CPRC
CANADIAN POLICE RESEARCH CENTRE

CCRP
CENTRE CANADIEN DE RECHERCHES POLICIÈRES

TR-03-98
Lead Shot Penetration in 10% Ordnance Gelatin

Dean B. Dahlstrom
Kramer D. Powley
Duncan MacPherson

TECHNICAL REPORT
September, 1995

Submitted by:
Duncan MacPherson
Technical Consultant

NOTE: Further information about this report can be obtained by calling the CPRC information number (613) 998-6343

EXECUTIVE SUMMARY

Range determination of shotshell loads may be most accurately determined by combining shot dispersion and pellet penetration. Various lead shot sizes were fired into bare gelatin, gelatin covered by heavy clothing and gelatin embedded with swine rib at three different distances. Shot deformation, and penetration were observed and recorded. Lead shot penetration in 10% ballistic gelatin of shot sizes smaller than 0 Buck follows a linear relationship at intermediate ranges allowing for accurate distance calculations.

These results are in quantitative agreement with analysis for penetrations into bare gelatin and in qualitative agreement with penetration dynamics phenomenology for the other tests (where quantification must be empirical).

SOMMAIRE

II est possible de determiner avec passablement d'exactitude les pot-tees possibles de charges de car-touches en combinant la dispersion et la penetration des plombs. Differents numéros de plomb ont été tires dans de la gelatine nue, dans de la gelatine couverte d'un tissu épais et dans de la gelatine couverte de côtes de porc, de trois distances differentes. On a observe et note la deformation et la penetration des plombs. La penetration d'un plomb d'un numero inferieur a 0 Buck dans un bloc de gelatine d'une concentration de 10 % suit une relation lineaire a des distances intermediaires, ce qui permet le calcul précis des distances.

Ces résultats concordent en quantite avec l'analyse de penetration dans de la gelatine seule et en qualité avec la phenomenologie de la dynamique de penetration des autres tests (où la quantification doit être empirique).

LEAD SHOT PENETRATION IN 10% ORDNANCE GELATIN

* Dean B. Dahlstrom, * Kramer D. Powley, and ** Duncan MacPherson

* Firearms Examiners,
Forensic Laboratory, Royal Canadian Mounted Police, Regina, Saskatchewan, Canada
** Technical Consultant,
El Segundo, California

Introduction:

Historically, distant shotgun range determinations have been based on the dispersion of shot on a target. DiMaio[1] states,

> "In all deaths from shotgun wounds, the size of the shot pattern on the body should be measured so that the range can be determined accurately." (p. 194)

He goes on,

> "The only reliable method of determining range is to obtain the actual weapon and the same brand of ammunition used and then conduct a series of test shots so as to reproduce on paper the pattern of the fatal wound on the body." (p. 195)

Shot penetration within the human body as an indication of distance, has rarely been considered, even when only a partial shot pattern exists. When only a partial pattern is present on a target, range estimations based on shot dispersion are only rough estimates and must be based on minimum and maximum distances dependant upon the pattern produced by the outer edge of the shot pattern or the central part of the pattern.

Several experimenters have observed a linear relationship between penetration depth and velocity at low projectile velocities.' The development of a definitive model of bullet penetration[3] showed that these observations were correct. Penetration is linear with velocity for all non-deforming bullet configurations when the velocity is below that cavitation velocity (V,), and nonlinear (logarithmic) at velocities above V,. The value of V_c depends on projectile shape and size; the detailed formula is Eq. (6-20) of Reference

MacPherson4 comments on the importance of sphericity of shot:

> "Sphericity must be obtained to ensure desirable and repeatable performance."

He adds,

> "Shot asphericty is not intrinsically a disadvantage in tissue penetration; the force on the tissue and the resulting tissue disruption depends on the shape of the penetrating projectile."

Gus Cotey, Jr.5 states,

> "A non-deforming sphere of a given SD (sectional density) and impact speed will penetrate tissue to a greater depth and crush less tissue relative to its cross sectional area per unit length of penetration than a blunt mushroom shaped bullet of equal SD and striking velocity by virtue of the former's more streamlined shape. However, in actuality even the hardest lead alloy buckshot pellets are subject to considerable deformation from post ignition acceleration forces, contact with the weapons bore, impacts with bones, etc."

Based on these authors' work, it would be extremely important if small lead spheres like those loaded into shotgun shells could be considered as almost uniform and non-deforming. If so, ranges could be calculated using measured penetrations.

Methods and Materials:

All tests were conducted with an Ithaca Model 37 12-gauge pump action shotgun, serial number 675243. The shotgun had a 26% inch barrel with a poly choke attached. The full choke setting was used for all test shots. The choke was measured using a star gauge. The shotgun was chambered for 2% inch shotshells only. The following shotshells were used for the test:

Make	Federal Classic Hi-Brass Lot #1538	Federal Classic Hi-Brass Lot #1507	Federal Hi-Power Lot #8539 Lot 1
Gauge	12	12	12
Length	2%	2%	2¾
Dram Equivalent	3%	3%	
Ounces of Shot	1%	1%	
Number of Shot			***12***
Shot Size	7% lead	4 lead	***0*** Buck lead

Five shotshells of each shot size were chronographed with an Electronic Counters Division of MV Ordnance Industries Model 4040 Chronograph at an instrumental distance of 10 feet.

Dr. M. Fackler's recipe for manufacturing 10% ordnance gelatin as outlined by Post" and Thompson' was followed. Our methodology was described in a previous work' Only variations will be discussed here.

Test events were conducted at 15, 30 and 50 meters.

Calibration of all gelatin blocks was conducted with an Archer Model 87 pneumatic air rifle, serial number E329 1, firing a copper-coated BB.

The 15 meter and 30 meter test events took place in the 37-meter range at the RCMP's Regina Forensic Laboratory Firearms Section. The range temperature was approximately 65°F.

The 50 meter test events were conducted at the Royal Canadian Mounted Police Training Academy outdoor range. At the time of the test the gelatin blocks were exposed to environmental conditions of 50 - 60°F for no more than 15 minutes.
One round of #4 and #7½ shot were fired into each gelatin block with the exception of the 50 meter test events where 2 rounds of each were tired. Numerous rounds of 0 Buck were needed to achieve even limited data at 50 meters.

Due to an overwhelming sample size, data was gathered from only half the gelatin block for #4 and #7½ at the 15 meter test events. All the pellets in the gelatin block for the 0 Buck were used. Any shot that impacted close to the edge of the gelatin block was dismissed because of slightly greater shot travel in these areas.

Shot penetration was recorded for each individual shot. Indentations in the clothing without penetration for individual impacts were also noted. The coat was X-rayed using a Scanray Torrex 150D to determine the presence and size of shot remaining in the garment. Due to the shot size of 0 Buck the area of impact through the ribs, either muscle, cartilage or bone, was determined and noted.

Penetration depths were determined for the shot which either passed through or fell short of the ribs. The ribs and surrounding tissue were then sectioned and x-rayed to determine the number and size of shot embedded in it. Recorded penetration depths for #7½ and #4 shot at distances of 15, 30, and 50 meters respectively, were determined by measuring the distance from the entrance surface of the gelatin to the centre of the rib mass. All pellets embedded in the rib mass were assigned these values. The rib

diameters were recorded. The weight and maximum and minimum diameters of all recovered shot was recorded.

Thirty untired control shot of each size was weighed and the maximum and minimum diameters recorded. Shot was measured using a Mitutoyo Digamatic caliper and weighed on a Mettler PL200 balance.

Results and Discussion:

The appendix tables are categorized by shot size. They include three separate test events at three distances for each category. The first page of each set is a control sample and the following pages include penetration depth, retained weight and shot deformation of tired pellets. No attempt was made to associate an individual pellet penetration with a specific retained weight or deformation measurement.

Penetration depths recorded for the 50 meter test event, shooting into both bare gelatin and gelatin with embedded rib for #7½ shot may be misleading. The data for the embedded rib measurement represents the distance from the gelatin surface to the centre of the rib mass. There was no attempt made to measure individual pellet depths within the structure even though the majority of pellets were located in the entrance side of the rib mass. This data, although appearing to give a greater penetration depth than bare gelatin, may in reality be slightly less. Those values associated with penetration into the rib mass will vary relative to the placement of the ribs in the gelatin.

Due to the minute and overlapping pellet paths into the rib mass for the test event utilizing ribs, areas of impact could not be accurately determined for #7½ or #4 shot. The variation of pellet penetration depths likely result from the tissue the pellet impacted. From our data we can assume those pellets which did not totally penetrate the rib mass probably impacted bone.

Muzzle to target distances may be more accurately determined at distant ranges when only a partial pattern exists by examining the shot penetration combined with shot dispersion. At close range, it appears from our limited testing that clothing and ribs do not have a marked effect on shot penetration. As the distance increases clothing does have a drastic effect on shot penetrations of lighter shot. There is virtually no effect on the Buckshot.

These results are entirely compatible with the dynamics of penetration. The effect of clothing is dynamically similar to the effect of skin on penetration; i.e., there is no penetration below a threshold velocity, but the reduction in velocity due to penetration is very small when the velocity is significantly above the threshold.

The threshold velocity must be determined empirically for the barrier under consideration, but is primarily a function of sectional density for relatively blunt projectiles.' These tests show that this threshold velocity for 7% shot and the clothing used in the tests is about 550 ft/sec, while the threshold velocity for 7% shot and bare human skin is about 360 ft/sec.[3]

Values of downrange shot velocities have historically been uncertain due to complexities in empirical measurement, and most tables of shot velocities are known to contain significant errors. Analytical calculations of downrange shot velocities have uncertainties due to cluster effects early in the trajectory and also drag uncertainties. One of the authors (MacPherson) has a test and analysis project ongoing to improve the archival sphere drag data base (which appears not to be as valid as commonly assumed); preliminary results of this effort have been used to calculate downrange velocities for the shot used in these tests. These calculated values are somewhat uncertain, but are reasonable, agree well with the best available empirical shot velocity data, and are much more accurate than data in most shot velocity tables. These calculated downrange shot velocities are used as inputs in the comparison of test results and analytic model predictions in bare gelatin.

Comparison of Test and Model Penetrations in Bare Gelatin

shot size	range meters	calculated velocity	V_c ft/sec	penetration depth values in inches			
				correction'	standard'	model"	test[4]
7%	15	865	940	-0.1	3.6	3.7	4.2
7%	30	675	940	-0.2	2.7	2.9	3.1
7%	50	500	940	-0.1	1.9	2.0	2.1
4	15	930	855	-0.2	5.5	5.7	5.6
4	30	765	855	-0.3	4.6	4.9	5.1
4	50	605	855	-0.2	3.4	3.6	3.4
0 buck	15	1055	640	-0.4	19.1	19.5	16.1
0 buck	30	960	640	-0.8	17.8	18.6	15.9
0 buck	50	860	640	-0.8	16.7	17.5	14.4

[1] the correction to the data taken in the test gelatin to penetration in standard gelatin

[2] the *Bullet Penetration* model of penetration in standard gelatin

[3] the *Bullet Penetration* model of penetration in the test gelatin

[4] the penetration measured in the tests

Linearity was calculated using the Pearson Product Moment Correlation Coefficient which measures the linear association of two data sets.

Note that the model predictions are quite good for the smaller shot, but are low for the buckshot. The low buckshot penetrations are a consequence of the buckshot deformation (quite apparent in the data tables); this deformation is a result of both higher velocity at gelatin entry and a higher sectional density (which maintains the velocity longer during the penetration. The problem of buckshot deformation due to the use of a too soft lead alloy has been recognized in the context of ammunition performance.'

Note also that the gelatin impact velocities are all below V_c for the 7% shot, and are almost all below V_c for the 4 shot; explaining the measured linear relationship between velocity and penetration depth for the smaller shot. The buckshot penetration depth would not be linear with velocity even if the shot hardness problem were solved because V_c is well below the gelatin impact velocities in all cases.

