The Forensic Aspects and Challenges of Winchester's Tin .22LR Bullets

By: Lucien C. Haag, Forensic Science Services, Inc. (FSSI), P.O. Box 5347, Carefree, AZ 85377

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ABSTRACT

The appearance of Winchester's pure tin, 26-grain bullets in their Varmint LF .22 long rifle ammunition, product X22LRHLF, represents a new and interesting challenge for forensic firearms examiners. The first clue that one is dealing with something well outside the norm is the weight of a recovered projectile followed by its exceptionally shiny appearance.

These bullets typically acquire the general rifling characteristics of the firearm from which they are discharged, but not necessarily reproducible striae patterns sufficient for firearms identification.

Although the shape and dimensions of these bullets are virtually identical to their lead counterpart, tin's substantially lower density compared to that of lead, results in their greatly-reduced weight of 26 grains.

While this lower weight results in a much higher muzzle velocity, it also results in a reduced ballistic coefficient, and a corresponding rapid loss of velocity over time and distance compared to the equivalent lead bullet.

Traditional tests for lead in bullet wipe with the sodium rhodizonate test may be of limited success, or even unsuccessful with this ammunition because the only sources of lead are the priming mixture in these cartridges and/or 'pick-up' from a bore previously fouled with traditional lead bullets.

Introduction

During the 2011 AFTE Training Seminar in Chicago, Illinois, Jim Roberts of the Ventura County Crime Laboratory, Ventura, California, provided this writer with a few rounds of Winchester *Super-X* .22 long rifle ammunition loaded with 26-grain, tin, hollow-point bullets. Aside from the unusual bullet weight and shiny appearance, the only other attribute in these early examples that appeared atypical was a flat, rather than a concave, base. Current specimens now have concave bases comparable to their lead counterparts.

Only some limited testing and examination of test-fired specimens were possible with the initial 2011 samples due to the relatively limited number of cartridges. This was remedied with the kind assistance of AFTE Technical Advisor Ed Harris (Paul Szabo's successor) at the Olin-Winchester company in East Alton, Illinois, who provided this writer with a current, 50-round box of their *Varmint LF* ammunition. Mr. Harris also stated that this ammunition was introduced in 2010 and is still in production as of 2017. **Figure 1a** and **1b** provide views of the top and end labels of the current 50-round plastic cartridge box.

Figure 1a: Cartridge box - Top

Figure 1b: Cartridge box - End

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	Lead	Tin
Density	11.34g/cc	7.31g/cc
Brinell Hardness	4.0	2.9
Melting Point	327.4°C	231.9°C
Boiling Point	1740°C	2507°C

Source: The Merck Index, 9th ed.

Table 1: Comparison of physical properties

INFINITION® DOPPLER RADAR SYSTEM

MUZZLE VEL.	100-yard VEL.	Calc. G1BC	Calc. G7BC
1544.5fps	1055.9fps	0.0851	0.0474
1577.1fps	1059.6fps	0.0823	0.0460
1572.0fps	1057.2fps	0.0822	0.0458
1599.1fps	1064.7fps	0.0812	0.0455
1550.9fps	1055.1fps	0.0841	0.0468
1564.1fps	1049.5fps	0.0809	0.0447
1569.1fps	1064.9fps	0.0848	0.0476
1567.9fps	1051.4fps	0.0810	0.0449
1568.1fps±16.6fps		**0.0827±0.0017**	**0.0461±0.0011**

Table 2: Summary of exterior ballistic results, Winchester 26-gr. Sn *VARMINT LF*®

Figure 2: Left To Right:
Varmint LF ***Wildcat*** ***Xpert22***

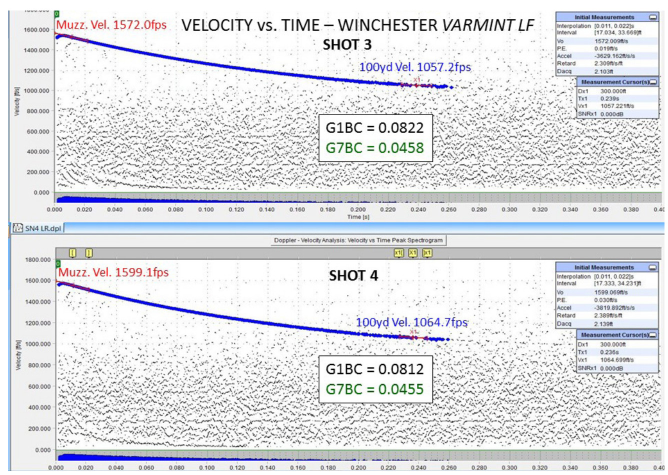

Figure 3: Representative Doppler radar results two shots from a Ruger 10/22 carbine

The cannelured brass cartridge cases bear the familiar *Super-X* headstamp. Although the bullets are lead-free, as determined by a negative sodium rhodizonate test on a filter paper rubbing of a randomly-selected bullet, the priming mixture in these rimfire cartridges contains lead. The absence of any detectable lead in these bullets was also established via SEM-EDS spectral analysis.

Before describing the various tests and test results with this novel ammunition, a brief review of the relevant physical properties of lead and tin are in order. These are provided in **Table 1** derived from the 9th edition of the *Merck Index** [1]. The most noteworthy properties depicted in this table are the greater softness of tin compared to lead and its lower melting point.

