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# **2019 Solid Copper Defensive Ammunition Wound Ballistics Test #2**



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# 2019 Solid Copper Ammo Test #2

- The 2019 Solid Copper Defensive Ammunition-Wound Ballistics Test #2 was conducted by Viper Weapons Training LLC, and selected ballistics experts. The contract company ensured continuity, consistency and accuracy of all tests and generated this final report briefing. It was accomplished at the request of multiple sources as an overview and comparison test of numerous Solid Copper Rounds in 9mm and .40 S&W
- The top 9mm and .40S&W Hollow Points from the 2016/17 Joint Agency Ballistics Test For Defensive Handgun Ammunition were included as a comparison
- **This second test added four rounds to the original test and increased the sample size of other rounds. All original test information is included in this presentation. New information is in Bold.**
- Test results, briefings and reports will only be distributed to the units and ammunition manufacturers involved. No civilian or open release of this report/briefing will occur
- We shortened Solid Copper Rounds to (SCR). This will include all the non-hollow point rounds regardless of company or design



# OVERVIEW

- Test Purpose and Focus
- Ammunition Tested (22 rounds)
- Protocols
- Target Media Description
- 5 Phases of the Test
- 4 Grading Criteria
- Volume of Wound Index (VWI)
- Results
  - Pictures
  - Data Tables
- Acknowledgements



# TEST PURPOSE

- The 2019 Solid Copper Defensive Ammunition-Wound Ballistics Test #2 compared multiple solid copper 9mm and .40S&W rounds to several 9mm and .40S&W Hollow Point rounds
- The test was conducted in 5 separate phases, using 4 grading criteria
- No conclusions or selections shall be made
  - Raw data from each shot will be averaged and may be used independently depending on the criteria desired by the receiving agency



# FOCUS

- The 2019 Solid Copper Test main focus was:
1. Comparison of Solid Copper Rounds in 9mm and .40S&W using the protocols and grading criteria previously established and reported on
  2. Compare the Solid Copper rounds to the best 9mm and .40S&W hollow points
  3. Compare Subsonic rounds



# AMMUNITION TESTED

➤ Ten 9mm Solid Copper Rounds (SCR) were tested:

1. Black Hills Honey Badger 100 grain +P
2. Black Hills Honey Badger 125 grain subsonic
3. Underwood XD 65 grain +P
4. Underwood XD 90 grain +P
5. Underwood XD 90 grain +P+
6. G9 EHP 80 grain
7. **G9 First Response 77 grain**
8. **G9 APC 77 grain**
9. **G9 Woodsman 124 grain +P**
10. Fort Scott 80 grain



# AMMUNITION TESTED

- Three .40S&W Solid Copper Rounds (SCR) were tested
  1. Underwood XD 115 grain
  2. G9 EHP Home Defense with Range Limiter 80 grain
  3. Fort Scott 125 grain



# AMMUNITION TESTED

- Six 9mm Hollow Point rounds were tested
  1. Federal HST 147 grain +P
  2. Hornady Critical Duty 135 grain +P
  3. Sig Sauer Elite V-Crown 124 grain
  4. **Speer Gold Dot 147 grain**
  5. Remington Golden Saber 147 grain
  6. Winchester Ranger T-Series 147 grain
  
- Three .40S&W Hollow Points rounds were tested
  1. Federal HST 180 grain
  2. Hornady Critical Duty 175 grain
  3. Sig Sauer Elite V-Crown 165 grain





# PROTOCOLS

All phases and tests were conducted with numerous testers for quality control and multiple measurements. All ammunition was tested with at least 4 rounds fired per phase. All failures are included in the data with no "flyers" being removed. All data shown was from shots fired with stock Glock 17/22.

The 5 phases mirrored what was accomplished during the 2016/17 Joint Agency Ballistic Test For Defensive Handgun Ammunition (available upon request). Comparison results from that test are included in this briefing to increase sample size.



# MEDIA

1. Calibrated IWBA 10% ordnance gelatin. (Phase 2/3)
  - Proper temperature verified and BB depth calibration accomplished immediately prior to shot
  - 1 16x6x6 inch block with a sideways block as a backstop
  - 22 inches of penetration can be measured
2. Single  $\frac{3}{4}$  inch thick AA fir plywood panel IAW FBI / DoD protocols. (Phase 3 and 5)
3. Denim barrier consisting of layers of standardized material. (Phases 2-5)
4. Animal Tissue - 2 boneless hanging briskets  
7-8" thick (Average human male is 10" thick), 36 $\pm$ 2 pounds, fat side out, back to back. (Phase 4/5)



# MEDIA DESCRIPTION

## Calibrated IWBA FBI 10% ordnance gelatin (Phase 2/3)

- Gel is consistent and easy to use/measure. It allows for a comparative study to take place with results that can be replicated
- Not designed to be a simulation of any human or animal tissue. Gel is a fluid and is non-compressible unlike human material
- Density and resistance are not similar to human tissue (as noted by 3 inches of BB penetration depth at calibration)
- Temporary Stretch Cavity does not represent any damaged or destroyed material
- Permanent cavity may be exaggerated by rounds causing compression such as fluid transfer or tumbling rounds (SCR Rounds in this test)
- Recovered bullet diameter doesn't equal gel wound diameter because of rounds turning or fragmenting (which happened frequently) and some rounds cut through material while others push and compress allowing the gel to recover, which is similar to results in actual tissue
- Using gel as a standardized material for comparison is valid and comparing penetration depths is valuable but does not produce results similar to tissue penetration depths. Using gel for wound diameter size and volumes is extremely artificial and next to impossible to measure



# MEDIA DESCRIPTION

Animal Tissue consisting of 2 boneless cow briskets (Phase 4/5)

- Chosen after discussions with a forensic pathologist, other medical doctors and a butcher
  - There are four main types of human tissue: **muscle**, epithelial, connective and nervous. Cow brisket closely represents human muscle tissue and organs
- It is a compressible realistic consistent media
- 7-8" thick (Average human male is 10" thick), total weight  $36 \pm 2$  pounds, hanging fat side forward, back to back. Point side up on one and down on the other to provide equal thickness.
- The exit wounds from each of the 2 briskets are measured for min and max diameter. Those four measurements are averaged and then converted to a hole area