Conclusion:

From our results it is apparent that velocity is a critical factor in shot penetration. This was previously found by Haag and Wolberg.' They warn against the estimation of range in "no gun" cases based upon the practice of estimating range on shot dispersion and penetration because of the effects of barrel shortening on muzzle velocity.

Our tables indicate that shot sizes 4 and 7% have deformed little and, for all practical applications, their penetration will follow a linear relationship when plotted against impact velocity. As the shot size increases, there is more deformation upon impact, and the calculation of penetration when plotted against impact velocity may be more theoretical than practical.

These test results in bare gelatin are in full quantitative agreement with the well established analytical penetration model. This correlation validates the entire experimental procedure and gives high confidence in the test results for the cloth and rib cases (which are analytically intractable and must be quantified empirically).

Once impact velocities have been determined based on measured shot penetration, muzzle to target distances may be accurately calculated, particularly if the muzzle velocity of the suspect shot can be determined.

When examining shotgun wounds as a result of multiple pellet penetrations it is important to examine all of the physical evidence available including the type, size and penetration of the shot within the body as well as the clothing worn by the victim.

Acknowledgments:

We would like to thank the RCMP Training Academy, in particular the staff of the Division Mess for the use of their facilities and their patience when we manufactured gelatin blocks.

For their continuing technical support and computer knowledge we also thank Mr. Alan Laughlin, Mr. Malcolm Gutfriend, Mr. Dave Bachynski, and Mrs. Nancy Wilson.

References:

1. Di Maio, Vincent J. M., Gunshot Wounds — Practical Aspects of Firearms, Ballistics, and Forensic Techniques, Elsevier Science Publishing Co. 1985.

2. Haag, L. C., Ballistic Gelatin: Controlling variances in preparation and a suggested method for the calibration of gelatin blocks. AFTE Journal 21(3): 483 - 489, 1989.

3. MacPherson, D., Bullet Penetration: Modeling the Dynamics and the Incapacitation Resulting from Wound Trauma, Ballistic Publications, El Segundo, CA 1994

4. MacPherson D., Technical comments on buckshot loads. Wound Ballistics Review, Journal of the International Wound Ballistics Association 2(4): 19 - 21, 1996.

5. Cotey, Gus Jr., Number 1 Buckshot, The Number 1 Choice. Wound Ballistics Review, Journal of the International Wound Ballistics Association 2(4): 10 - 18, 1996.

6. Post, S., Lecture given at First International Wound Ballistics Conference, Sacramento, CA, March 27, 1994.

7. Thompson, E., Ordnance Gelatin Testing Procedures, AFTE Journal 25(2): 87 - 107, 1993.

8. Dahlstrom, D.B. and K. D. Powley, Comparative Performance of 9mm Parabellum, .38 Special and .40 Smith and Wesson Ammunition in Ballistic Gelatin, Canadian Police Research Centre Technical Report TR-01-95, Sep 1994.

9. Haag, L. C. and E. Wolberg, Shotgun Barrel Shortening Effects on Pattern, Wad Formation, Pellet Velocity and Penetration. Paper dated March 1994, publisher unknown.

Linearity of Data Using Calculated Downrange Velocities

Test Type: BARE

Shot Size: 7½

Penetration (in)	Velocity (ft/sec)
4.20	865
3.10	675
2.09	500
Pearson Coefficient:	**1.000000**

Shot Size: 4

Penetration (in)	Velocity (ft/sec)
5.60	930
5.07	765
3.44	605
Pearson Coefficient:	**0.956847**

Shot Size: 0 Buck

Penetration (in)	Velocity (ft/sec)
16.08	1055
15.90	960
14.42	860
Pearson Coefficient:	**0.917188**

Test Type: RIBS

Shot Size: 7½

Penetration (in)	Velocity (ft/sec)
3.39	865
2.76	675
2.37	500
Pearson Coefficient:	**0.993813**

Shot Size: 4

Penetration (in)	Velocity (ft/sec)
4.92	930
3.80	765
3.20	605
Pearson Coefficient:	**0.986594**

Shot Size: 0 Buck

Penetration (in)	Velocity (ft/sec)
17.10	1055
15.28	960
14.33	860
Pearson Coefficient:	**0.981205**

Test Type: CLOTH

Shot Size: 7½

Penetration (in)	Velocity (ft/sec)
3.10	865
1.90	675
0.00	500
Pearson Coefficient:	**0.988263**

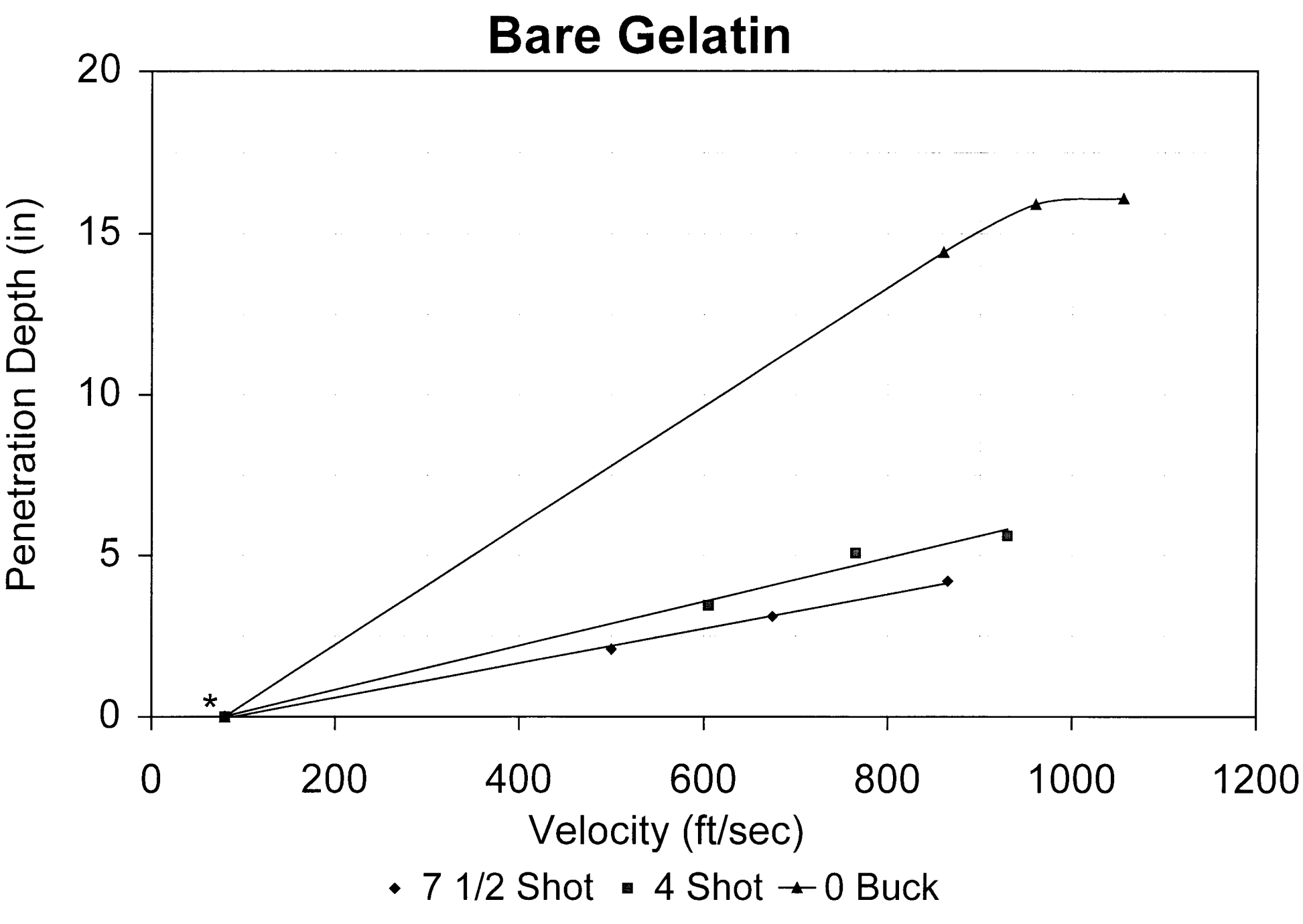
Shot Size: 4

Penetration (in)	Velocity (ft/sec)
4.98	930
3.93	765
1.60	605
Pearson Coefficient:	**0.974986**

Shot Size: 0 Buck

Penetration (in)	Velocity (ft/sec)
16.89	1055
16.95	960
13.87	860
Pearson Coefficient:	**0.864907**

Linearity of the data was calculated using the Pearson Product Moment Correlation Coefficient



* Pellet penetration threshold velocity 80 ft/sec

Conclusion:

From our results it is apparent that velocity is a critical factor in shot penetration. This was previously found by Haag and Wolberg. They warn against the estimation of range in "no gun" cases based upon the practice of estimating range on shot dispersion and penetration because of the effects of barrel shortening on muzzle velocity.

Our tables indicate that shot sizes 4 and 7% have deformed little and, for all practical applications, their penetration will follow a linear relationship when plotted against impact velocity. As the shot size increases, there is more deformation upon impact, and the calculation of penetration when plotted against impact velocity may be more theoretical than practical.

These test results in bare gelatin are in full quantitative agreement with the well established analytical penetration model. This correlation validates the entire experimental procedure and gives high confidence in the test results for the cloth and rib cases (which are analytically intractable and must be quantified empirically).

Once impact velocities have been determined based on measured shot penetration, muzzle to target distances may be accurately calculated, particularly if the muzzle velocity of the suspect shot can be determined.

When examining shotgun wounds as a result of multiple pellet penetrations it is important to examine all of the physical evidence available including the type, size and penetration of the shot within the body as well as the clothing worn by the victim.

Acknowledgments:

We would like to thank the RCMP Training Academy, in particular the staff of the Division Mess for the use of their facilities and their patience when we manufactured gelatin blocks.

For their continuing technical support and computer knowledge we also thank Mr. Alan Laughlin, Mr. Malcolm Gutfriend, Mr. Dave Bachynski, and Mrs. Nancy Wilson.

References:

1. Di Maio, Vincent J. M., Gunshot Wounds — Practical Aspects of Firearms, Ballistics, and Forensic Techniques, Elsevier Science Publishing Co. 1985.

2. Haag, L. C., Ballistic Gelatin: Controlling variances in preparation and a suggested method for the calibration of gelatin blocks. AFTE Journal 21(3): 483 - 489, 1989.

3. MacPherson D., Bullet Penetration: Modeling the Dynamics and the Incapacitation Resulting from Wound Trauma, Ballistic Publications, El Segundo, CA 1994

4. MacPherson, D., Technical comments on buckshot loads. Wound Ballistics Review, Journal of the International Wound Ballistics Association 2(4): 19 - 2 1, 1996.

5. Cotey, Gus Jr., Number 1 Buckshot, The Number 1 Choice. Wound Ballistics Review, Journal of the International Wound Ballistics Association 2(4): 10 - 18, 1996.

6. Post, S., Lecture given at First International Wound Ballistics Conference, Sacramento, CA, March 27, 1994.

7. Thompson, E., Ordnance Gelatin Testing Procedures, AFTE Journal 25(2): 87 - 107, 1993.

8. Dahlstrom, D.B. and K. D. Powley, Comparative Performance of 9mm Parabellum, .38 Special and .40 Smith and Wesson Ammunition in Ballistic Gelatin, Canadian Police Research Centre Technical Report TR-01-95, Sep 1994.

9. Haag, L. C. and E. Wolberg, Shotgun Barrel Shortening Effects on Pattern, Wad Formation, Pellet Velocity and Penetration. Paper dated March 1994, publisher unknown.