Velocity Comparisons – Exterior Ballistics

For this purpose, a common Ruger 10/22 semi-automatic rifle with an 18-inch barrel and conventional 6-right rifling was used to obtain and compare velocity values for the Winchester *Varmint LF* ammunition and two Winchester products containing traditional lead bullets. These consisted of Winchester *Wildcat* with 40-grain round nose bullets and Winchester *Xpert22* with 36-grain hollow point bullets. A profile view of these three cartridges is depicted in **Figure 2**. A *CED* chronograph positioned 10-feet beyond the muzzle was employed for some initial velocity measurements. Later, an *Infinition* Doppler radar system was used to obtain muzzle velocity values and downrange velocity values at 100 yards. From these tests, the in-flight stability of the 26-grain tin bullets could be assessed and their effective G1 and G7 ballistic coefficients could be calculated. These were derived from the Doppler radar data and Sierra Bullets' *Infinity-7* exterior ballistics program [2].

Velocity and Ballistic Coefficient Results

The average muzzle velocity for 25 shots of the *Varmint LF* ammunition from the Ruger 10/22 was 1571 fps ±17 fps. The calculated G1 and G7 BCs for this bullet were 0.0827* ±0.0017 and 0.0461 ±0.011 respectively for eight Doppler radar plots. Two of these plots are depicted in **Figure 3.** The data from these 8 shots are listed in **Table 2**. For comparison,

*Some variation in tin's Brinell hardness value can be found in other reference sources, but nearly all show it to be similar to that of lead.

*The manufacturer's product literature lists the G1 BC of the *Varmint LF* bullet as 0.062.

the average muzzle velocity results for 11 rounds of the Winchester *Wildcat* and *Xpert22* ammunition fired from the same Ruger 10/22 were 1280 fps ±18 fps and 1148 fps ±12 fps respectively. By way of comparison, the G1 BC for common, 40-grain, lead round nose, .22LR bullets is approximately 0.13. To put these BC differences in perspective, if both bullets were launched with a muzzle velocity of 1300 fps under standard conditions, the tin bullet with a G1 BC of 0.0827 would have a 100-yard velocity of 943 f/s whereas the 40-grain solid lead bullet with a G1 BC of 0.130 would have a residual velocity of 1028 f/s at 100 yards. If the manufacturer's BC of 0.062 is used for this same calculation, a 100-yard velocity of 883 f/s is obtained.

Terminal Ballistics

Blocks of *ClearBallistics* synthetic gelatin and calibrated ballistic soap were used to evaluate and compare the penetration and 'wound ballistic' behavior of the *Varmint LF* tin bullets with the traditional lead bullets loaded in the Winchester *Wildcat* and *Xpert22* ammunition. All bullets were launched from a Ruger 10/22 carbine positioned 15 feet from the target material. A CED chronograph with infrared light sources was positioned immediately in front of each block of medium to record the impact velocity. Standard 0.173-inch steel BBs weighing 5.25 grains were used to evaluate the retardation properties of the target materials via a plot of penetration depths at three widely separated impact velocities. [3]. A Daisy 880 *Powerline* air rifle was used for this purpose.

Penetration Test Results

The BB penetration results in the 5x5x15-inch block of MBM ballistic soap for impact velocities of 359 fps, 626 fps and 754 fps were 1.4 in., 3.4 in., and 4.4 in. respectively. These results formed a straight line as expected when plotted in Excel. The resultant penetration equation was used to calculate the 590 fps penetration value. This calculation yielded a penetration value of 3.2 inches which is in close agreement with the desired value of 3.34 inches [3].

A *Varmint LF* tin bullet with an impact velocity of 1490 fps penetrated to a depth of 10.25-inches in the MBM ballistic soap. This bullet yawed, but did *not* expand. A Winchester *Wildcat* bullet with an impact velocity of 1247 fps penetrated to a depth of 14-inches and came to rest intact and un-deformed as expected. The *Xpert22* hollow point bullet struck the ballistic soap block with an impact velocity of 1139 fps. It expanded and broke into 3 major fragments with the two larger fragments penetrating to a depth of 7 and 6-inches respectively. The recovered bullets and bullet fragments are shown in **Figure 4**.

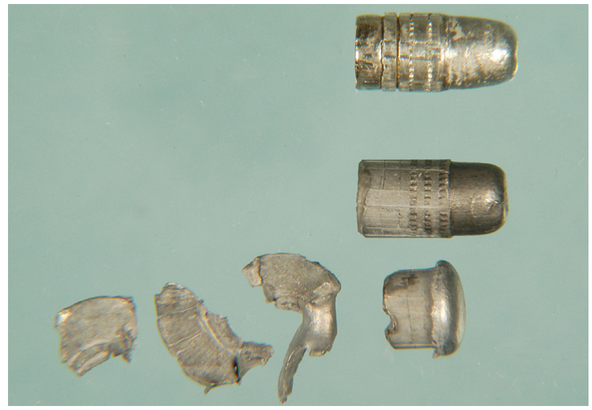

Figure 4: Bullets recovered from a block of ballistic soap
Upper – Win. X22LRHLF 26-gr Tin HP
Middle – Win. Wildcat 40-gr LRN
Lower – Win. Xpert22 40-gr LHP

The BB penetration results for a 5x5x15-inch block of the *ClearBallistics* product for impact velocities of 367 fps, 621 fps and 741 fps were 1.4 in., 4.25 in., and 5.6 in. respectively. These results also formed a straight line when plotted in Excel. The resultant penetration equation was used to calculate a 590 fps penetration value of 3.9 inches which is substantially greater than the desired value of 3.34 inches. This is in agreement with past measurements with this product, and is due, in part, to its low density (less than 1.0 g/cc). It should be recalled that the density of soft solids such as ordnance gelatin and ballistic soap used in wound ballistics studies is a critically important parameter which directly affects penetration depth by projectiles [4]. By comparison, the nominal density of muscle tissue is 1.06 g/cc [5].