# 5 PHASES

The 2019 Solid Copper Defensive Ammunition-Wound Ballistics Test #2 was conducted in 5 separate phases. All shots fired with a stock Glock 17/22

1. All rounds chronographed
2. Calibrated 10% ordnance gelatin IAW IWBA standards with a standard denim barrier
3. Calibrated 10% ordnance gelatin with a single  $\frac{3}{4}$  inch thick AA fir plywood panel and a standard denim barrier
4. Animal Tissue with a standard denim barrier
5. Animal Tissue with a single  $\frac{3}{4}$  inch thick AA fir plywood panel and a standard denim barrier



# PHASE 1-CHRONOGRAPH

- All rounds fired at least 6 times and chronographed
- Testing actual vs. advertised velocities, consistency and reliability
- All velocities averaged
- Noted in data tables as VEL



## **PHASE 2- IWBA 10% ordnance gelatin with a 4 layer denim barrier**

1. All rounds fired at least 4 times into calibrated IWBA 10% ordnance gelatin with a standard 4 layer denim barrier
2. Recovered rounds inspected for failures, retained weight and overall dimensions
3. Testing Overall Penetration Depth
  - FBI standard 12” minimum and 18” desired
  - Noted in data tables as PEN
4. Testing Overall Permanent Wound Cavity (PWC)
  - Measured in cubic inch volume. Wound diameter (noted in tables as Diam) converted to area and multiplied by penetration depth (PEN)
  - Compressibility issues occur with many of the Solid Copper Rounds causing inflated unrealistic values
  - Noted in data tables as PWC



## **PHASE 3- IWBA 10% ordnance gelatin with Plywood & 4 layers of denim**

1. All rounds were fired at least 4 times into media
2. Calibrated IWBA 10% ordnance gelatin with a single  $\frac{3}{4}$  inch thick AA fir plywood panel IAW FBI / DoD protocols and a standard 4 layers of denim barrier
3. Recovered rounds inspected for failures, retained weight and overall dimensions
4. Testing Overall Penetration Depth
5. Testing Overall Permanent Wound Cavity
  - Measured in cubic inch volume
  - Compressibility issues occur with SCR rounds causing inflated unrealistic results
6. Testing Barrier Performance and Consistency





## **PHASE 4-Animal Tissue with a 4 layer denim barrier**

1. All rounds fired at least 6 times into Animal Tissue with a denim barrier
2. Rounds not recovered
  - No Penetration depths measured in this phase
3. Measuring Overall Wound dimensions
  - Exit wound channels from each of the two back-to-back briskets measured for min and max diameter then averaged. Average diameter converted to hole area
  - Noted in data tables as AREA



## **PHASE 5-Animal Tissue with a plywood and 4 layer denim barrier**

1. All rounds were fired at least 6 times into Animal Tissue with a single  $\frac{3}{4}$  inch thick AA fir plywood panel and a denim barrier
2. Rounds not recovered
  - No Penetration depths measured in this phase
3. Measuring Overall Wound dimensions
  - Exit wound channels from each of the two back-to-back briskets measured for min and max diameter then averaged. Average diameter converted to hole area and recorded
  - Noted in data tables as AREA
4. Testing Barrier Performance and Consistency



# 4 GRADING CRITERIA

The 2019 Solid Copper Test was graded using 4 criteria

1. Penetration Phase 2 data. Desired 18"  $\pm$  10% and a minimum of 12"
2. Consistency and Reliability
  - Standard Deviation for each shot tested within a Phase
  - Failure to function (Tumble, Failure to open, fragmentation and jacket separation). Both Fort Scott rounds are designed to Tumble. In all other rounds, tumbling is a failure
3. Barrier Performance
  - Ability to function through a simple barrier
  - % lost from non-barrier shots to barrier shots from Phase 2/3 and Phase 4/5
4. Permanent Wound Cavity and Volume of Wound Index (VWI)
  - Measured in cubic inches for the Ballistics gel tests of Phase 2/3
  - Measured as average hole size from Phase 4/5 expressed in Area
  - Calculations made to produce a Volume of Wound Index (VWI)



# Volume of Wound Index (VWI)

- Due to Ballistics gel being a fluid and non-compressible, rounds that cause a compression will create a permanent wound cavity that is exaggerated. To better understand and grade rounds that cause compression errors a non-compressible media was used
- IWBA gel (Phase 2/3) is a very consistent media for measuring Penetration depths
- Animal Tissue (Phase 4/5) is a very consistent and realistic media for measuring the wound area
- VWI was created by averaging the Penetration results from Phases 2/3 and multiplying it by the hole area from the tissue tests in Phases 4/5 (averaged together)
- This VWI represents the best calculation for comparative purposes by incorporating barrier and non-barrier data along with consistent and realistic medias



# RESULTS

- The 2019 Solid Copper Defensive Ammunition-Wound Ballistics Test #2 documented all raw data from each shot in each phase
- Averages were calculated and reported
- No conclusions, rank ordering or choosing was accomplished
- All data was graded using the aforementioned 4 grading criteria
- Each agency may use the data as they see fit and can calculate any other grades they wish