Shot Deformation (in.)								
min	max	avg	min	max	avg	min	max	avg
.081	.097	0.089	.088	.099	0.094	.078	.094	0.086
.078	.097	0.088	.087	.095	0.091	.093	.100	0.097
.084	.093	0.089	.089	.095	0.092	.087	.091	0.089
.089	.100	0.095	.073	.098	0.086	.087	.095	0.091
.089	.096	0.093	.087	.095	0.091	.085	.091	0.088
.082	.093	0.088	.091	.100	0.096	.085	.093	0.089
.089	.093	0.091	.085	.099	0.092	.089	.097	0.093
.081	.092	0.087	.090	.096	0.093	.091	.094	0.093
.092	.095	0.094	.076	.098	0.087	.095	.095	0.095
.088	.094	0.091	.088	.091	0.090	.088	.093	0.091
.082	.094	0.088	.089	.092	0.091	.088	.099	0.094
.091	.095	0.093	.088	.095	0.092	.079	.086	0.083
.082	.088	0.085	.091	.094	0.093	.089	.093	0.091
.091	.097	0.094						
MIN_{AVG} (n = 40)		**0.086**	**MAX_{AVG} (n = 40)**		**0.095**	**$OVERALL_{AVG}$**		**0.091**

DATE:	TEST TYPE:	DISTANCE:
95sept21	cloth	50 m

AMMO MANUFACTURER:	SHOT WEIGHT:	SHOT SIZE:	LOT No.:
Federal Classic Hi-brass	1¼ oz.	7½	1538

Chron. Velocity (ft/sec) at 10 ft	
1	1196
2	1225
3	1227
4	1216
5	1220
AVG	**1216.8**

Calibration Velocity (ft/sec)	Calibration Temperature (°C)	Calibration Penetration (cm)
592	4	8.6
594	4	8.8

Penetration Depth (in.)									
0*	0**	0***							
								AVG (*n* = 3)	??

* 37 pellets marked surface of storm coat; no penetration

** 55 pellets within lining of storm coat (X-rayed)

*** no pellets penetrated shirt

DATE:	TEST TYPE:	DISTANCE:
95sept19	rib	15 m

AMMO MANUFACTURER:	SHOT WEIGHT:	SHOT SIZE:	LOT No.:
Federal Classic Hi-brass	1¼ oz.	7½	1538

Chron. Velocity (ft/sec) at 10 ft	
1	1196
2	1225
3	1227
4	1216
5	1220
AVG	**1216.8**

Calibration Velocity (ft/sec)	Calibration Temperature (°C)	Calibration Penetration (cm)
576	4	8.0
602	4	8.4

Rib Diameter (inches)	
.28	.51
.31	.68

Penetration Depth (in.)									
5.25	2.75	3.0	4.125	3.0	4.75	4.125	2.75	4.625	3.125
5.0	2.75	3.75	4.5	3.5	4.5	5.75	3.5	3.5	4.125
3.0	3.625	4.875	3.125	4.5	4.5	4.0	4.25	4.375	3.125
4.875	2.75	4.75	4.25	5.0	4.25	5.625	4.125	5.625	4.125
3.625	4.5	3.625	4.625	4.0	4.25	4.0	4.25	3.75	4.125
3.25	4.25	3.125	4.5	3.0	2.75*	2.75*	2.75*	2.75*	2.75*
2.75*	2.75*	2.75*	2.75*	2.75*	2.75*	2.75*	2.75*	2.75*	2.75*
2.75*	2.75*	2.75*	2.75*	2.75*	2.75*	2.75*	2.75*	2.75*	2.75*
2.75*	2.75*	2.75*	2.75*	2.75*	2.75*	2.75*	2.75*	2.75*	2.75*
2.75*	2.75*	2.75*	2.75*	2.75*	2.75*	2.75*	2.75*	2.75*	2.75*
2.75*	2.75*	2.75*	2.75*	2.75*	2.75*	2.75*	2.75*	2.75*	2.75*
								AVG (n = 110)	**3.393**

* 55 pellets X-rayed in ribs 2.75 inches from entrance surface

Retained Weight (mg)									
82	77	74	84	82	86	81	78	80	80
80	78	85	79	77	85	72	75	84	80
74	86	83	74	74	77	80	84	85	81
77	75	88	74	77	78	79	66	76	81
87	77	84	77	80	72	82	77	80	80
75	82	77	81	84					
								AVG (n = 55)	**79.3**

Shot Deformation (in.)								
min	max	avg	min	max	avg	min	max	avg
0.089	0.094	0.092	0.086	0.096	0.091	0.09	0.108	0.099
0.091	0.096	0.094	0.09	0.093	0.092	0.084	0.097	0.091
0.092	0.103	0.098	0.083	0.098	0.091	0.089	0.097	0.093
0.086	0.097	0.092	0.085	0.095	0.090	0.091	0.097	0.094
0.092	0.097	0.095	0.085	0.094	0.090	0.089	0.095	0.092
0.087	0.093	0.090	0.087	0.093	0.090	0.09	0.095	0.093
0.088	0.091	0.090	0.091	0.094	0.093	0.088	0.096	0.092
0.087	0.095	0.091	0.086	0.092	0.089	0.087	0.091	0.089
0.084	0.094	0.089	0.093	0.095	0.094	0.089	0.092	0.091
0.086	0.096	0.091	0.089	0.096	0.093	0.091	0.098	0.095
0.082	0.096	0.089	0.088	0.09	0.089	0.088	0.097	0.093
0.078	0.096	0.087	0.087	0.096	0.092	0.088	0.093	0.091
0.09	0.092	0.091	0.083	0.089	0.086	0.089	0.094	0.092
0.091	0.094	0.093	0.091	0.095	0.093	0.092	0.096	0.094
0.092	0.097	0.095	0.083	0.1	0.092	0.082	0.094	0.088
0.086	0.094	0.090	0.093	0.098	0.096	0.084	0.089	0.087
0.089	0.097	0.093	0.09	0.095	0.093	0.086	0.089	0.088
0.081	0.085	0.083	0.085	0.091	0.088	0.09	0.096	0.093
0.082	0.087	0.085						
MIN_{AVG} (n = 55)		0.088	MAX_{AVG} (n=55)		0.095	$OVERALL_{AVG}$		0.091

DATE:	TEST TYPE:	DISTANCE:
95sept20	rib	30 m

AMMO MANUFACTURER:	SHOT WEIGHT:	SHOT SIZE:	LOT No.:
Federal Classic Hi-brass	1¼ oz.	7½	1538

Chron. Velocity (ft/sec) at 10 ft	
1	1196
2	1225
3	1227
4	1216
5	1220
AVG	**1216.8**

Calibration Velocity (ft/sec)	Calibration Temperature (°C)	Calibration Penetration (cm)
578	4	8.5
575	4	8.3

Rib Diameter (inches)	
.43	.46
.45	.47

Penetration Depth (in.)									
3.25	3.0	2.875	3.0	3.125	3.0	2.75	2.75	3.0	3.25
2.375	3.75	3.875	3.625	3.0	3.625	3.0	3.5	3.0	3.125
3.0	2.875	3.25	3.25	2.75	2.25	2.25	3.0	2.0	4.0
3.0	3.0	2.75	2.5*	2.5*	2.5*	2.5*	2.5*	2.5*	2.5*
2.5*	2.5*	2.5*	2.5*	2.5*	2.5*	2.5*	2.5*	2.5*	2.5*
2.5*	2.5*	2.5*	2.5*	2.5*	2.5*	2.5*	2.5*	2.5*	2.5*
2.5*	2.5*	2.5*	2.5*	2.5*	2.5*	2.5*	2.5*		
							AVG (n = 68)		**2.76**

* 35 pellets X-rayed in ribs 2.5 inches from entrance surface

Retained Weight (mg)									
68	83	83	69	84	83	79	82	78	78
78	88	81	86	81	77	83	87	87	82
86	79	74	83	89	76	86	77	77	85
85	80	79							
							AVG (n = 33)		**81.0**

Shot Deformation (in.)									
min	max	avg	min	max	avg	min	max	avg
.080	.092	0.086	.052	.145	0.099	.090	.093	0.092
.095	.100	0.098	.090	.095	0.093	.098	.101	0.100
.092	.098	0.095	.093	.094	0.094	.084	.093	0.089
.087	.092	0.090	.088	.097	0.093	.088	.100	0.094
.086	.100	0.093	.086	.095	0.091	.093	.103	0.098
.087	.093	0.090	.088	.094	0.091	.085	.090	0.088
.092	.095	0.094	.094	.094	0.094	.094	.096	0.095
.093	.098	0.096	.088	.096	0.092	.094	.095	0.095
.090	.096	0.093	.094	.095	0.095	.090	.097	0.094
.084	.088	0.086	.092	.093	0.093	.092	.097	0.095
.094	.098	0.096	.092	.094	0.093	.088	.095	0.092
MIN_{AVG} (*n* = 33)		**0.089**	**MAX_{AVG} (n=33)**		**0.097**	**$OVERALL_{AVG}$**		**0.093**

DATE: 95sept21	TEST TYPE: rib	DISTANCE: 50 m	
AMMO MANUFACTURER: Federal Classic Hi-brass	SHOT WEIGHT: 1¼ oz.	SHOT SIZE: 7½	LOT No.: 1538

Chron. Velocity (ft/sec) at 10 ft	
1	1196
2	1225
3	1227
4	1216
5	1220
AVG	**1216.8**

Calibration Velocity (ft/sec)	Calibration Temperature (°C)	Calibration Penetration (cm)
578	4	8.5
575	4	8.4

Rib Diameter (inches)	
.33	.62
.44	.66

Penetration Depth (in.)									
1.875	2.375	2.0	2.875	1.875	2.0	2.0	2.25	1.75	2.25
1.625	2.0	2.0	2.25	2.25	2.5	2.125	2.25	2.0	2.375
1.875	2.25	2.0	2.25	1.625	1.875	2.0	2.125	2.0	1.875
1.75	2.5	2.125	2.25	2.5	2.5	2.5*	2.5*	2.5*	2.5*
2.5*	2.5*	2.5*	2.5*	2.5*	2.5*	2.5*	2.5*	2.5*	2.5*
2.5*	2.5*	2.5*	2.5*	2.5*	2.5*	2.5*	2.5*	2.5*	2.5*
2.5*	2.5*	2.5*	2.5*	2.5*	2.5*	2.5*	2.5*	2.5*	2.5*
2.5*	2.5*	2.5*	2.5*	2.5*	2.5*	2.5*	2.5*	2.5*	2.5*
2.5*	2.5*	2.5*	2.5*	2.5*	2.5*	2.5*	2.5*	2.5*	2.5*
2.5*	2.5*	2.5*	2.5*	2.5*	2.5*	2.5*	2.5*	2.5*	2.5*
2.5*	2.5*	2.5*	2.5*	2.5*	2.5*	2.5*	2.5*	2.5*	2.5*
								AVG (n = 110)	**2.374**

* 64 pellets X-rayed in ribs 2.5 inches from entrance surface

Retained Weight (mg)									
83	69	76	80	88	83	78	89	77	80
81	73	86	82	85	84	83	82	87	84
83	73	90	81	89	82	90	77	78	75
80	87	85	83	78	81				
								AVG (n = 36)	**81.7**

Shot Deformation (in.)								
min	max	avg	min	max	avg	min	max	avg
.088	.093	0.091	.077	.088	0.083	.087	.091	0.089
.083	.094	0.089	.088	.095	0.092	.088	.095	0.092
.086	.091	0.089	.080	.107	0.094	.087	.094	0.091
.096	.101	0.099	.091	.096	0.094	.091	.095	0.093
.094	.097	0.096	.096	.098	0.097	.090	.093	0.092
.090	.097	0.094	.092	.097	0.095	.092	.095	0.094
.083	.099	0.091	.092	.097	0.095	.088	.097	0.093
.089	.094	0.092	.093	.095	0.094	.084	.090	0.087
.090	.093	0.092	.094	.102	0.098	.093	.097	0.095
.089	.092	0.091	.086	.093	0.090	.091	.097	0.094
.091	.101	0.096	.091	.099	0.095	.088	.099	0.094
.088	.097	0.093	.090	.093	0.092	.084	.088	0.086
MIN_{AVG} (n = 36)		0.089	MAX_{AVG} (n=36)		0.096	$OVERALL_{AVG}$		0.092