Nonetheless, the *ClearBallistics* product provided a useful comparison medium and was consequently included in this study.

One round of each of the three ammunition types was shot into the *ClearBallistics* block with the following results:

- Winchester *Wildcat* 40-gr LRN bullet at 1236 fps perforated the 15-inch block and was recovered from a Kevlar panel.
- Winchester *Xpert22* 36-gr LHP bullet at 1140 fps penetrated to a depth of 10-inches. The bullet fully mushroomed without fragmentation. Additional shots produced comparable results.
- Winchester *Varmint LF*, 26-gr, tin HP at 1511 fps penetrated to a depth of 12.5 inches without any

Figure 5: Bullets recovered from a block of Clearballistics
Upper – Win. X22LRHLF 26-gr Tin HP
Middle – Win. Wildcat 40-gr LRN
Lower – Win. Xpert22 40-gr LHP

expansion of its hollow point. These bullets are shown in **Figure 5**.

An additional technique was employed using an *Infinition* Doppler radar system to study and compare the behavior of these three bullets as they perforated a 5.5-inch thick block of the *ClearBallistics* medium. This target was positioned 47-feet downrange and shot multiple times with each type of ammunition discharged in the Ruger 10/22 carbine. The *Infinition* Doppler radar unit allowed for the measurement of the impact and exit velocities as well as the stability (or instability) of each bullet after exiting the target. **Figure 6a**, **6b** and **6c** provide examples of Velocity vs. Distance plots for each of the three bullet types as they strike, perforate, and depart the target block. **Table 3** summarizes the results of these shots.

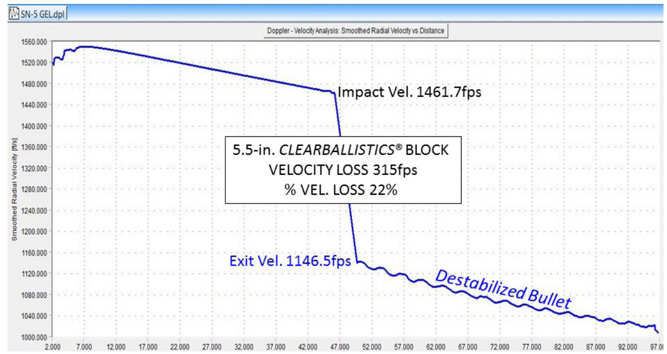

Figure 6a: Representative Doppler track, Winchester 26-gr. Sn *VARMINT LF*®, velocity vs. distance

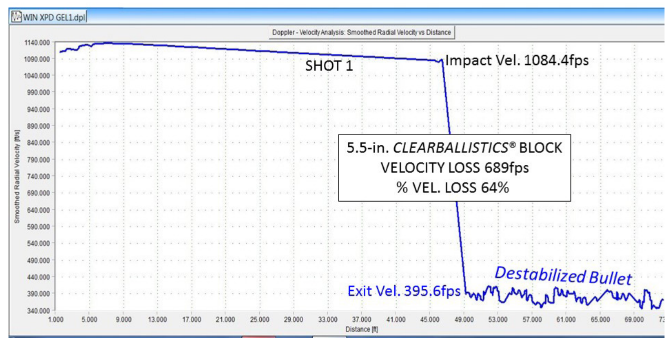

Figure 6b: Representative Doppler track, Winchester 36-gr. LHP *XPERT22*®, velocity vs. distance

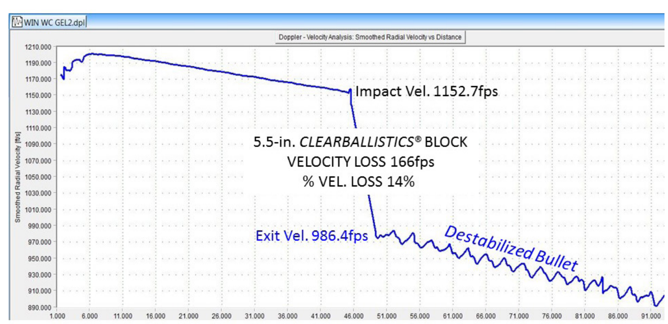

Figure 6c: Representative Doppler track, Winchester 40-gr. LRN *Wildcat*®, velocity vs. distance

Firearms Identification

MUZZLE VEL.	IMPACT VEL.	EXIT VEL.	VEL. LOSS	% VEL. LOSS
WINCHESTER 26-gr Sn *VARMINT LF*®				
1574fps	1452fps	872fps	480fps	33%
1563fps	1440fps	983fps	457fps	32%
1456fps	1357fps	1029fps	328fps	24%
1588fps	1473fps	1086fps	387fps	26%
1572fps	1462fps	1147fps	315fps	22%
1566fps	1450fps	1044fps	406fps	28%
1553fps ±48fps	**1439fps ±42fps**	**1027fps ±94fps**	**396fps ±67fps**	**28% ±4%**
WINCHESTER 36-gr L-HP *EXPERT22*®				
1151fps	1084fps	396fps	688fps	63%
1128fps	1073fps	413fps	660fps	61%
1156fps	1100fps	404fps	696fps	63%
1145fps ±15fps	**1086fps ±14fps**	**404fps ±9fps**	**681fps ±19fps**	**62% ±1%**
WINCHESTER 40-gr LRN *WILDCAT*®				
1304fps	1240fps	1033fps	207fps	17%
1213fps	1153fps	986fps	166fps	14%
1214fps	1161fps	1002fps	159fps	14%
1285fps	1221fps	946fps	275fps	23%
1272fps	1203fps	734fps	469fps	39%
1258fps ±42fps	**1196fps ±38fps**	**940fps ±119fps**	**255fps ±128fps**	**21% ±10%**