# Phase 4/5 Description



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# Phase 4 Measuring



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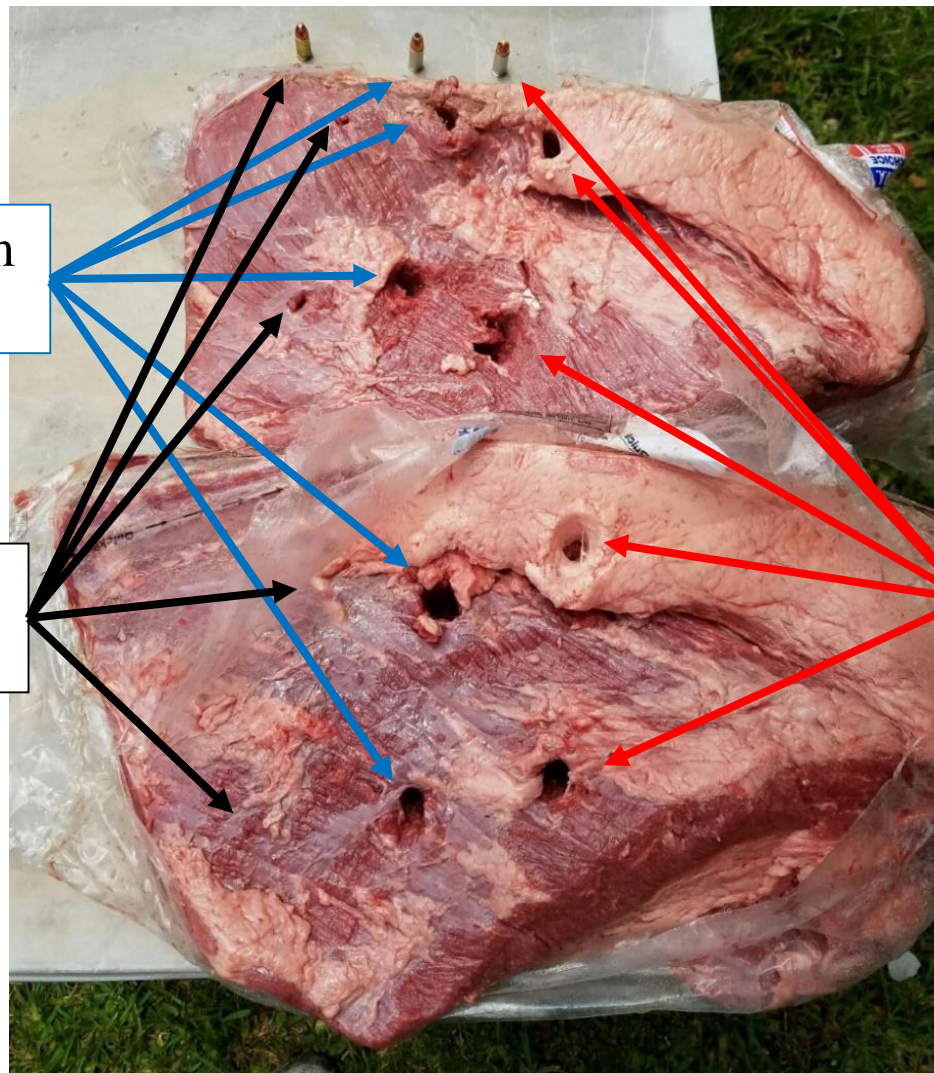