	TEST TYPE: Control	
AMMO MANUFACTURER: Federal Classic Hi-Brass	SHOT WEIGHT: 1¼ oz.	SHOT SIZE: 4	LOT No.: 1507

Weight (mg)									
186	191	207	194	203	210	208	171	194	200
197	194	203	191	189	207	184	191	208	171
199	201	188	189	185	203	192	208	194	207
								AVG (*n* = 30)	**195.5**

Diameter (in.)									
min	**max**	**avg**	**min**	**max**	**avg**	**min**	**max**	**avg**
.118	.131	0.125	.126	.132	0.129	.114	.128	0.121
.121	.129	0.125	.120	.133	0.127	.122	.132	0.127
.129	.135	0.132	.112	.132	0.122	.120	.127	0.124
.112	.129	0.121	.114	.122	0.118	.126	.129	0.128
.117	.126	0.122	.121	.131	0.126	.118	.127	0.123
.121	.129	0.125	.119	.125	0.122	.118	.125	0.122
.119	.129	0.124	.111	.127	0.119	.127	.135	0.131
.115	.125	0.120	.124	.129	0.127	.117	.129	0.123
.121	.126	0.124	.121	.130	0.126	.119	.125	0.122
.120	.129	0.125	.122	.126	0.124	.116	.123	0.120
MIN_{AVG} (*n* = 30)		**0.119**	**MAX_{AVG} (*n* = 30)**		**0.129**	**$OVERALL_{AVG}$**		**0.124**

DATE:	TEST TYPE:	DISTANCE:
95sept19	bare	15 m

AMMO MANUFACTURER:	SHOT WEIGHT:	SHOT SIZE:	LOT No.:
Federal Classic Hi-brass	1¼ oz.	4	1507

Chron. Velocity (ft/sec) at 10 ft	
1	1206
2	1166
3	1227
4	1219
5	1224
AVG	**1208.4**

Calibration Velocity (ft/sec)	Calibration Temperature (°C)	Calibration Penetration (cm)
595	4	9.0
582	4	8.5

Penetration Depth (in.)									
4.5	9.875	4.625	5.75	5.0	6.0	5.25	4.0	5.0	5.5
7.0	5.625	4.75	6.75	4.75	6.75	8.0	5.625	5.0	5.375
6.5	6.5	5.625	5.125	4.0	5.25	9.375	6.0	5.875	5.0
7.125	5.5	5.25	5.75	6.375	5.125	5.375	7.875*	5.5	4.75
5.375	7.5	9.125	7.75	4.5	4.5	5.875	7.25	6.375	5.75
5.75	5.25	6.125	5.125	5.75	4.75	5.0	5.25	5.125	5.375
5.125	6.875	5.75	5.25	5.375	5.0	5.125	4.625	3.75	5.0
6.75	4.75	5.125	5.0	6.0	5.875	4.125	5.0	5.5	5.125
4.625	4.5	5.375	5.125	4.5	5.625	5.5	4.125	5.0	5.25
5.0									
								AVG (*n* = 91)	**5.607**

Retained Weight (mg)									
378*	197	181	183	227	183	192	187	195	201
194	182	206	192	194	198	195	175	208	192
200	199	194	197	184	192	181	183	175	200
187	200	195	206	191	200	187	205	205	207
200	178	181	195	186	191	195	200	191	174
186	189	177	183	194	189	200	199	190	200
195	177	203	208	198	185	179	193	177	188
184	193	188	196	204	187	197	196	202	189
188	202	202	194	192	188	189	178	181	190
187									
								AVG (*n* = 91)	**194.2**

*fused shot

Shot Deformation (in.)								
min	max	avg	min	max	avg	min	max	avg
.111	.130	0.1205	.108	.125	0.117	.120	.135	0.128
.116	.130	0.123	.111	.125	0.118	.120	.132	0.126
.099	.145	0.122	.118	.131	0.125	.124	.131	0.128
.123	.143	0.133	.116	.134	0.125	.118	.131	0.125
.112	.135	0.1235	.117	.126	0.122	.116	.135	0.126
.118	.130	0.124	.125	.135	0.130	.118	.125	0.122
.118	.129	0.1235	.106	.135	0.121	.121	.128	0.125
.115	.127	0.121	.115	.124	0.120	.115	.127	0.121
.114	.128	0.121	.117	.128	0.123	.110	.125	0.118
.116	.128	0.122	.124	.128	0.126	.114	.134	0.124
.116	.129	0.1225	.117	.129	0.123	.105	.136	0.121
.118	.129	0.1235	.120	.128	0.124	.111	.126	0.119
.116	.131	0.1235	.119	.128	0.124	.113	.123	0.118
.122	.132	0.127	.118	.128	0.123	.113	.139	0.126
.123	.131	0.127	.106	.135	0.121	.122	.127	0.125
.106	.145	0.1255	.116	.125	0.121	.120	.122	0.121
.116	.127	0.1215	.120	.132	0.126	.125	.130	0.128
.120	.131	0.1255	.115	.130	0.123	.120	.127	0.124
.119	.133	0.126	.117	.134	0.126	.117	.133	0.125
.125	.130	0.1275	.115	.135	0.125	.105	.127	0.116
.111	.133	0.122	.113	.128	0.121	.117	.130	0.124
.118	.126	0.122	.115	.131	0.123	.118	.138	0.128
.115	.133	0.124	.119	.129	0.124	.097	.149	0.123
.114	.130	0.122	.115	.126	0.121	.106	.138	0.122
.119	.125	0.122	.117	.139	0.128	.120	.128	0.124
.121	.131	0.126	.117	.125	0.121	.125	.127	0.126
.121	.128	0.1245	.116	.127	0.122	.119	.125	0.122
.119	.123	0.121	.114	.146	0.130	.119	.127	0.123
.120	.134	0.127	.120	.132	0.126	.123	.135	0.129
.119	.133	0.126	.119	.127	0.123	.121	.129	0.125
.135*	.191*	0.163						
MIN_{AVG} (n = 91)		**0.117**	**MAX_{AVG} (n=91)**		**0.131**	**$OVERALL_{AVG}$**		**0.124**

* fused shot

DATE:	TEST TYPE:	DISTANCE:
95sept20	bare	30 m

AMMO MANUFACTURER:	SHOT WEIGHT:	SHOT SIZE:	LOT No.:
Federal Classic Hi-brass	1¼ oz.	4	1507

Chron. Velocity (ft/sec) at 10 ft	
1	1206
2	1166
3	1227
4	1219
5	1224
AVG	**1208.4**

Calibration Velocity (ft/sec)	Calibration Temperature (°C)	Calibration Penetration (cm)
589	4	9.1
594	4	9.2

Penetration Depth (in.)									
4.875	4.5	5.25	5.125	5.125	7.375	5.375	4.75	5.125	5.25
5.0	5.0	5.75	4.625	4.75	5.125	4.375	5.25	4.25	5.0
4.625	6.325	4.875	5.375	5.0	4.625	5.375	5.5	6.625	4.75
5.125	4.75	5.5	5.0	5.0	5.375	6.375	4.625	5.25	4.5
4.5	5.0	5.0	4.75	4.875	4.375	5.0	5.0	5.125	4.875
5.0	4.625	4.875	4.375	5.0					
							AVG (*n* = 55)		**5.070**

Retained Weight (mg)									
196	185	213	186	194	188	193	184	194	206
192	188	189	194	185	203	182	208	194	198
220	203	193	186	194	185	187	200	181	191
195	201	203	184	193	202	194	194	193	186
177	200	182	196	198	179	186	187	180	189
197	188	192	206	197					
							AVG (*n* = 55)		**192.9**

Shot Deformation (in.)								
min	max	avg	min	max	avg	min	max	avg
.125	.130	0.128	.116	.129	0.123	.118	.124	0.121
.111	.133	0.122	.112	.128	0.120	.117	.123	0.120
.121	.131	0.126	.122	.130	0.126	.111	.127	0.119
.115	.135	0.125	.126	.133	0.130	.121	.131	0.126
.116	.137	0.127	.123	.126	0.125	.124	.132	0.128
.115	.130	0.123	.122	.129	0.126	.118	.128	0.123
.117	.121	0.119	.114	.127	0.121	.113	.124	0.119
.120	.129	0.125	.122	.129	0.126	.117	.127	0.122
.120	.126	0.123	.121	.127	0.124	.114	.127	0.121
.123	.128	0.126	.110	.124	0.117	.122	.132	0.127
.123	.128	0.126	.117	.130	0.124	.118	.124	0.121
.125	.127	0.126	.119	.126	0.123	.115	.126	0.121
.101	.130	0.116	.116	.124	0.120	.112	.127	0.120
.124	.128	0.126	.121	.129	0.125	.123	.128	0.126
.118	.123	0.121	.119	.126	0.123	.116	.125	0.121
.116	.124	0.120	.113	.120	0.117	.120	.123	0.122
.122	.130	0.126	.125	.135	0.130	.122	.129	0.126
.123	.130	0.127	.121	.130	0.126	.106	.131	0.119
.117	.130	0.124						
MIN_{AVG} (n = 55)		0.118	MAX_{AVG} (n=55)		0.128	$OVERALL_{AVG}$		0.123

DATE:	TEST TYPE:	DISTANCE:
95sept21	bare	50 m

AMMO MANUFACTURER:	SHOT WEIGHT:	SHOT SIZE:	LOT No.:
Federal Classic Hi-brass	1¼ oz.	4	1507

Chron. Velocity (ft/sec) at 10 ft	
1	1206
2	1166
3	1227
4	1219
5	1224
AVG	**1208.4**

Calibration Velocity (ft/sec)	Calibration Temperature (°C)	Calibration Penetration (cm)
589	4	9.0
592	4	9.3

Penetration Depth (in.)									
3.625	3.25	3.75	3.625	3.5	3.375	3.5	3.0	3.0	3.125
3.375	3.5	3.5	3.5	3.625	3.5	3.625	3.5	3.625	
								AVG (*n* = 19)	**3.447**

Retained Weight (mg)									
208	199	189	193	192	191	189	198	181	187
189	190	185	200	182	187	194	181	191	
								AVG (*n* = 19)	**190.8**

Shot Deformation (in.)								
min	max	avg	min	max	avg	min	max	avg
.115	.128	0.122	.117	.132	0.125	.121	.127	0.124
.120	.132	0.126	.119	.131	0.125	.122	.137	0.130
.116	.126	0.121	.121	.130	0.126	.118	.129	0.124
.122	.130	0.126	.122	.132	0.127	.122	.126	0.124
.117	.133	0.125	.114	.131	0.123	.121	.130	0.126
.117	.123	0.120	.113	.134	0.124	.121	.126	0.124
.124	.126	0.125						
MIN_{AVG} (*n* = 19)		**0.119**	**MAX_{AVG} (n=19)**		**0.130**	**$OVERALL_{AVG}$**		**0.124**

DATE:	TEST TYPE:	DISTANCE:
95sept19	cloth	15 m

AMMO MANUFACTURER:	SHOT WEIGHT:	SHOT SIZE:	LOT No.:
Federal Classic Hi-brass	1¼ oz.	4	1507

Chron. Velocity (ft/sec) at 10 ft	
1	1206
2	1166
3	1227
4	1219
5	1224
AVG	**1208.4**

Calibration Velocity (ft/sec)	Calibration Temperature (°C)	Calibration Penetration (cm)
590	3	9.2
585	3	9.0

Penetration Depth (in.)									
3.375	4.125	6.875	4.25	5.0	4.5	7.375*	4.75	5.0	4.375
7.125	5.0	6.0	4.5	5.5	5.0	5.5	5.0	5.0	4.5
5.25	4.875	4.625	5.625	4.25	5.25	5.375	6.625*	4.875	4.25
4.5	5.875	4.75	4.5	5.0	5.25	4.875	5.25	4.75	4.875
3.875	5.0	4.75	4.875	5.5	6.0	4.125	5.625	6.5	6.5
4.625	4.125	6.875	4.75	4.125	5.25	2.5	3.0	4.875	3.625
4.5	4.875	4.375	4.75	5.375	6.0	5.5	3.875	6.125	4.5
4.125	6.25	4.0							
								AVG (*n* = 73)	**4.988**