Table 3: Doppler radar velocity loss results for perforating shots in synthetic gelatin

A total of three handguns and two rifles chambered for .22LR were used to prepare test-fired bullets for firearms identification. The handguns consisted of a High Standard *SportKing* semi-automatic pistol with a 6¾-inch, 6-right barrel; a High Standard *Model R-101* revolver with a 3-inch, 6-right barrel; and a *Sterling* semi-automatic pistol with a 2¼-inch, 10-right barrel. These firearms are shown in **Figure 7a**. The two rifles consisted of the Ruger 10/22 with an 18-inch, 6-right barrel and a Remington 40X target rifle with a 28-inch, 6-right barrel (See **Figure 7b**).

Multiple specimens of the tin and conventional lead bullets from each of these firearms were collected from a water recovery tank. Three (3) types of comparisons were carried out:

1. lead bullets to lead bullets to assess the ease or difficulty in matching these bullet among themselves.
2. tin bullets to tin bullets for the same reason.
3. tin bullets to lead bullets in any previous outcome where the satisfactory matches were made.

The comparisons were greatly facilitated with the assistance of Sergey Perunov who scanned them with the *Evofinder* device and then forwarded the image files to this writer after which numerous comparisons were carried out. Traditional microscopy was largely limited to preliminary examinations of the rifling engravings, the presence or absence of gas-cutting, and photography through the stereo-microscope. These examinations frequently revealed considerable gas cutting and a loss of tin during the discharge process, especially from the skirts of the tin bullets. This also appeared to be associated with the particular firearm used to prepare the test-fired specimens. **Figure 8** provides examples of gas cutting near the bases of tin bullets fired from the three handguns among the five firearms employed in these tests. A standard 40-grain lead bullet fired from the High Standard *SportKing* pistol is included at the top of this figure for comparison purposes. Gas cutting was somewhat less, but not totally absent, for *Varmint LF* bullets fired from the two rifles.

Figure 7a: Handguns used for these tests

Figure 7b: Ruger 10/22 and Remington 40X

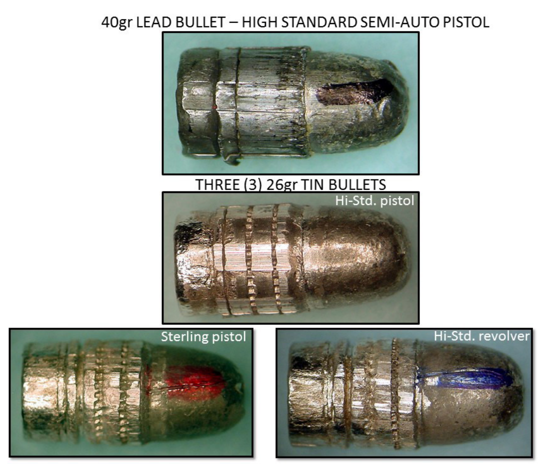

Figure 8: Lead bullet from High Standard pistol (top) and tin bullets from three handguns

Firearms Identification Results

Figure 9a provides an *Evofinder* scan and comparison of the complete bearing surfaces of two, 40-gr lead bullets fired from the High Standard *SportKing* pistol. **Figure 9b** depicts the best land impression match for lead bullets from this pistol.

Figure 10 shows the complete, surviving, bearing surfaces for two, 26-gr, tin bullets fired from the High Standard *SportKing* pistol. Substantial gas cutting and slippage can be seen in this figure. *No* subsequent areas of matching striae were found upon closer examination at higher magnification.

The results for the High Standard Model *R-101* revolver were comparable to those for the semi-automatic pistol.

Fair land impression matches were found for lead bullets, but no successful matches could be found among the tin bullets

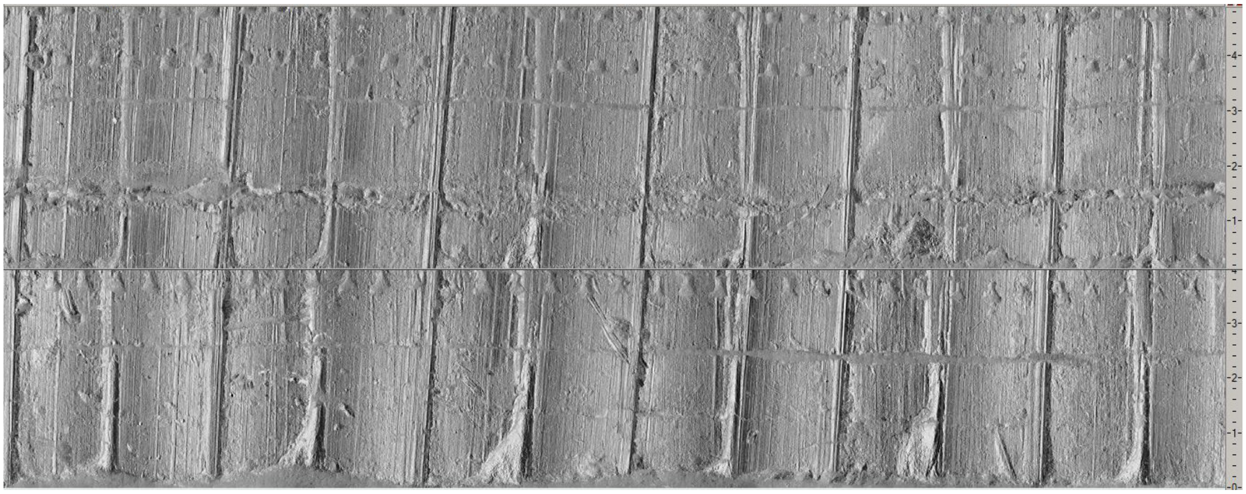

Figure 9a: *Evofinder* image of the bearing surfaces of two lead bullets from the High Standard *Sportking* pistol