# 9mm Phase 4, Brisket 1&2

Federal 9mm  
147 gr HST

Winchester  
9mm

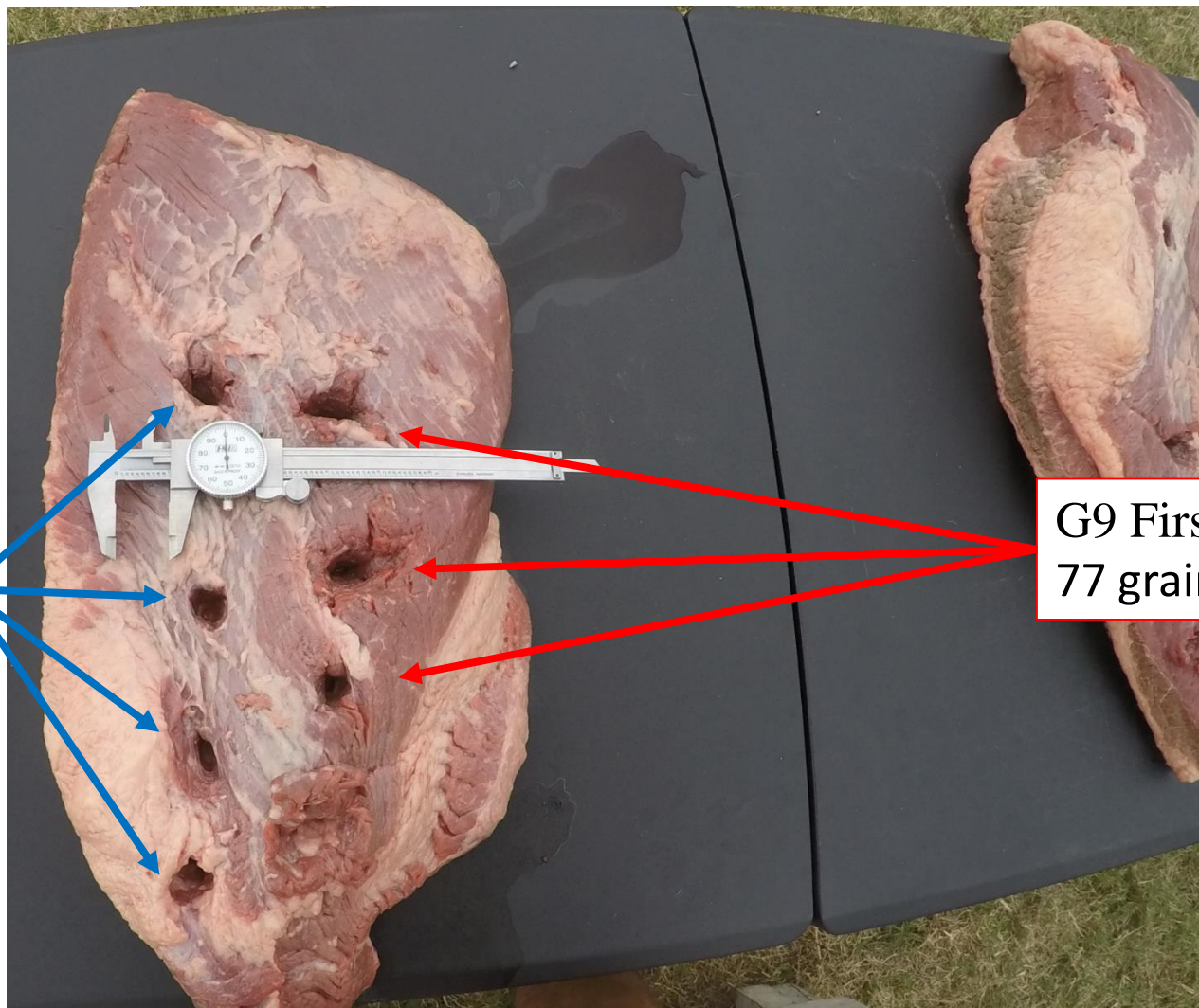
Lehigh Defense  
9mm XD +P







# 9mm Phase 4, Brisket 1&2

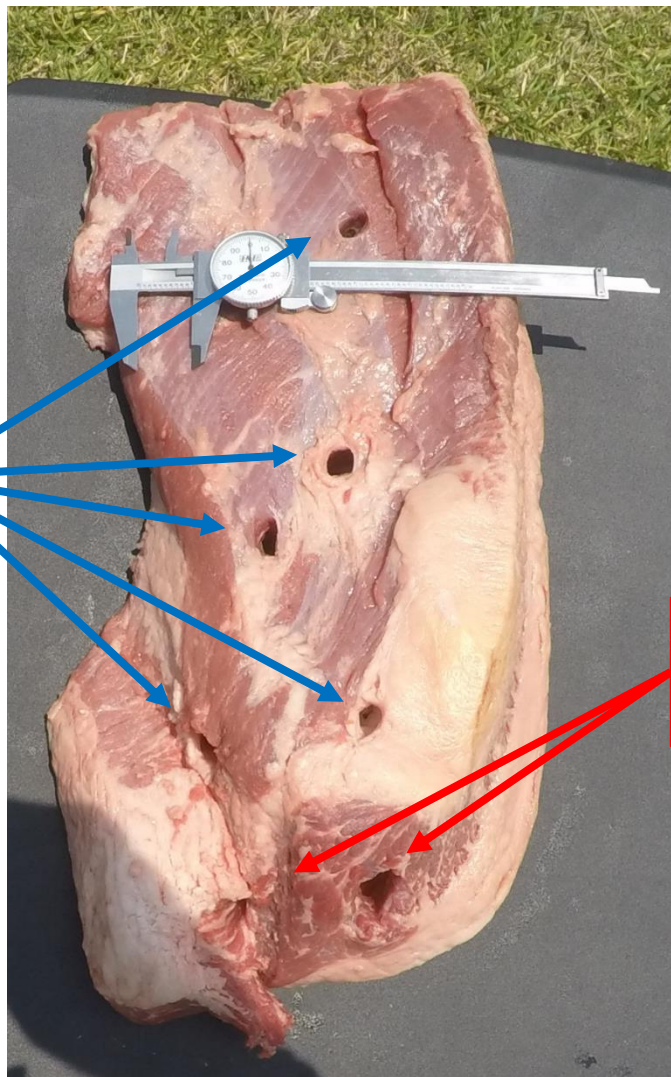


G9 APC  
77 grain

G9 First Response  
77 grain



# 9mm Phase 4, Brisket 2



G9 Woodsman +P  