Retained Weight (mg)									
191	195	178	185	208	205	204	201	194	181
200	198	174	195	188	195	206	188	201	191
185	384*	194	206	180	199	197	185	200	384*
182	174	180	194	204	199	208	193	212	188
183	188	187	208	191	184	195	199	200	172
181	200	201	188	192	189	211	175	194	194
200	183	184	195	189	203	186	192	192	183
189	173	184							
								AVG (*n* = 73)	**197.4**

* fused shot

Shot Deformation (in.)								
min	max	avg	min	max	avg	min	max	avg
.121	.124	0.123	.110	.134	0.122	.126	.129	0.128
.110	.129	0.120	110	.136	0.123	.119	.143	0.131
.122	.128	0.125	.109	.131	0.120	.108	.129	0.119
.111	.128	0.120	.141*	.196*	0.169	.117	.128	0.123
.123	.132	0.128	.110	.126	0.118	.120	.126	0.123
.121	.130	0.126	.118	.135	0.127	.125	.134	0.130
.121	.138	0.130	.119	.138	0.129	.124	.140	0.132
.105	.130	0.118	.126	.129	0.128	.111	.132	0.122
.120	.135	0.128	.133	.140	0.137	.103	.134	0.119
.125	.130	0.128	.122	.131	0.127	.124	.127	0.126
.114	.126	0.120	.125	.135	0.130	.112	.137	0.125
.120	.122	0.121	.120	.136	0.128	.119	.131	0.125
.126	.130	0.128	.112	.139	0.126	.135*	.196*	0.166
.121	.134	0.128	.124	.135	0.130	.122	.127	0.125
.124	.133	0.129	.114	.125	0.120	.105	.130	0.118
.121	.127	0.124	.116	.137	0.127	.115	.129	0.122
.120	.133	0.127	.108	.137	0.123	.123	.127	0.125
.127	.129	0.128	.124	.128	0.126	.119	.127	0.123
.125	.131	0.128	.110	.123	0.117	.119	.153	0.136
.125	.133	0.129	.120	.127	0.124	.116	.127	0.122
.118	.124	0.121	.120	.125	0.123	.124	.131	0.128
.121	.129	0.125	.117	.149	0.133	.128	.134	0.131
.123	.129	0.126	.112	.128	0.120	.116	.130	0.123
.118	.131	0.125	.113	.125	0.119	.114	.130	0.122
.124	.127	0.126						
MIN_{AVG} (n = 73)		**0.119**	**MAX_{AVG} (n=73)**		**0.133**	**$OVERALL_{AVG}$**		**0.126**

* fused shot

DATE:	TEST TYPE:	DISTANCE:
95sept20	cloth	30 m

AMMO MANUFACTURER:	SHOT WEIGHT:	SHOT SIZE:	LOT No.:
Federal Classic Hi-brass	1¼ oz.	4	1507

Chron. Velocity (ft/sec) at 10 ft	
1	1206
2	1166
3	1227
4	1219
5	1224
AVG	**1208.4**

Calibration Velocity (ft/sec)	Calibration Temperature (°C)	Calibration Penetration (cm)
589	3	9.7
585	3	9.3

Penetration Depth (in.)									
4.5	3.25	3.625	4.5	3.875	3.625	4.5	4.125	3.875	3.875
4.5	4.125	4.625	4.25	3.5	4.75	4.0	4.25	3.25	4.5
3.875	3.875	4.125	4.5	3.0	3.75	4.75	4.0	4.25	3.125
3.625	3.0	3.75	4.25	4.0	3.0	4.375	4.0	3.75	3.375
3.75	3.25	4.5	4.0	4.125	4.25	3.125	4.5	3.25	
								AVG (*n* = 49)	**3.931**

Retained Weight (mg)									
191	185	181	204	214	174	167	200	182	199
201	178	173	190	196	183	177	200	188	184
199	179	172	185	176	195	228	209	195	230
205	205	193	183	186	185	193	187	183	200
192	180	182	173	185	193	200	187	194	
								AVG (*n* = 49)	**190.6**

Shot Deformation (in.)								
min	max	avg	min	max	avg	min	max	avg
.127	.139	0.133	.119	.127	0.123	.117	.127	0.122
.119	.128	0.124	.123	.129	0.126	.122	.128	0.125
.129	.134	0.132	.126	.132	0.129	.121	.136	0.129
.118	.128	0.123	.115	.131	0.123	.121	.129	0.125
.122	.140	0.131	.122	.126	0.124	.116	.129	0.123
.120	.127	0.124	.120	.127	0.124	.113	.130	0.122
.121	.129	0.125	.112	.130	0.121	.126	.134	0.130
.118	.130	0.124	.125	.134	0.130	.115	.128	0.122
.116	.127	0.122	.126	.135	0.131	.114	.124	0.119
.118	.125	0.122	.116	.129	0.123	.123	.128	0.126
.121	.131	0.126	.117	.130	0.124	.109	.126	0.118
.120	.127	0.124	.118	.129	0.124	.114	.124	0.119
.120	.123	0.122	.119	.124	0.122	.119	.127	0.123
.124	.135	0.130	.117	.127	0.122	.117	.129	0.123
.117	.126	0.122	.119	.126	0.123	.129	.133	0.131
.122	.135	0.129	.113	.126	0.120	.112	.130	0.121
.121	.127	0.124						
MIN_{AVG} (n = 49)		0.119	MAX_{AVG} (n=49)		0.129	$OVERALL_{AVG}$		0.124

DATE:	TEST TYPE:	DISTANCE:
95sept21	cloth	50 m

AMMO MANUFACTURER:	SHOT WEIGHT:	SHOT SIZE:	LOT No.:
Federal Classic Hi-brass	1¼ oz.	4	1507

Chron. Velocity (ft/sec) at 10 ft	
1	1206
2	1166
3	1227
4	1219
5	1224
AVG	**1208.4**

Calibration Velocity (ft/sec)	Calibration Temperature (°C)	Calibration Penetration (cm)
592	4	8.6
594	4	8.8

Penetration Depth (in.)									
2.125	2.0	2.0	1.625	1.75	1.125	1.25	1.125	1.25	1.75
1.625									
								AVG (n = 11)	**1.602**

Retained Weight (mg)									
200	203	182	203	179	184	185	197	186	193
184									
								AVG (n = 11)	**190.5**

Shot Deformation (in.)									
min	max	avg	min	max	avg	min	max	avg
.123	.128	0.126	.119	.124	0.122	.124	.129	0.127
.119	.129	0.124	.123	.129	0.126	.120	.128	0.124
.123	.129	0.126	.123	.128	0.126	.120	.126	0.123
.118	.128	0.123	.120	.122	0.121			
MIN_{AVG} (n = 11)	**0.121**		MAX_{AVG} (n=11)	**0.127**		$OVERALL_{AVG}$	**0.124**	

DATE:	TEST TYPE:	DISTANCE:
95sept19	rib	15 m

AMMO MANUFACTURER:	SHOT WEIGHT:	SHOT SIZE:	LOT No.:
Federal Classic Hi-brass	1¼ oz	4	1507

Chron. Velocity (ft/sec) at 10 ft	
1	1206
2	1166
3	1227
4	1219
5	1224
AVG	**1208.4**

Calibration Velocity (ft/sec)	Calibration Temperature (°C)	Calibration Penetration (cm)
576	4	8.0
602	4	8.4

Rib Diameter (inches)	
.28	.51
.31	.68

Penetration Depth (in.)									
5.375	6.125	5.5	5.875	5.75	6.25	7.0	5.125	4.25	6.0
5.75	4.25	5.5	5.625	6.625	5.0	5.25	6.5	6.0	3.0
6.25	5.75	5.25	4.625	2.5	6.5	6.5	4.0	4.375	4.375
5.625	5.25	5.75	5.5	5.125	5.25	5.25	4.75	4.125	5.0
3.75	5.0	5.125	3.75	3.75	3.75	2.75*	2.75*	2.75*	2.75*
2.75*									
								AVG (*n* = 51)	**4.929**

* 5 pellets X-rayed in ribs 2.75 inches from entrance surface

Retained Weight (mg)									
183	185	191	187	194	193	187	194	193	187
185	195	181	177	206	199	180	205	183	189
189	194	184	191	188	187	213	186	186	191
189	199	185	187	178	186	189	187	178	192
191	196	204	175	192	188				
								AVG (*n* = 46)	**189.5**

Shot Deformation (in.)								
min	max	avg	min	max	avg	min	max	avg
.113	.127	0.120	.119	.128	0.124	.123	.128	0.126
.122	.125	0.124	.106	.135	0.121	.120	.125	0.123
.108	.136	0.122	.122	.133	0.128	.118	.130	0.124
.122	.128	0.125	.113	.130	0.122	.118	.130	0.124
.110	.138	0.124	.116	.120	0.118	.113	.129	0.121
.097	.138	0.118	.120	.123	0.122	.127	.134	0.131
.126	.131	0.129	.117	.127	0.122	.121	.124	0.123
.120	.125	0.123	.120	.126	0.123	.120	.127	0.124
.118	.130	0.124	.121	.128	0.125	.105	.131	0.118
.123	.127	0.125	.116	.126	0.121	.123	.132	0.128
.120	.127	0.124	.109	.149	0.129	.119	.129	0.124
.116	.124	0.120	.118	.129	0.124	.124	.132	0.128
.114	.130	0.122	.126	.133	0.130	.118	.130	0.124
.118	.122	0.120	.121	.127	0.124	.117	.130	0.124
.118	.126	0.122	.119	.125	0.122	.117	.128	0.123
.118	.128	0.123						
MIN_{AVG} (n = 46)		**0.118**	**MAX_{AVG} (n=46)**		**0.129**	**$OVERALL_{AVG}$**		**0.123**

DATE:	TEST TYPE:	DISTANCE:
95sept20	rib	30 m

AMMO MANUFACTURER:	SHOT WEIGHT:	SHOT SIZE:	LOT No.:
Federal Classic Hi-brass	1¼ oz.	4	1507

Chron. Velocity (ft/sec) at 10 ft	
1	1206
2	1166
3	1227
4	1219
5	1224
AVG	**1208.4**

Calibration Velocity (ft/sec)	Calibration Temperature (°C)	Calibration Penetration (cm)
578	4	8.5
575	4	8.3

Rib Diameter (inches)	
.43	.46
.45	.47

Penetration Depth (in.)									
4.375	4.5	2.875	4.5	4.5	5.0	4.875	5.25	5.0	5.0
3.25	3.125	4.75	3.0	4.0	4.5	4.25	4.25	4.5	4.0
2.5*	2.5*	2.5*	2.5*	2.5*	2.5*	2.5*			
								AVG (*n* = 27)	**3.815**

* 7 pellets X-rayed in ribs 2.5 inches from entrance surface

Retained Weight (mg)									
184	190	204	178	193	189	199	183	190	203
208	179	191	180	202	186	192	184	195	187
								AVG (*n* = 20)	**190.9**

Shot Deformation (in.)									
min	**max**	**avg**	**min**	**max**	**avg**	**min**	**max**	**avg**
.124	.133	0.129	.126	.131	0.129	.121	.123	0.122
.122	.132	0.127	.122	.126	0.124	.117	.128	0.123
.127	.136	0.132	.122	.127	0.125	.127	.131	0.129
.115	.130	0.123	.115	.127	0.121	.120	.137	0.129
.115	.132	0.124	.117	.126	0.122	.120	.125	0.123
.125	.128	0.127	.121	.127	0.124	.124	.128	0.126
.120	.127	0.124	.116	.130	0.123			
MIN_{AVG} (*n* = 20)		**0.121**	**MAX_{AVG} (n=20)**		**0.129**	**$OVERALL_{AVG}$**		**0.125**