Figure 9b: High Standard *Sportking* pistol best match on a land impression – 150% image – lead bullets

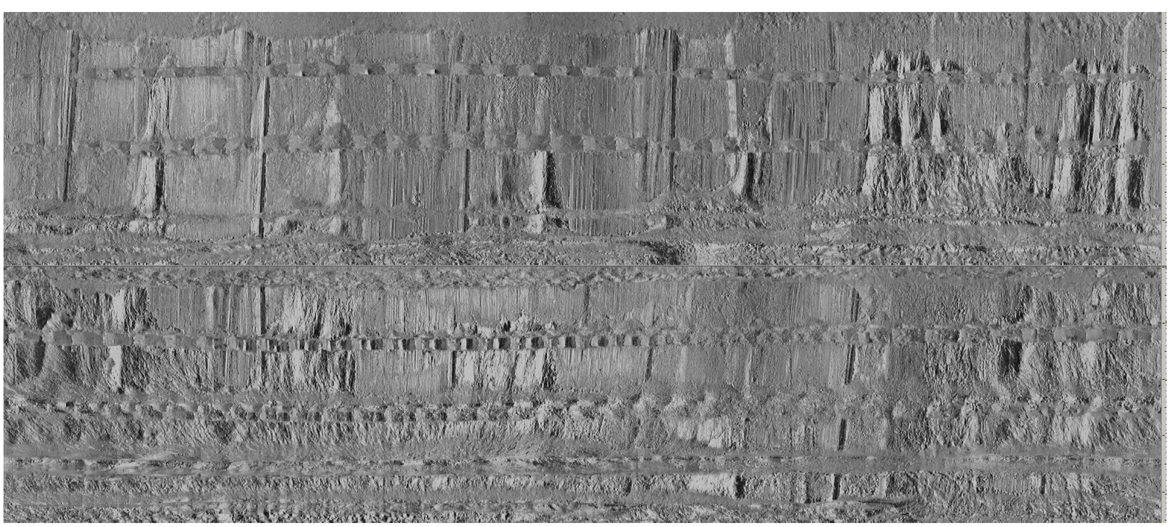

Figure 10: *Evofinder* image of the bearing surfaces of two tin bullets from the High Standard *Sportking* pistol

Figure 11a: *Evofinder* image of the bearing surfaces of two lead bullets from the *Sterling* pistol

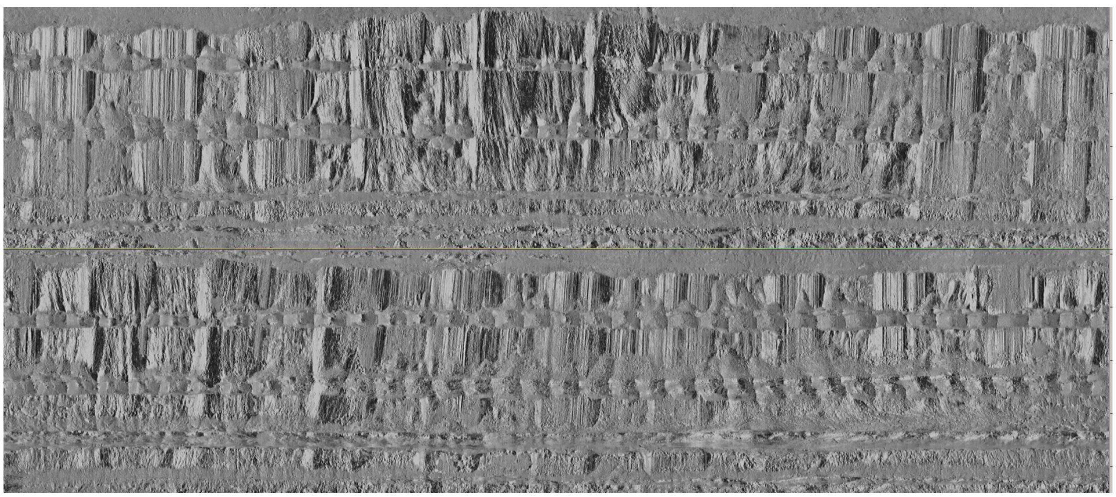

Figure 11b: *Evofinder* image of the bearing surfaces of two tin bullets from the *Sterling* pistol

which, as with the *SportKing* pistol, displayed much gas-cutting and slippage.

The short-barreled, 10-right *Sterling* pistol produced relatively clear land and groove impressions in lead bullets [See **Figure 11a**]. However, no satisfactory matches were found among the six, test-fired, lead bullets scanned by Sergey Perunov. Rifling marks on tin bullets were *un*suitable for comparison purposes. Poor engagement with the rifling, slippage and gas cutting predominate on the bearing surfaces of these bullets. [See **Figure 11b**].

The very poor rifling engravings and substantial gas cutting observed on the *Varmint LF* bullets raised a question as to the in-flight stability of these tin bullets when fired from handguns. This was evaluated through multiple Doppler radar plots of these bullets when fired from the High Standard *SportKing* pistol and High Standard Model *R-101* revolver. These tests revealed that although poorly engraved by the rifling, all bullets showed satisfactory spin-stabilization.