124 gr

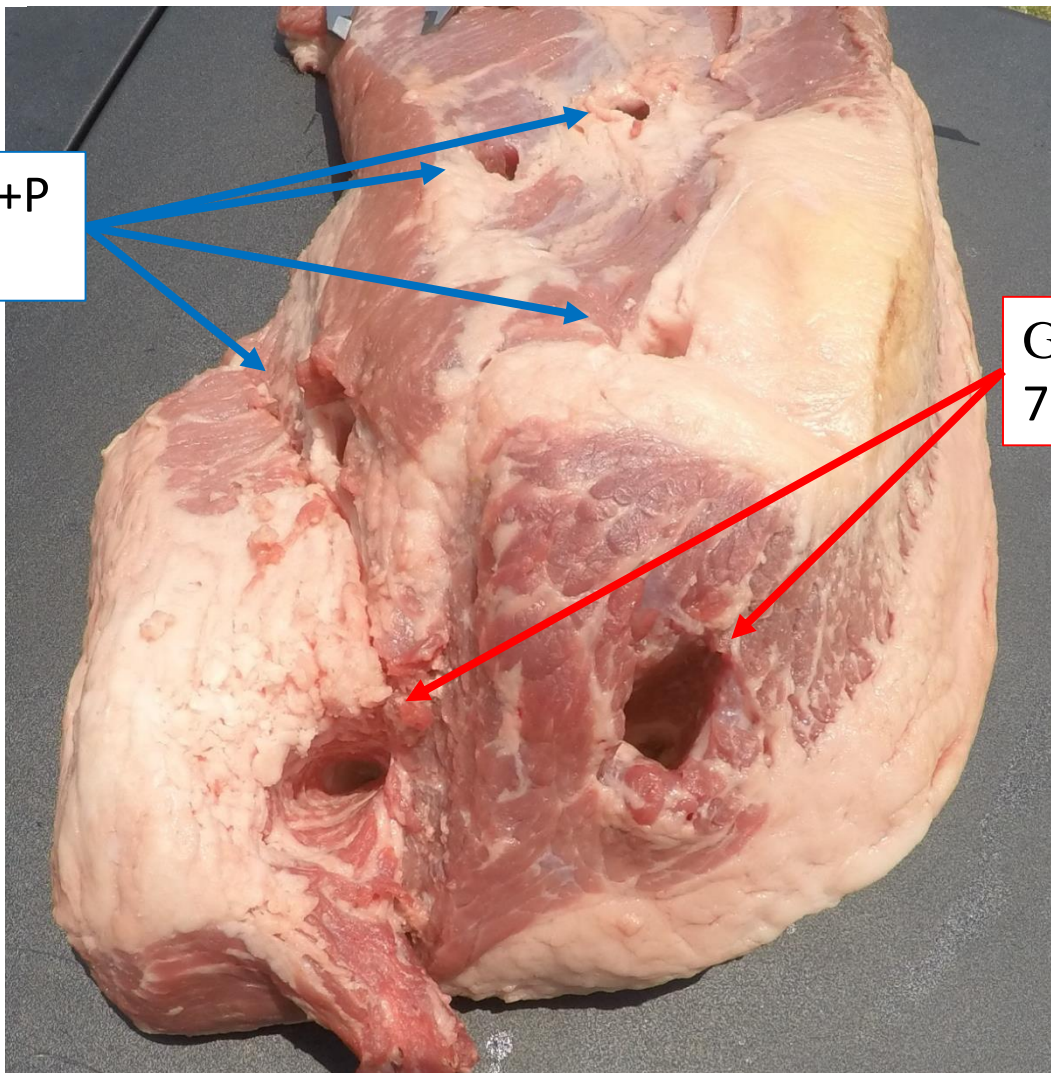
G9 APC  
77 grain





# 9mm Phase 4, Brisket 2

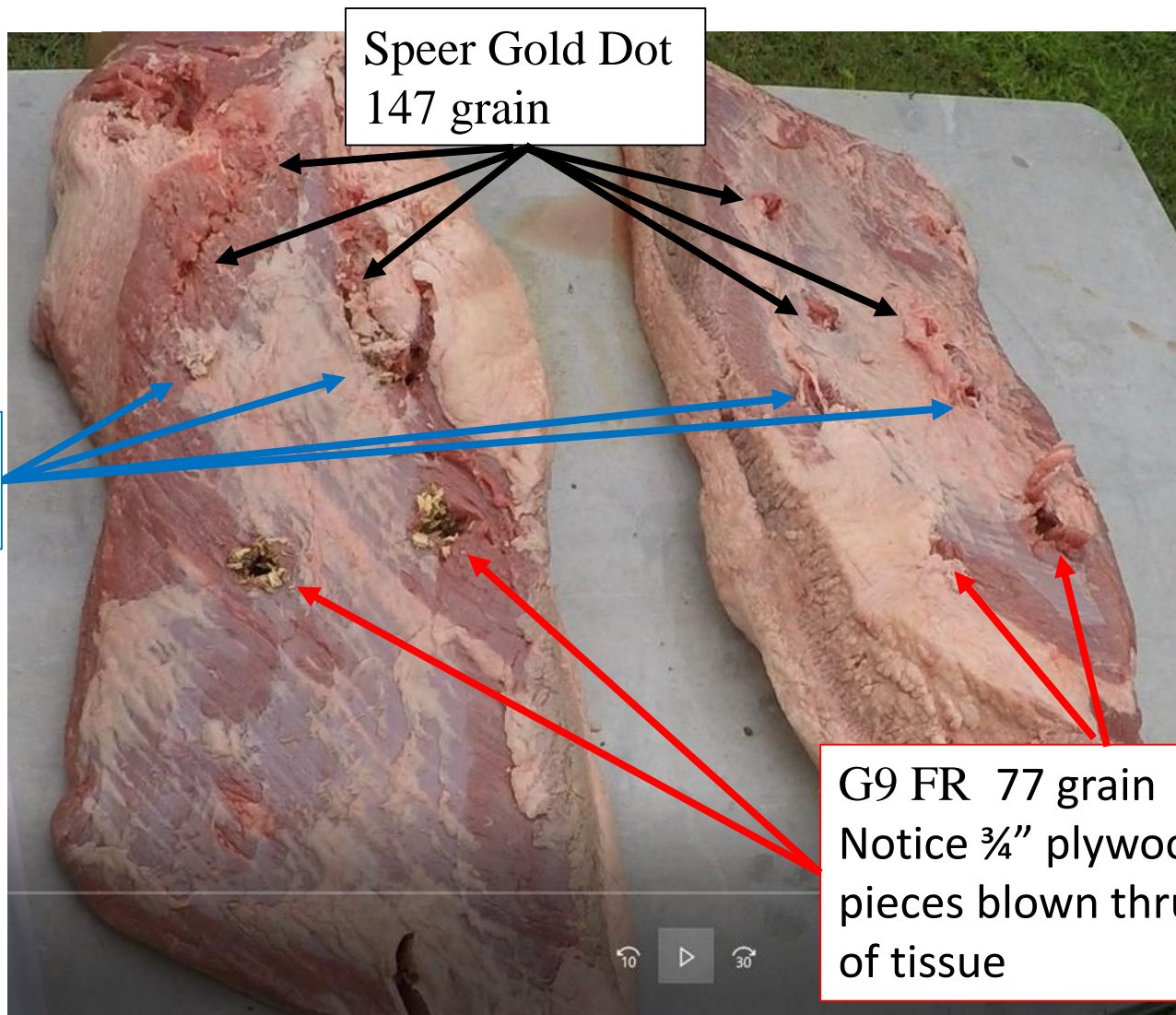
G9 Woodsman +P  
124 gr



G9 APC  
77 grain



# 9mm Phase 4, Brisket 1&2



Speer Gold Dot  
147 grain

Underwood  
90 grain +P+

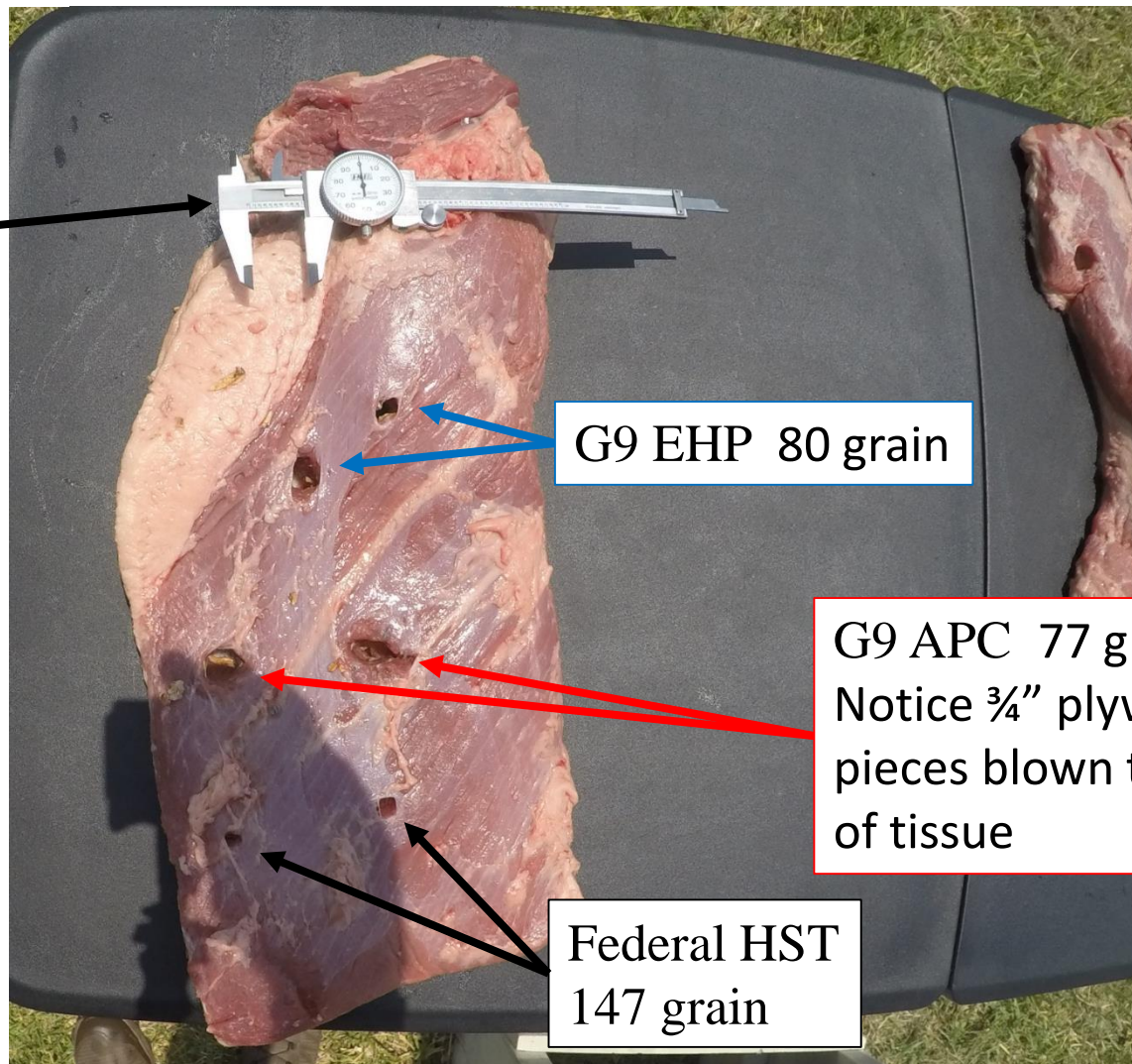