DATE:	TEST TYPE:	DISTANCE:
95sept21	rib	50 m

AMMO MANUFACTURER:	SHOT WEIGHT:	SHOT SIZE:	LOT No.:
Federal Classic Hi-brass	1¼ oz.	4	1507

Chron. Velocity (ft/sec) at 10 ft	
1	1206
2	1166
3	1227
4	1219
5	1224
AVG	**1208.4**

Calibration Velocity (ft/sec)	Calibration Temperature (°C)	Calibration Penetration (cm)
578	4	8.5
575	4	8.4

Rib Diameter (inches)	
.33	.62
.44	.66

Penetration Depth (in.)									
3.25	3.25	3.0	3.0	3.375	3.125	3.625	4.0	3.5	3.5
4.0	3.25	3.5	3.25	3.5	3.75	4.0	3.25	3.5	3.75
3.625	3.5	3.75	3.25	3.5	4.0	3.375	4.0	3.875	4.0
3.625	3.5	3.75	3.5	3.125	3.25	2.5*	2.5*	2.5*	2.5*
2.5*	2.5*	2.5*	2.5*	2.5*	2.5*	2.5*	2.5*	2.5*	2.5*
								AVG (*n* = 50)	**3.240**

* 14 pellets X-rayed in ribs 2.5 inches from entrance wound

Retained Weight (mg)									
207	205	194	181	193	189	183	186	206	187
186	185	206	196	188	178	182	198	184	202
197	181	179	196	185	185	174	175	190	201
205	186	187	197	200	208				
								AVG (*n* = 36)	**191.2**

Shot Deformation (in.)								
min	max	avg	min	max	avg	min	max	avg
.114	.139	0.127	.126	.132	0.129	.117	.129	0.123
.122	.129	0.126	.122	.129	0.126	.120	.127	0.124
.130	.130	0.130	.128	.133	0.131	.117	.129	0.123
.116	.131	0.124	.121	.127	0.124	.122	.126	0.124
.118	.126	0.122	.103	.128	0.116	.121	.126	0.124
.112	.127	0.120	.121	.125	0.123	.118	.133	0.126
.124	.130	0.127	.121	.129	0.125	.124	.133	0.129
.112	.129	0.121	.123	.127	0.125	.122	.125	0.124
.119	.135	0.127	.123	.134	0.129	.125	.128	0.127
.120	.130	0.125	.123	.128	0.126	.105	.134	0.120
.129	.129	0.129	.127	.133	0.130	.115	.126	0.121
.119	.135	0.127	.116	.126	0.121	.122	.126	0.124
MIN_{AVG} (n = 36)		**0.120**	MAX_{AVG} (n=36)		**0.130**	$OVERALL_{AVG}$		**0.125**

	TEST TYPE: Control	
AMMO MANUFACTURER: Federal Hi Power Buckshot	SHOT WEIGHT:	SHOT SIZE: 0 buck	LOT No.: 8539 lot1

Weight (mg)									
3460	3240	3430	3250	3230	3290	3250	3250	3450	3450
3260	3270	3450	3440	3240	3250	3250	3260	3470	3250
3440	3250	3260	3460	3250	3260	3240	3250	3470	3460
								AVG (n = 30)	**3326.0**

Diameter (in.)									
min	**max**	**avg**	**min**	**max**	**avg**	**min**	**max**	**avg**
.317	.325	0.321	.321	.331	0.326	.320	.329	0.325
.325	.331	0.328	.318	.320	0.319	.317	.320	0.319
.326	.333	0.330	.317	.325	0.321	.320	.331	0.326
.317	.326	0.322	.318	.320	0.319	.327	.330	0.329
.319	.328	0.324	.320	.331	0.326	.317	.320	0.319
.319	.327	0.323	.324	.331	0.328	.314	.325	0.320
.317	.329	0.323	.316	.326	0.321	.322	.331	0.327
.316	.329	0.323	.317	.322	0.320	.322	.332	0.327
.318	.324	0.321	.316	.324	0.320	.326	.331	0.329
.318	.321	0.320	.317	.323	0.320	.322	.330	0.326
MIN_{AVG} (n = 30)		**0.319**	**MAX_{AVG} (n = 30)**		**0.327**	**$OVERALL_{AVG}$**		**0.323**

DATE:	TEST TYPE:	DISTANCE:
95sept19	bare	15 m

AMMO MANUFACTURER:	SHOT WEIGHT:	SHOT SIZE:	LOT No.:
Federal Hi Power Buckshot		0 buck	8539lot1

Chron. Velocity (ft/sec) at 10 ft	
1	1209
2	1200
3	1166
4	1195
5	1202
AVG	**1194.4**

Calibration Velocity (ft/sec)	Calibration Temperature (°C)	Calibration Penetration (cm)
595	4	9.0
582	4	8.5

Penetration Depth (in.)									
15.875	16.0	16.0	16.75	16.5	15.25	16.25			
								AVG (*n* = 7)	**16.089**

Retained Weight (mg)									
3250	3230	3210	3210	3190	3270	3220			
								AVG (*n* = 7)	**3225.7**

Shot Deformation (in.)									
min	**max**	**avg**	**min**	**max**	**avg**	**min**	**max**	**avg**
.307	.342	0.325	.317	.340	0.329	.315	.332	0.324
.248	.420	0.334	.308	.328	0.318	.301	.345	0.323
.301	.353	0.327						
MIN_{AVG} (*n* = 7)	**0.300**		**MAX_{AVG} (n=7)**	**0.351**		**$OVERALL_{AVG}$**		**0.326**

DATE:	TEST TYPE:	DISTANCE:
95sept20	bare	30 m

AMMO MANUFACTURER:	SHOT WEIGHT:	SHOT SIZE:	LOT No.:
Federal Hi Power Buckshot		0 buck	8539 lot1

Chron. Velocity (ft/sec) at 10 ft	
1	1209
2	1200
3	1166
4	1195
5	1202
AVG	1194.4

Calibration Velocity (ft/sec)	Calibration Temperature (°C)	Calibration Penetration (cm)
589	4	9.1
594	4	9.2

Penetration Depth (in.)									
14.0	17.0	17.25	14.25	15.5	17.5				
								AVG (n = 6)	15.917

Retained Weight (mg)									
3150	3240	3210	3200	3200	3190				
								AVG (n = 6)	3198.3

Shot Deformation (in.)									
min	max	avg	min	max	avg	min	max	avg	
.301	.329	0.315	.310	.328	0.319	.311	.327	0.319	
.305	.332	0.319	.307	.340	0.324	.302	.332	0.317	
MIN_{AVG} (n = 6)	0.306		MAX_{AVG} (n = 6)	0.331		$OVERALL_{AVG}$			0.319

DATE:	TEST TYPE:	DISTANCE:
95sept21	bare	50 m

AMMO MANUFACTURER:	SHOT WEIGHT:	SHOT SIZE:	LOT No.:
Federal Hi Power Buckshot		0 buck	8539 lot1

Chron. Velocity (ft/sec) at 10 ft	
1	1209
2	1200
3	1166
4	1195
5	1202
AVG	**1194.4**

Calibration Velocity (ft/sec)	Calibration Temperature (°C)	Calibration Penetration (cm)
589	4	9.0
592	4	9.3

Penetration Depth (in.)									
13.625	15.5	14.75	15.0	13.25					
								AVG (*n* = 5)	**14.425**

Retained Weight (mg)									
3200	3260	3170	3210	3200					
								AVG (*n* = 5)	**3208.0**

Shot Deformation (in.)									
min	**max**	**avg**	**min**	**max**	**avg**	**min**	**max**	**avg**
.318	.331	0.325	.322	.412	0.367	.324	.335	0.330
.303	.336	0.320	.309	.335	0.322			
MIN_{AVG} (*n* = 5)	**0.315**		**MAX_{AVG} (n = 5)**	**0.350**		**$OVERALL_{AVG}$**		**0.333**

DATE:	TEST TYPE:	DISTANCE:
95sept19	cloth	15 m

AMMO MANUFACTURER:	SHOT WEIGHT:	SHOT SIZE:	LOT No.:
Federal Hi Power Buckshot		0 buck	8539 lot1

Chron. Velocity (ft/sec) at 10 ft	
1	1209
2	1200
3	1166
4	1195
5	1202
AVG	**1194.4**

Calibration Velocity (ft/sec)	Calibration Temperature (°C)	Calibration Penetration (cm)
590	3	9.2
585	3	9.0

Penetration Depth (in.)									
17.375	17.25	16.75	15.0	18.0	18.0	15.5	17.25		
								AVG (*n* = 8)	**16.891**

Retained Weight (mg)									
3270	3240	3240	3470	3480	3450	3460	3370		
								AVG (*n* = 8)	**3372.5**

Shot Deformation (in.)									
min	**max**	**avg**	**min**	**max**	**avg**	**min**	**max**	**avg**
.315	.336	0.326	.326	.340	0.333	.299	.328	0.314
.324	.347	0.336	.314	.352	0.333	.308	.339	0.324
.312	.354	0.333	.323	.334	0.329			
MIN_{AVG} (*n* = 8)		**0.315**	**MAX_{AVG} (n = 8)**		**0.341**	**$OVERALL_{AVG}$**		**0.328**

DATE:	TEST TYPE:	DISTANCE:
95sept20	cloth	30 m

AMMO MANUFACTURER:	SHOT WEIGHT:	SHOT SIZE:	LOT No.:
Federal Hi Power Buckshot		0 buck	8539 lot1

Chron. Velocity (ft/sec) at 10 ft	
1	1209
2	1200
3	1166
4	1195
5	1202
AVG	**1194.4**

Calibration Velocity (ft/sec)	Calibration Temperature (°C)	Calibration Penetration (cm)
589	3	9.7
585	3	9.3

Penetration Depth (in.)									
17.0	16.0	17.5	16.375	16.5	16.0	17.0	16.125	17.0	20*
								AVG (*n* = 10)	**16.950**

* complete penetration

Retained Weight (mg)									
3240	3450	3230	3230	3260	3250	3440	3450	3470	
								AVG (*n* = 9)	**3335.6**

Shot Deformation (in.)									
min	max	avg	min	max	avg	min	max	avg
.315	.338	0.327	.310	.337	0.324	.321	.340	0.331
.319	.330	0.325	.316	.341	0.329	.318	.333	0.326
.300	.328	0.314	.318	.334	0.326	.314	.324	0.319
MIN_{AVG} (*n* = 9)	**0.315**		**MAX_{AVG} (n = 9)**	**0.334**		**$OVERALL_{AVG}$**		**0.324**

DATE:	TEST TYPE:	DISTANCE:
95sept21	cloth	50 m

AMMO MANUFACTURER:	SHOT WEIGHT:	SHOT SIZE:	LOT No.:
Federal Hi Power Buckshot		0 buck	8539 lot1

Chron. Velocity (ft/sec) at 10 ft	
1	1209
2	1200
3	1166
4	1195
5	1202
AVG	1194.4

Calibration Velocity (ft/sec)	Calibration Temperature (°C)	Calibration Penetration (cm)
592	4	8.6
594	4	8.8

Penetration Depth (in.)									
11.875	16.0	13.0	14.25	14.25					
							AVG (n = 5)		13.875

Retained Weight (mg)									
3270	3470	3250	3440	3220					
							AVG (n = 5)		3330.0

Shot Deformation (in.)									
min	max	avg	min	max	avg	min	max	avg	
.311	.334	0.323	.302	.332	0.317	.317	.332	0.325	
.321	.335	0.328	.319	.333	0.326				
MIN_{AVG} (n = 5)	0.314		MAX_{AVG} (n = 5)	0.333		$OVERALL_{AVG}$			0.324

DATE:	TEST TYPE:	DISTANCE:
95sept19	rib	15 m

AMMO MANUFACTURER:	SHOT WEIGHT:	SHOT SIZE:	LOT No.:
Federal Hi Power Buckshot		0 buck	8539 lot1