Firearms identification issues faired a little better with the two rifles, although in an odd way, starting with the Ruger 10/22. **Figure 12a** shows a full circumference comparison between two lead bullets from the Ruger rifle. The best match for these two bullets was in a *groove* impression to which an aqua-colored width bar has been added by the author. *No* satisfactory matches were found on any of the six land impressions. **Figure 12b** provides an enlarged view of the groove impression containing some matching striae and showing a groove width of 1.755mm (0.069-in.); a value in good agreement with the FBI's GRC database. **Figure 13** shows a full circumference comparison between a lead bullet and a tin bullet fired from the Ruger 10/22 rifle in which a clear difference can be seen between the land and groove impression widths. This difference recurred among other members of the

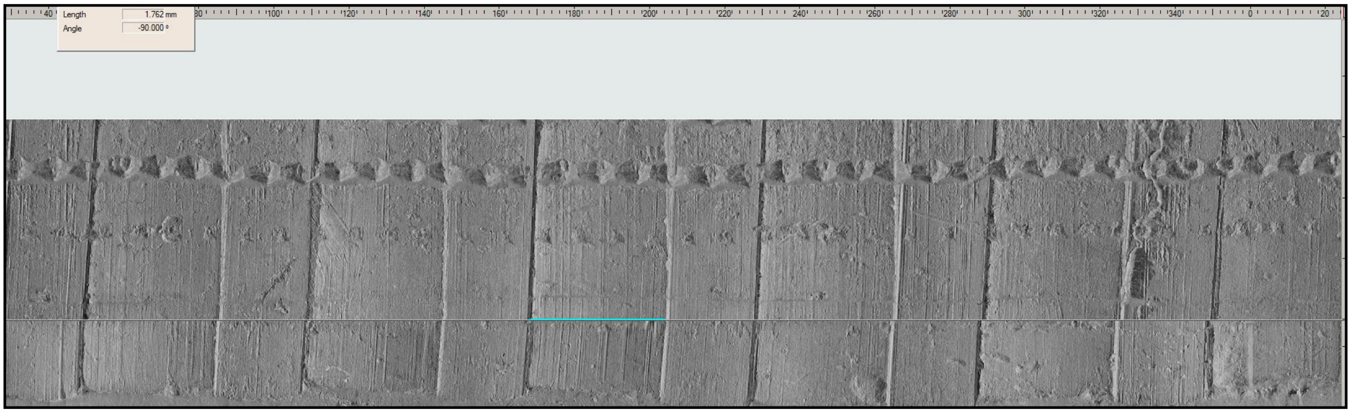

Figure 12a: *Evofinder* image of the full bearing surfaces of two lead bullets from the Ruger 10/22 rifle with a groove width measurement included

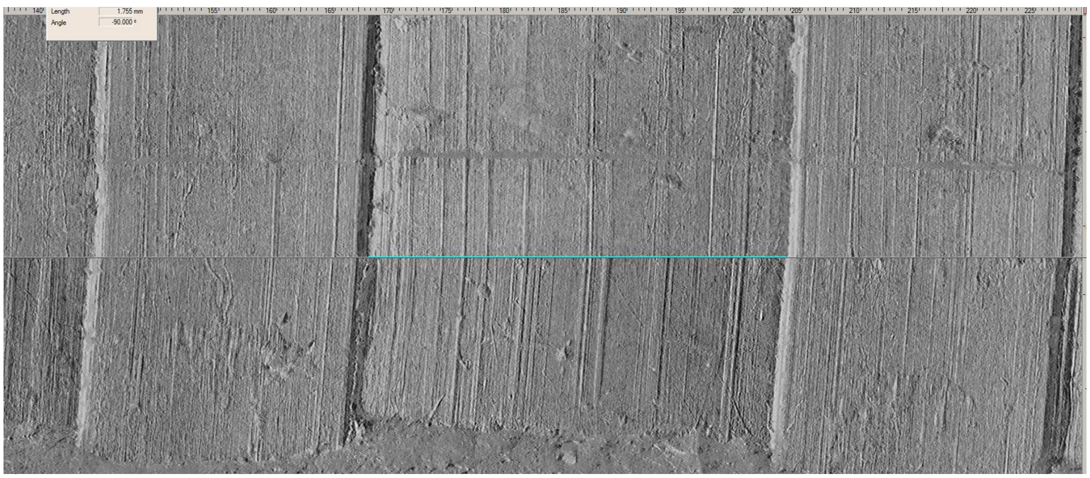

Figure 12b: 150% magnified view of two lead bullets from the Ruger 10/22 rifle with a groove width measurement included

Note: the groove width value is 1.755mm (0.069-in.)