G9 FR 77 grain  
Notice  $\frac{3}{4}$ " plywood barrier  
pieces blown thru 3.5"  
of tissue





# 9mm Phase 5, Brisket 1&2

Micrometer  
Set to 1"



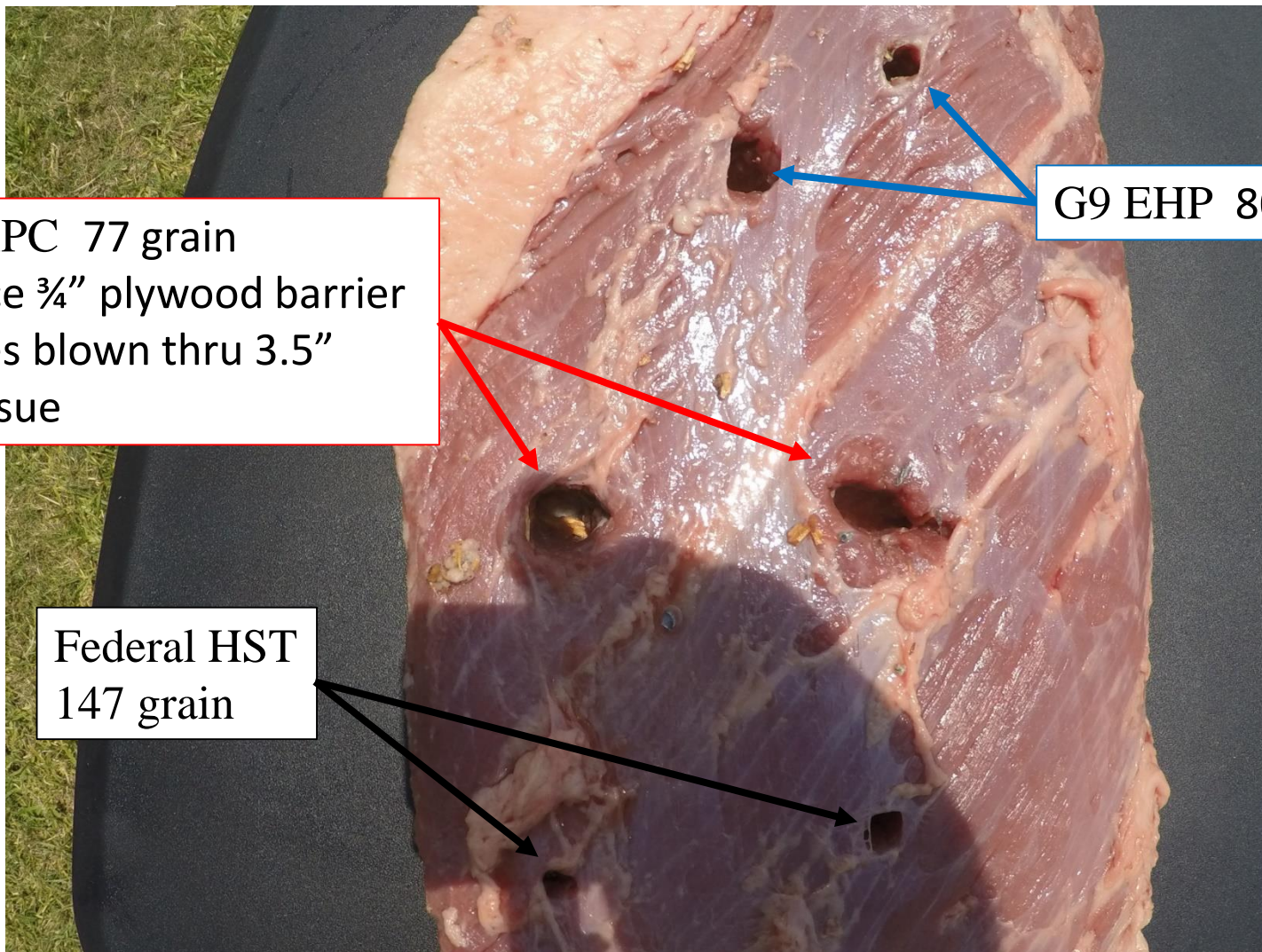
G9 EHP 80 grain

G9 APC 77 grain  
Notice  $\frac{3}{4}$ " plywood barrier  
pieces blown thru 3.5"  
of tissue