Chron. Velocity (ft/sec) at 10 ft	
1	1209
2	1200
3	1166
4	1195
5	1202
AVG	**1194.4**

Calibration Velocity (ft/sec)	Calibration Temperature (°C)	Calibration Penetration (cm)
576	4	8.0
602	4	8.4

Rib Diameter (inches)	
.28	.51
.31	.68

Penetration Depth (in.)									
16.5[m]	16.25[m]	15.875[c]	16.625[c]	14.5[b]	20[+m]	20[+m]			
								AVG (*n* = 7)	**17.1**

[b] bone
[c] cartilage
[m] muscle
[+] complete penetration

Retained Weight (mg)									
3370	3230	3250	3250	3410					
								AVG (*n* = 5)	**3302.0**

Shot Deformation (in.)									
min	**max**	**avg**		**min**	**max**	**avg**		**min**	**max**	**avg**
.302	.342	0.322		.307	.336	0.322		.320	.347	0.334
.302	.337	0.320		.300	.338	0.319				
MIN_{AVG} (*n* = 5)		**0.306**		**MAX_{AVG} (n = 5)**		**0.340**		**$OVERALL_{AVG}$**		**0.323**

DATE:	TEST TYPE:	DISTANCE:
95sept20	rib	30 m

AMMO MANUFACTURER:	SHOT WEIGHT:	SHOT SIZE:	LOT No.:
Federal Hi Power Buckshot		0 buck	8539 lot1

Chron. Velocity (ft/sec) at 10 ft	
1	1209
2	1200
3	1166
4	1195
5	1202
AVG	1194.4

Calibration Velocity (ft/sec)	Calibration Temperature (°C)	Calibration Penetration (cm)
578	4	8.5
575	4	8.3

Rib Diameter (inches)	
.43	.46
.45	.47

Penetration Depth (in.)									
14.25[m]	16.0[m]	14.75[m]	13.0[b]	16.75[b]	16.75[b]	15.25[b]	15.5[b]		
								AVG (n = 8)	15.281

[b] bone
[c] cartilage
[m] muscle

Retained Weight (mg)									
3460	3270	3250	3440	3440	3230	3250	3230		
								AVG (n = 8)	3321.3

Shot Deformation (in.)								
min	max	avg	min	max	avg	min	max	avg
.306	.357	0.332	.304	.335	0.320	.322	.343	0.333
.303	.350	0.327	.314	.340	0.327	.326	.337	0.332
.317	.345	0.331	.317	.331	0.324			
MIN_{AVG} (n = 8)	0.314		MAX_{AVG} (n = 8)	0.342		$OVERALL_{AVG}$	0.328	

DATE:	TEST TYPE:	DISTANCE:
95sept21	rib	50 m

AMMO MANUFACTURER:	SHOT WEIGHT:	SHOT SIZE:	LOT No.:
Federal Hi Power Buckshot		0 buck	8539 lot1

Chron. Velocity (ft/sec) at 10 ft	
1	1209
2	1200
3	1186
4	1195
5	1202
AVG	**1198.4**

Calibration Velocity (ft/sec)	Calibration Temperature (°C)	Calibration Penetration (cm)
578	4	8.5
575	4	8.4

Rib Diameter (inches)	
.33	.62
.44	.66

Penetration Depth (in.)									
13.5[b]	15.5[b]	14.0[c]							
								AVG (*n* = 3)	**14.333**

[b] bone
[c] cartilage

Retained Weight (mg)									
3310	3270	3250							
								AVG (*n* = 3)	**3276.7**

Shot Deformation (in.)									
min	**max**	**avg**	**min**	**max**	**avg**	**min**	**max**	**avg**
.323	.332	0.328	.303	.371	0.337	.308	.336	0.322
MIN_{AVG} (*n* = 3)	**0.311**	**MAX_{AVG} (n = 3)**	**0.346**	**$OVERALL_{AVG}$**	**0.329**

	TEST TYPE: Control	
AMMO MANUFACTURER: Federal Classic Hi-Brass	SHOT WEIGHT: 1¼ oz.	SHOT SIZE: 7½	LOT No.: 1538

Weight (mg)									
86	80	76	82	85	77	87	76	82	83
77	78	82	81	82	79	75	65	80	87
84	86	73	87	75	73	82	84	79	81
								AVG (n = 30)	**80.1**

Diameter (in.)									
min	**max**	**avg**	**min**	**max**	**avg**	**min**	**max**	**avg**
.091	.094	0.093	.086	.091	0.089	.084	.089	0.087
.092	.096	0.094	.086	.092	0.089	.087	.093	0.090
.089	.094	0.092	.085	.094	0.090	.087	.091	0.089
.086	.093	0.090	.091	.096	0.094	.089	.096	0.093
.091	.096	0.094	.090	.094	0.092	.092	.095	0.094
.094	.099	0.097	.092	.095	0.094	.082	.092	0.087
.081	.087	0.084	.089	.094	0.092	.092	.096	0.094
.091	.094	0.093	.084	.092	0.088	.087	.091	0.089
.092	.097	0.095	.086	.092	0.089	.089	.094	0.092
.090	.096	0.093	.087	.092	0.090	.090	.095	0.093
MIN_{AVG} (n = 30)		**0.088**	MAX_{AVG} (n = 30)		**0.094**	$OVERALL_{AVG}$		**0.091**

DATE:	TEST TYPE:	DISTANCE:
95SEP19	bare	15 m

AMMO MANUFACTURER:	SHOT WEIGHT:	SHOT SIZE:	LOT No.:
Federal Classic Hi Brass	1¼ oz.	7½	1538

Chron. Velocity (ft/sec) at 10 ft	
1	1196
2	1225
3	1227
4	1216
5	1220
AVG	**1216.8**

Calibration Velocity (ft/sec)	Calibration Temperature (°C)	Calibration Penetration (cm)
595	4	9.0
582	4	8.5

Penetration Depth (in.)									
3.5	4.0	3.375	4.0	4.25	3.875	4.25	3.5	5.875	3.625
3.625	4.5	3.875	5.25	3.875	4.125	3.125	3.625	3.75	4.5
4.125	4.125	4.625	6.25	4.125	4.25	4.0	4.75	3.375	3.25
4.875	3.75	3.5	3.375	4.25	3.75	4.875	3.25	3.5	4.0
3.625	3.5	3.5	3.875	4.0	4.125	4.125	5.5	4.875	4.0
6.375	3.375	5.125	4.54	5.0	5.5	3.25	3.5	3.125	4.75
4.25	3.875	3.75	3.25	4.75	3.75	3.75	4.125	5.625	4.0
4.5	5.0	4.0	4.0	2.875	5.75	3.125	3.5	3.75	4.75
6.125	4.0	3.25	3.75	5.625	5.25	4.625	4.0	4.0	4.25
5.5	3.0	4.25	3.75	4.625	5.25	2.75	3.5	3.625	4.5
5.125	3.125	4.0	5.0	4.5	3.875	3.5	3.5	6.875	4.625
								AVG (*n* = 110)	**4.2**

Retained Weight (mg)									
85	81	79	74	83	81	83	85	86	72
64	75	76	77	80	81	76	80	86	83
81	83	79	81	85	80	80	73	83	81
82	83	81	75	77	86	84	87	86	77
86	83	74	80	86	89	81	88	80	79
77	75	74	85	76	76	74	76	74	82
73	79	74	77	81	86	78	78	79	74
75	84	78	84	81	80	88	76	76	75
78	82	79	77	74	74	78	77	74	90
74	79	82	84	82	75	80	82	74	88
79	86	82	76	78	74	82	80	77	77
								AVG (*n* = 110)	**79.6**

Shot Deformation (in.)								
min	max	avg	min	max	avg	min	max	avg
.086	.098	0.092	.086	.091	0.089	.087	.096	0.092
.086	.093	0.090	.096	.102	0.099	.095	.095	0.095
.087	.093	0.090	.085	.097	0.091	.085	.092	0.089
.089	.100	0.095	.079	.097	0.088	.088	.095	0.092
.076	.092	0.084	.089	.096	0.093	.088	.092	0.090
.092	.096	0.094	.094	.098	0.096	.087	.093	0.090
.090	.100	0.095	.082	.109	0.096	.091	.099	0.095
.093	.098	0.096	.080	.096	0.088	.090	.094	0.092
.088	.104	0.096	.091	.093	0.092	.091	.096	0.094
.093	.099	0.096	.093	.097	0.095	.086	.091	0.089
.094	.095	0.095	.083	.097	0.090	.087	.094	0.091
.092	.096	0.094	.091	.095	0.093	.081	.086	0.084
.092	.095	0.094	.091	.092	0.092	.095	.099	0.097
.085	.103	0.094	.095	.103	0.099	.079	.099	0.089
.094	.097	0.096	.087	.095	0.091	.091	.096	0.094
.091	.094	0.093	.090	.093	0.092	.092	.095	0.094
.078	.091	0.085	.092	.099	0.096	.090	.096	0.093
.073	.096	0.085	.081	.089	0.085	.090	.093	0.092
.086	.097	0.092	.095	.095	0.095	.088	.099	0.094
.094	.096	0.095	.082	.091	0.087	.093	.097	0.095
.087	.096	0.092	.089	.091	0.090	.088	.097	0.093
.089	.093	0.091	.090	.093	0.092	.088	.093	0.091
.093	.099	0.096	.083	.093	0.088	.090	.092	0.091
.091	.100	0.096	.094	.098	0.096	.090	.095	0.093
.090	.097	0.094	.091	.094	0.093	.089	.097	0.093
.089	.094	0.092	.088	.093	0.091	.087	.091	0.089
.087	.095	0.091	.088	.091	0.090	.085	.094	0.090
.082	.095	0.089	.080	.098	0.089	.090	.097	0.094
.092	.096	0.094	.091	.095	0.093	.089	.092	0.091
.087	.097	0.092	.089	.095	0.092	.082	.096	0.089
.086	.093	0.090	.087	.096	0.092	.086	.097	0.092
.092	.095	0.094	.088	.103	0.096	.086	.096	0.091
.086	.097	0.092	.091	.094	0.093	.091	.094	0.093
.087	.100	0.094	.085	.095	0.090	.086	.100	0.093
.093	.098	0.096	.091	.096	0.094	.084	.096	0.090
.082	.096	0.089	.089	.096	0.093	.090	.098	0.094
.083	.093	0.088	.090	.092	0.091			
MIN_{AVG} (n = 110)		0.088	MAX_{AVG} (n = 110)		0.096	$OVERALL_{AVG}$		0.092

DATE:	TEST TYPE:	DISTANCE:
95sept20	bare	30 m

AMMO MANUFACTURER:	SHOT WEIGHT:	SHOT SIZE:	LOT No.:
Federal Classic Hi-brass	1¼ oz.	7½	1538

Chron. Velocity (ft/sec) at 10 ft	
1	1196
2	1225
3	1227
4	1216
5	1220
AVG	**1216.8**

Calibration Velocity (ft/sec)	Calibration Temperature (°C)	Calibration Penetration (cm)
589	4	9.1
594	4	9.2

Penetration Depth (in.)									
3.25	3.25	3.0	3.25	3.125	2.875	3.0	3.625	3.375	2.875
3.375	3.0	2.875	3.25	3.0	3.25	3.625	3.0	3.25	3.0
3.625	3.125	3.0	3.0	2.875	3.625	3.125	3.0	3.0	2.875
3.5	2.875	3.125	2.75	2.875	3.0	3.25	3.125	3.375	3.125
3.25	3.125	2.75	3.375	3.375	3.125	3.125	3.5	3.5	3.25
3.375	3.125	3.125	3.0	2.875	2.5	2.25	2.75	3.125	3.25
3.125	3.0	3.125	3.5	3.375	3.125	3.0	3.25	3.375	3.25
2.625	3.625	3.125	3.125	2.875	2.875	2.875	3.25	3.0	3.25
3.125	3.25	3.375	3.25	3.125	3.25	3.375	3.375	3.375	3.125
3.125	3.25	3.0	3.0	3.25	3.375	3.0	3.0	3.125	4.125
3.25	3.0	3.0	3.25						
								AVG (*n* = 104)	**3.1**

