.6000	1219.7	0.0703	-0.9	0.7
30	928	92.43	750.1	6.4066	1149.3	0.0862	-1.4	1.1
35	901	87.13	707.1	6.2202	1083.4	0.1026	-1.9	1.6
40	875	82.19	667.0	6.0410	1021.9	0.1195	-2.6	2.1
45	850	77.57	629.5	5.8689	964.5	0.1369	-3.3	2.8
50	827	73.27	594.6	5.7038	911.0	0.1548	-4.2	3.5

Exterior Ballistics Calculator

Version 4.01 BETA VERSION

Shotshell Flat Trajectory

I. CARTRIDGE DATA

Shell Identification: 12 Gau 2 3/4" Red Load
Shot Weight: 0.8960 ounces
Shot Material: Lead - 2% Sb
Shot Density: 0.40220 lb/in³
Shot Diameter: 0.320 in.
Approximate Pellet Count: 8
Ballistic Coefficient: 0.060900 (Calculated)
Velocity over 3' @ 3': 1,410 fps
Drag Factor: G99

II. ENVIRONMENTAL DATA

Temperature: 70° F
Atmospheric pressure: 30.00 inches of Hg
Properties of air basis: SAAMI data and functions

III. CALCULATED LOAD PARAMETERS

Pellets Per Ounce: 9
Pellet Sectional Density: 0.06739 lb/sq. in.

IV. PREDICTED PERFORMANCE

Range (yards)	Remaining Velocity (feet/sec)	Pellet Energy (lb-feet)	Payload Energy (lb-ft)	Pellet Momentum (lb-ft/sec)	Pellet Energy Density (lb-ft/in ²)	Flight Time (sec)	Drop (inches)	Wind Drift 10 mph Wind (inches)
1	1,410	213.20	1730.2	9.7299	2651.0	0.0000	0.0	0.0
5	1,376	203.09	1648.1	9.4964	2525.3	0.0086	0.0	0.0
10	1,329	189.37	1536.8	9.1700	2354.7	0.0197	-0.1	0.1
15	1,281	175.90	1427.5	8.8378	2187.1	0.0312	-0.2	0.2
20	1,234	163.24	1324.7	8.5137	2029.7	0.0431	-0.3	0.5
25	1,189	151.56	1229.9	8.2036	1884.5	0.0555	-0.6	0.8
30	1,146	140.89	1143.4	7.9097	1751.9	0.0684	-0.8	1.2
35	1,106	131.18	1064.5	7.6321	1631.1	0.0817	-1.2	1.6
40	1,068	122.33	992.7	7.3701	1521.0	0.0955	-1.6	2.2
45	1,032	114.26	927.2	7.1228	1420.7	0.1098	-2.1	2.8
50	998	106.89	867.4	6.8893	1329.0	0.1246	-2.7	3.6