Federal HST  
147 grain



# 9mm Phase 5, Brisket 1



G9 APC 77 grain  
Notice  $\frac{3}{4}$ " plywood barrier  
pieces blown thru 3.5"  
of tissue

G9 EHP 80 grain

Federal HST  
147 grain





# PENETRATION 9mm

1. Phase 2 Penetration data for a desired 18"  $\pm 10\%$  and a minimum of 12"
2. Penetration with Barrier was calculated in Phase 3
3. Phase 2 and 3 penetration depths were averaged for the VWI calculation

## RESULTS:

1. All of the 9mm SCR exhibited 16-34.0 inches in Phase 2. All of the Hollow Points had 15.7 inches or less except for one that only surpassed that distance due to Failure-to-Expand
2. Barrier Penetration in Phase 3 yielded an SCR range of 14.7-33.0 inches, while the Hollow Points displayed 13.5-16.5 inches



# **PENETRATION .40 S&W**

1. Phase 2 Penetration data for a desired 18” and a minimum of 12”
2. Penetration with Barrier was calculated in Phase 3
3. Phase 2 and 3 penetration depths were averaged for the VWI calculation

## **RESULTS:**

1. All of the .40 SCR exhibited >18.5 inches in Phase 2 (Fort Scott failed to tumble). All of the Hollow Points had 16-18 inches
2. Barrier Penetration in Phase 3 yielded an SCR range of 18-21 inches (Fort Scott failed to tumble), while the Hollow Points displayed 16.5-17.6 inches
3. Except for the Fort Scott, the .40 S&W SCR averaged 18-19 inches while .40 Hollow points averaged 16-18 inches





# CONSISTENCY/RELIABILITY

Consistency and Reliability was graded in each phase and between phases to determine the effects of barriers.

- Standard Deviation for each shot tested within a Phase
- Failure to Function (tumble, failure to open, fragmentation and jacket separation)
- Comparison of Phase 2/3 data for Barrier effectiveness
- Comparison of Phase 4/5 data for Barrier effectiveness

## RESULTS:

1. All the SCRs (except the Fort Scott which had a very high failure rate) exhibited similar consistent results with shot-to-shot deviations less than 10% and Barriers reducing effectiveness by approximately 5%. No Failures-to-Function were noted on any SCR shots other than the Fort Scott which consistently failed.  
**(The 9mm G9 APC exhibited a 0% deviation and 0% barrier degradation)**
2. Hollow Points exhibited erratic results with shot-to-shot deviations exceeding 50% and Barriers reducing effectiveness by approximately 20%. Multiple Failure-to-Function were noted and averaged approximately 30% matching previous tests. (Fragmentation, Failure to expand, tumbling, jacket separation)



# BARRIER PERFORMANCE

## Barrier performance

- Percent decrease from non-barrier shots to barrier shots from Phase 2/3 and Phase 4/5

## RESULTS:

1. SCRs exhibited similar reliable and consistent results with shot-to-shot deviations minimally effected by the barriers used. The barriers reduced effectiveness by approximately 5%. No Failures-to-Function (i.e. tumbling) were noted on any shots with or without barriers, except for the Fort Scott rounds.
2. Hollow Points had increased Failure-to-Function (increased fragmentation and turning) during the barrier tests and exhibited reduced effectiveness by approximately 20%.



# PWC / VWI

## Permanent Wound Cavity (PWC) and Volume of Wound Index (VWI)

- Measured in cubic inches (ci) for the Ballistics gel tests of Phase 2/3
- Measured as average hole size from Phase 4/5. Average Diameters converted to Area
- Some SCRs display exaggerated huge Permanent Wound Cavities (PWC) in ballistics gel. They create a compression that expands fluids more than actual tissue. Measured PWCs from Phase 2/3 gel tests are available in the attached tables. However, comparing gel PWCs between SCR rounds and Hollow points results in unrealistic data favoring the SCRs
- To display a realistic result VWI is calculated using only the penetration depths in the Phase 2/3 gel tests (averaged together) and the wound areas from tissue in Phases 4/5 (averaged together)



# VOLUME of WOUND INDEX

## RESULTS:

- 9mm SCRs exhibited a VWI of 6.0-20.1 inches
- .40 S&W SCRs exhibited a VWI of 5.1-14.25 inches
- 9mm Hollow Points had a VWI of 4.2-6.0 inches
- .40 S&W Hollow Points had a VWI of 7.0-8.2 inches



# SUBSONICS

- Subsonic ammunition was one of the 3 main focus areas
- 7 of the 22 rounds tested are subsonic
  - 1 SCR (Black Hills Honey Badger 125 grain Subsonic)
  - 6 Hollow Points
    - 9mm - Federal HST, Speer GD, Remington Golden Sabre, Winchester Ranger T
    - .40 S&W - Federal HST, Hornady Critical Duty
- The Black Hills achieved the deepest penetration in both Phase 2 and 3 and recorded the lowest degradation do to barriers
  - The increase of some penetration depths of the hollow points was solely the result of Failure to Expand causing the rounds to behave similar to Full Metal Jacket (FMJ) rounds
- The Black Hills 125 grain had a zero failure rate as compared to approximately 30% for the hollow points
- The Black Hills round recorded the largest 9mm wound area in both Phase 4/5 and recorded the largest subsonic 9mm VWI of 6.73 compared to 4.27-5.98 for the 4 subsonic 9mm hollow points tested. The subsonic .40 S&W hollow points had a VWI of 7.0-8.2