Retained Weight (mg)									
83	78	86	87	78	78	77	76	83	81
82	82	77	82	84	76	77	68	79	80
74	75	81	86	84	79	79	74	75	82
85	73	75	89	75	78	85	86	73	78
83	73	85	77	72	78	73	82	78	75
66	90	86	73	77	82	85	76	84	75
83	78	80	75	89	82	75	81	74	78
77	81	77	84	84	81	86	75	81	76
77	74	80	81	76	74	77	77	78	82
79	77	83	81	77	87	84	74	76	79
81	83	79	82						
								AVG (*n* = 104)	**79.3**

Shot Deformation (in.)								
min	max	avg	min	max	avg	min	max	avg
.086	.093	0.090	.087	.092	0.090	.087	.096	0.092
.089	.093	0.091	.088	.097	0.093	.090	.094	0.092
.091	.094	0.093	.087	.092	0.090	.086	.092	0.089
.085	.097	0.091	.093	.098	0.096	.076	.098	0.087
.077	.096	0.087	.093	.094	0.094	.086	.096	0.091
.083	.088	0.086	.089	.093	0.091	.083	.092	0.088
.086	.097	0.092	.088	.095	0.092	.086	.091	0.089
.088	.096	0.092	.088	.090	0.089	.088	.095	0.092
.083	.093	0.088	.089	.094	0.092	.086	.094	0.090
.082	.092	0.087	.085	.092	0.089	.085	.095	0.090
.086	.092	0.089	.081	.103	0.092	.090	.093	0.092
.091	.093	0.092	.089	.097	0.093	.085	.094	0.090
.087	.093	0.090	.086	.098	0.092	.090	.093	0.092
.090	.095	0.093	.089	.095	0.092	.090	.094	0.092
.084	.093	0.089	.090	.095	0.093	.089	.096	0.093
.084	.098	0.091	.089	.094	0.092	.090	.097	0.094
.088	.094	0.091	.092	.094	0.093	.088	.093	0.091
.088	.096	0.092	.089	.100	0.095	.090	.095	0.093
.088	.090	0.089	.083	.092	0.088	.082	.093	0.088
.088	.094	0.091	.087	.095	0.091	.086	.092	0.089
.085	.096	0.091	.080	.094	0.087	.089	.096	0.093
.094	.095	0.095	.089	.096	0.093	.088	.092	0.090
.091	.101	0.096	.086	.095	0.091	.082	.092	0.087
.089	.093	0.091	.090	.097	0.094	.088	.095	0.092
.089	.093	0.091	.088	.101	0.095	.085	.093	0.089
.088	.092	0.090	.081	.099	0.090	.093	.096	0.095
.096	.102	0.099	.089	.094	0.092	.088	.095	0.092
.086	.094	0.090	.095	.098	0.097	.090	.096	0.093
.087	.090	0.089	.091	.095	0.093	.089	.094	0.092
.086	.093	0.090	.091	.096	0.094	.089	.097	0.093
.091	.097	0.094	.087	.092	0.090	.091	.094	0.093
.082	.095	0.089	.087	.095	0.091	.093	.098	0.096
.087	.093	0.090	.093	.096	0.095	.087	.093	0.090
.086	.092	0.089	.090	.094	0.092	.091	.095	0.093
.086	.093	0.090	.076	.084	0.080			
MIN_{AVG} (n = 104)		0.087	MAX_{AVG} (n = 104)		0.095	$OVERALL_{AVG}$		0.091

DATE:	TEST TYPE:	DISTANCE:
95sept21	bare	50 m

AMMO MANUFACTURER:	SHOT WEIGHT:	SHOT SIZE:	LOT No.:
Federal Classic Hi-brass	1¼ oz.	7½	1538

Chron. Velocity (ft/sec) at 10 ft	
1	1196
2	1225
3	1227
4	1216
5	1220
AVG	1216.8

Calibration Velocity (ft/sec)	Calibration Temperature (°C)	Calibration Penetration (cm)
589	4	9.0
592	4	9.3

Penetration Depth (in.)									
2.125	2.0	2.125	2.25	2.0	2.25	1.875	2.375	2.125	2.0
2.0	`1.875	2.25	2.0	2.0	2.125	1.875	2.125	2.25	2.25
2.125									
								AVG (n = 21)	2.095

Retained Weight (mg)									
77	86	72	87	79	80	86	84	86	85
79	84	82	82	83	81	86	82	84	80
90									
								AVG (n = 21)	82.6

Shot Deformation (in.)									
min	max	avg	min	max	avg	min	max	avg	
.092	.097	0.095	.092	.096	0.094	.094	.096	0.095	
.088	.097	0.093	.093	.098	0.096	.093	.098	0.096	
.094	.096	0.095	.088	.098	0.093	.091	.098	0.095	
.094	.097	0.096	.093	.096	0.095	.091	.095	0.093	
.085	.097	0.091	.096	.099	0.098	.091	.095	0.093	
.092	.099	0.096	.095	.099	0.097	.095	.099	0.097	
.096	.097	0.097	.092	.100	0.096	.096	.097	0.097	
MIN_{AVG} (n = 21)		0.092	MAX_{AVG} (n = 21)		0.097	$OVERALL_{AVG}$			0.095

DATE:	TEST TYPE:	DISTANCE:
95sept19	cloth	15 m

AMMO MANUFACTURER:	SHOT WEIGHT:	SHOT SIZE:	LOT No.:
Federal Classic Hi-brass	1¼ oz.	7½	1538

Chron. Velocity (ft/sec) at 10 ft	
1	1196
2	1225
3	1227
4	1216
5	1220
AVG	**1216.8**

Calibration Velocity (ft/sec)	Calibration Temperature (°C)	Calibration Penetration (cm)
590	3	9.2
585	3	9.0

Penetration Depth (in.)									
3.5	3.125	3.25	2.5	3.25	2.25	2.75	3.375	2.125	3.625
3.125	3.125	1.875	2.5	2.25	2.875	3.25	3.625	3.5	2.25
2.75	3.75	3.125	4.0	2.375	3.5	3.625	3.0	4.25	3.25
3.375	5.25	3.0	3.5	3.5	3.5	6.25	2.375	3.5	3.0
3.0	2.75	2.5	2.75	3.625	4.25	3.75	3.0	3.25	3.375
3.5	3.0	2.875	2.875	3.0	2.365	3.25	2.625	2.875	2.75
3.125	2.5	3.75	2.5	3.125	3.125	3.25	3.375	2.75	3.625
2.25	2.625	2.625	3.0	3.75	2.375	3.5	3.125	3.625	3.0
2.75	3.375	3.125	2.75	2.875	3.125	3.0	3.625	2.25	4.125
2.875	2.5	2.625	2.625	3.0	3.75	3.5	2.75	3.25	3.125
3.125	3.125	2.875	3.125	3.375	3.0	3.375	3.125	2.875	2.875
								AVG (*n* = 110)	**3.1**

Retained Weight (mg)									
78	86	86	84	78	88	79	76	87	85
83	85	82	85	81	85	84	85	87	79
84	83	81	74	83	86	84	83	82	83
78	84	78	80	76	76	75	84	87	83
79	84	82	85	81	78	87	85	87	82
82	75	87	79	86	85	81	89	86	78
78	82	86	76	81	77	81	84	84	85
79	85	77	84	65	85	82	76	90	83
80	85	85	77	81	86	72	77	80	89
82	79	79	61	86	79	77	83	75	82
79	83	78	83	82	88	80	89	77	76
								AVG (*n* = 110)	**81.6**

Shot Deformation (in.)								
min	max	avg	min	max	avg	min	max	avg
.091	.097	0.094	.086	.105	0.096	.092	.096	0.094
.093	.096	0.095	.079	.099	0.089	.088	.098	0.093
.075	.091	0.083	.075	.091	0.083	.089	.098	0.094
.082	.098	0.090	.075	.099	0.087	.087	.096	0.092
.082	.095	0.089	.077	.105	0.091	.084	.090	0.087
.072	.092	0.082	.080	.085	0.083	.085	.101	0.093
.084	.096	0.090	.084	.102	0.093	.085	.104	0.095
.090	.099	0.095	.088	.097	0.093	.081	.091	0.086
.092	.096	0.094	.093	.098	0.096	.093	.096	0.095
.091	.094	0.093	.082	.097	0.090	.083	.095	0.089
.091	.098	0.095	.092	.093	0.093	.088	.094	0.091
.084	.097	0.091	.089	.096	0.093	.092	.093	0.093
.095	.099	0.097	.092	.095	0.094	.085	.094	0.090
.085	.104	0.095	.095	.097	0.096	.091	.100	0.096
.089	.094	0.092	.090	.096	0.093	.086	.094	0.090
.084	.087	0.086	.086	.091	0.089	.093	.097	0.095
.093	.097	0.095	.093	.097	0.095	.087	.097	0.092
.091	.098	0.095	.088	.098	0.093	.089	.099	0.094
.089	.099	0.094	.077	.107	0.092	.092	.096	0.094
.091	.094	0.093	.091	.099	0.095	.092	.101	0.097
.079	.089	0.084	.092	.094	0.093	.089	.095	0.092
.093	.097	0.095	.078	.093	0.086	.087	.096	0.092
.093	.103	0.098	.087	.091	0.089	.091	.098	0.095
.092	.095	0.094	.086	.095	0.091	.091	.094	0.093
.090	.094	0.092	.091	.095	0.093	.091	.095	0.093
.086	.091	0.089	.092	.098	0.095	.079	.099	0.089
.092	.098	0.095	.090	.094	0.092	.084	.090	0.087
.081	.096	0.089	.077	.090	0.084	.087	.103	0.095
.084	.091	0.088	.081	.094	0.088	.083	.093	0.088
.082	.096	0.089	.088	.092	0.090	.081	.093	0.087
.084	.093	0.089	.087	.094	0.091	.085	.095	0.090
.089	.096	0.093	.090	.092	0.091	.091	.094	0.093
.065	.096	0.081	.093	.095	0.094	.086	.092	0.089
.093	.097	0.095	.077	.099	0.088	.088	.097	0.093
.080	.100	0.090	.091	.093	0.092	.092	.095	0.094
.092	.094	0.093	.096	.100	0.098	.084	.096	0.090
.086	.094	0.090	.084	.100	0.092			
MIN_{AVG} (n = 110)		**0.087**	**MAX_{AVG} (n = 110)**		**0.096**	**$OVERALL_{AVG}$**		**0.091**

DATE:	TEST TYPE:	DISTANCE:
95sept20	cloth	30 m

AMMO MANUFACTURER:	SHOT WEIGHT:	SHOT SIZE:	LOT No.:
Federal Classic Hi-brass	1¼ oz.	7½	1538

Chron. Velocity (ft/sec) at 10 ft	
1	1196
2	1225
3	1227
4	1216
5	1220
AVG	**1216.8**

Calibration Velocity (ft/sec)	Calibration Temperature (°C)	Calibration Penetration (cm)
589	3	9.7
585	3	9.3

Penetration Depth (in.)									
2.125	2.25	1.625	1.75	1.375	1.5	2.5	2.125	1.25	2.625
2.75	2.25	1.375	2.625	1.875	1.875	2.0	2.625	2.0	2.375
1.5	2.25	1.625	2.25	1.25	2.125	1.875	2.25	1.25	2.25
1.5	2.875	1.125	2.0	2.125	1.125	1.5	1.0	1.75	1.625
								AVG (*n* = 40)	**1.903**

Retained Weight (mg)									
76	79	80	78	77	74	75	84	83	79
82	90	78	76	76	79	75	85	75	81
71	82	85	83	76	86	89	78	78	85
79	76	72	76	85	79	81	83	79	78
								AVG (*n* = 40)	**79.6**