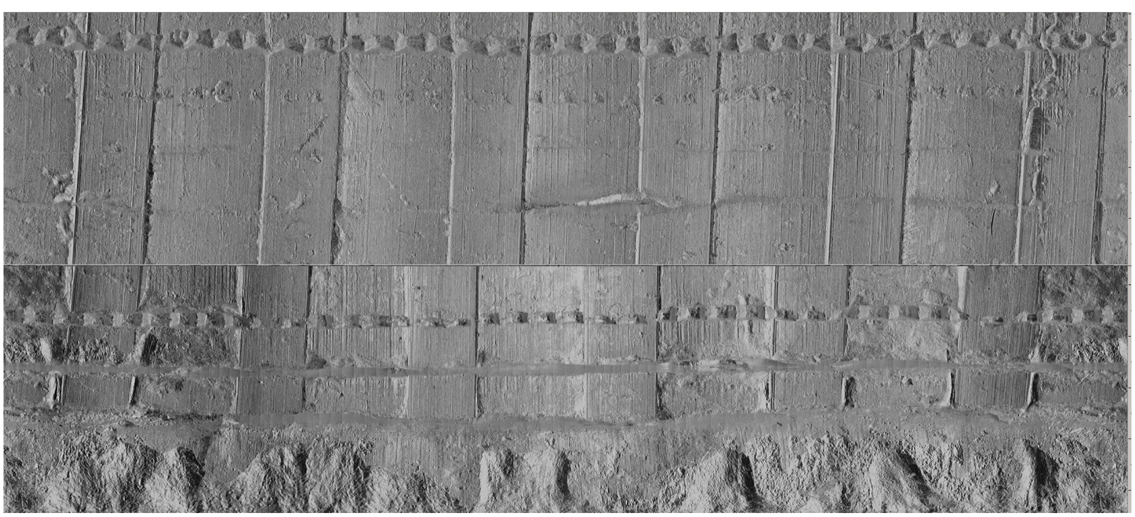

Figure 13: *Evofinder* image of the full bearing surfaces of a lead bullet (top) and a tin bullet (bottom) from the Ruger 10/22 rifle

Note the apparent disparity in land and groove widths between these two bullets

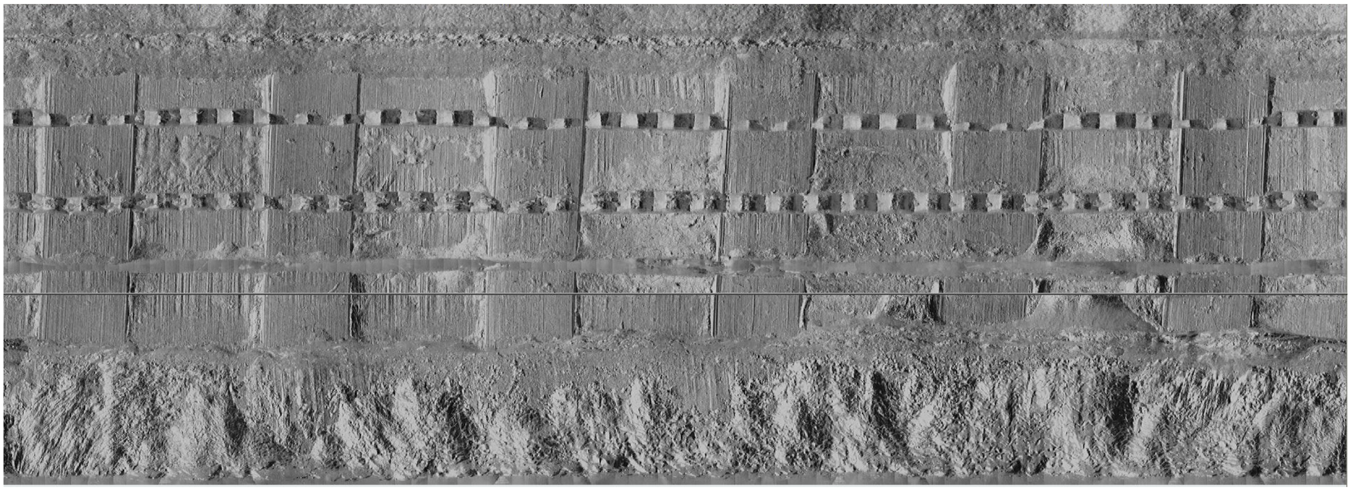

Figure 14a: *Evofinder* image of the full bearing surfaces of two tin bullets from the Ruger 10/22 rifle
Note the gas-cutting at the skirt of the lower bullet

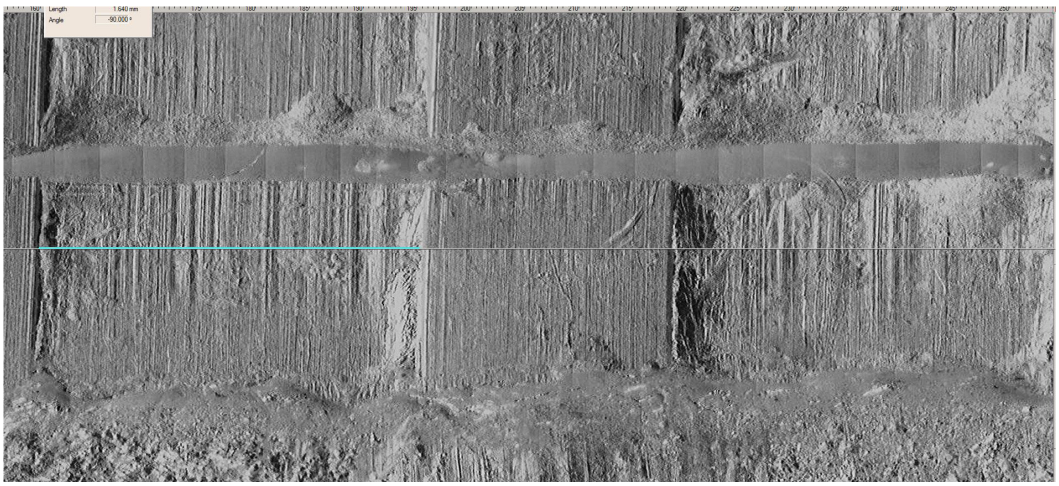

Figure 14b: 150% magnified view of two tin bullets from the Ruger 10/22 rifle with a groove width measurement included
Note: the groove width value is 1.640mm (0.065-in.)

lead and tin bullets from this rifle. **Figure 14a** depicts a full circumference comparison between two tin bullets from the Ruger 10/22 rifle. **Figure 14b** shows a reasonably good striae match between two groove impressions with an added width bar showing a value of 1.640mm (0.065-in.). *No* match was found between lead bullets versus tin bullets fired from the Ruger 10/22 rifle.