# DATA TABLE DEFINITIONS

- Rounds- All 22 rounds tested. Listed by caliber with the Solid Copper Rounds (SCR) above the Hollow Points. All shots fired with a stock Glock 17/22
- VEL- Velocity from Phase 1 (slide 14)
- PEN- Average inches of penetration thru gel (Phase 2/3) (slide 15 and 16)
- Diam- Largest permanent diameter in gel (Phase 2/3) Averaged over all shots for that round in that phase
- PWC- Permanent Wound Cavity volume converting Diam to area ( $A = \pi r^2$ ) and multiplied by PEN (average penetration depth). This is artificially large due to two reasons
  1. Using the largest diameter
  2. The rounds that cause compression create an exaggerated wound channel in non-compressible gel
- AREA- Phase 4/5 (slide 17 and 18) tissue test measurements of average diameter of exit wound from each brisket averaged together and then converted to area ( $A = \pi r^2$ )
- VWI- Volume of Wound Index (slide 20) Average Area from Phase 4/5 multiplied by average PEN from Phase 2/3
  - Includes data from realistic tissue, consistent to measure gel penetration and barriers

# 9mm RESULTS

ROUNDG	VEL	PHASE 2			PHASE 3			PHASE 4	PHASE 5	VWI
9mm SCR		PEN	Diam	PWC	PEN	Diam	PWC	AREA	AREA	VOL
BH HB 100 +P	1310	16.0"	.75	7.0 ci	14.7"	.7	5.7 ci	.47	.41	6.765
BH 125 Subsonic	1020	17.5"	.65	5.8 ci	17"	.62	5.1 ci	.41	.37	6.73
Underwood 65 +P	1760	16.5"	1.1	15.7	15.5"	.95	11.0	.65	.63	10.24
Underwood 90 +P	1505	16.7"	.87	9.9 ci	16"	.83	8.5 ci	.6	.59	9.74
Underwood 90 +P+	1585	17.5"	.95	12.4	16.6"	.93	11.3	.65	.65	11.1
Fort Scott 80	1405	19.5"	.42	2.7 ci	18.6"	.42	2.6 ci	.27	.25	5.0
G9 EHP 80	1405	17.5"	1.1	16.6 ci	17"	.98	12.8 ci	.69	.67	11.73
G9 1 <sup>st</sup> Response 77	1540	19.5"	1.2	22.0 ci	19.0"	1.1	18.0 ci	.75	.73	14.25
G9 APC 77	1555	19.5"	1.2	22.0 ci	19.5"	1.2	22.0 ci	.75	.76	14.72
G9 Woodsman 124	1260	34.0"	1.0	34.0 ci	33.0"	1.0	33.0 ci	.6	.6	20.1
9 Hollow Point		PEN	Diam	PWC	PEN	Diam	PWC	AREA	AREA	VOL
Federal HST 147	1005	15.2"	.57	3.9 ci	15.5"	.52	3.3 ci	.41	.35	5.98
Hornady C Duty 135	1120	14.5"	.52	3.1 ci	13.5"	.5	2.7 ci	.35	.31	4.62
Sig VC 124	1150	13.8"	.55	3.3 ci	16.5"	.42	2.3 ci	.4	.35	5.76
Speer Gold Dot 147	970	15.7"	.56	3.9 ci	14.6"	.5	2.9 ci	.36	.32	5.15
Remington GS 147	980	17"	.55	4.0 ci	16"	.5	3.1 ci	.3	.25	4.455
Winches Rang T 147	1000	14.5"	.63	4.5 ci	16"	.4	2.0 ci	.3	.25	4.27

# 40 S&W RESULTS

ROUND	VEL	PHASE 2			PHASE 3			PHASE 4	PHASE 5	VWI
.40 S&W SCR		PEN	Diam	PWC	PEN	Diam	PWC	AREA	AREA	VWI
G9 EHP-HDRL 80	1640	19"	1.3	25.2 ci	18.5"	1.2	20.9 ci	.77	.75	14.25
Fort Scott 125	1290	22"	.48	4.0 ci	20.8"	.46	3.5 ci	.2	.28	5.1
Underwood XD 115	1425	18.5"	.9	11.8 ci	18.1"	.9	11.5 ci	.635	.575	11.1
.40 S&W HP		PEN	Diam	PWC	PEN	Diam	PWC	AREA	AREA	VWI
Federal HST 180	1000	18"	.6	5.2 ci	17.6"	.57	4.5 ci	.49	.43	8.2
Hornady C Duty 175	1020	17.9"	.61	5.2 ci	17.2"	.6	4.8 ci	.4	.4	7.04
Sig VC 165	1100	16"	.64	5.1 ci	16.5"	.58	4.4 ci	.45	.41	6.99

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# ADDITIONAL COMMENTS

- For data consistency all shots fired with a stock Glock 17/22 with 4.49” barrels
- Minimal testing was done with non-standard barrel lengths. No data from non-standard barrel lengths was included into the data tables
  - Glock 19 with stock 4.02” barrel. SCRs exhibited a reduced muzzle velocity of approximately 50-70 fps.
  - Glock 17 with KKM Threaded 5.03” barrel. Used during the subsonic tests. SCRs exhibited a muzzle velocity increase of approximately 50-70 fps
  - Glock 34 with KKM Threaded 5.85” barrel. SCRs exhibited a muzzle velocity increase of approximately 120-160 fps
  - Phase 4 tissue tests showed a corresponding increase in hole area with an increase in muzzle velocity with SCRs
- All testers remarked at the low recoil the Solid Copper Rounds exhibited. Both in single shot and during our full magazine rapid fire test for feed reliability. Muzzle rise and felt recoil were noticeably reduced while using the SCR.



# ACKNOWLEDGEMENTS

- There are so many people to credit with the amount of data that was measured and calculated in this report presentation. People involved in this test came from multiple police departments, a local gun store and 2 training schools. One local grocery store chain gave a great discount on the brisket used in Phases 4 and 5. The tests were accomplished at 2 outdoor ranges
- No ammunition manufacturers were allowed to attend any test. They were only allowed to provide ammunition and nothing else
- A very special thanks to all the volunteers who helped set up, tear down, measure, re-measure, document, calculate and check all the data. Only through their diligent thorough work could this much accurate data be generated
- There are no conclusions in this test. Testing was accomplished only to provide quantifiable raw data on a large scale with an enormous sample size on multiple realistic media



# CONTACT US

Please contact us for questions or follow-on testing

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