Plain lead bullets from the Remington 40X competition rifle followed a similar course as those from the Ruger 10/22. These bullets were sharply engraved by the rifling (See **Figure 15a**), but the only area**s** of matching striae were located in the groove impressions (See **Figure 15b**). A full bearing surface comparison of a lead bullet versus a tin bullet from this rifle depicted in **Figure 16** shows the same sort of disparity as with the Ruger 10/22 (Compare **Figure 13** with **Figure 16**). **Figure 17a** depicts the full bearing surfaces of two tin bullets from the Remington 40X rifle. Tin bullets discharged from this rifle could be matched among themselves, but only by means of groove impressions. An example is provided in **Figure 17b**. *No* match between a lead bullet and a tin bullet was found.

Gunshot Residue Results

The thermal erosion of tin from these bullets upon discharge was also manifested in close-proximity gunshot residue deposits. This phenomenon, and the frequent gas cutting, stand to be a consequence of tin's lower melting point as compared to lead (231.9^0C vs. 327.4^0C). An example is provided in **Figure 18a** and **18b** in which the High Standard *SportKing* pistol was discharged into the filter paper side of a sheet of *BenchKote*® at standoff distances of 9-inches with

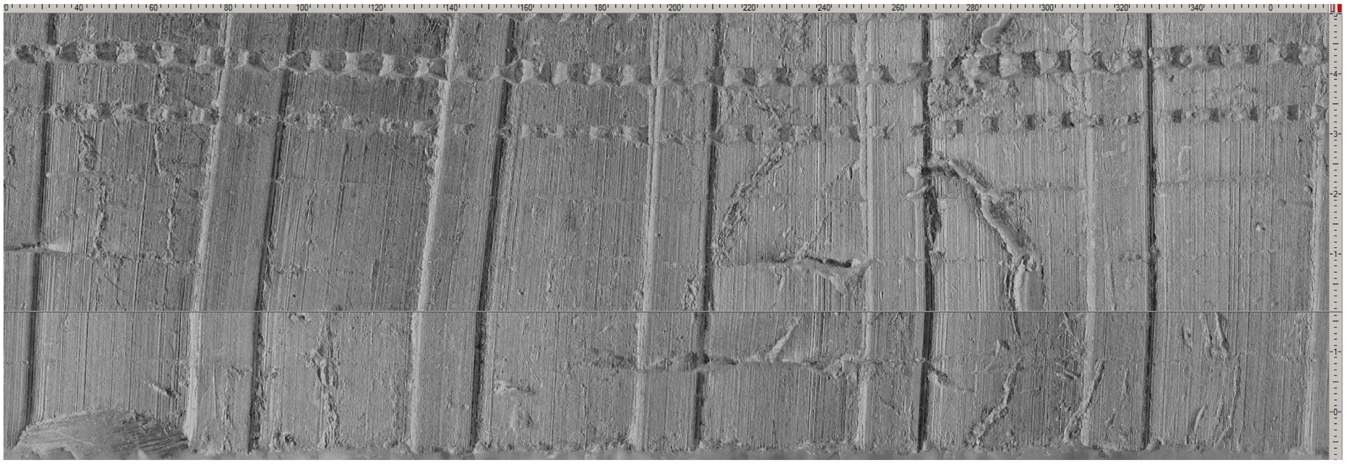

Figure 15a: *Evofinder* image of the full bearing surfaces of two lead bullets from the Remington 40X rifle

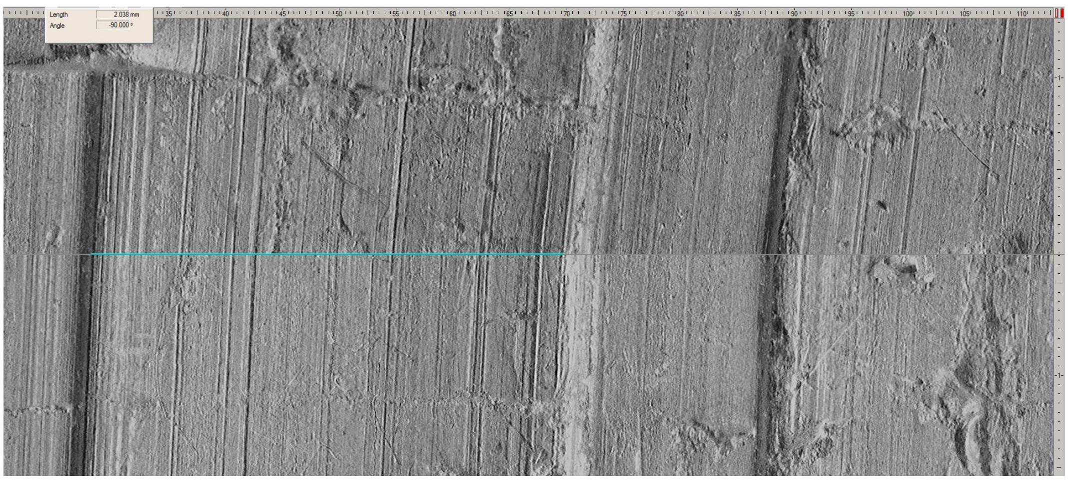

Figure 15b: 150% magnified view of two lead bullets from the Remington 40X rifle with a groove width measurement included
Note: the groove width value is 2.038mm (0.080-in.)

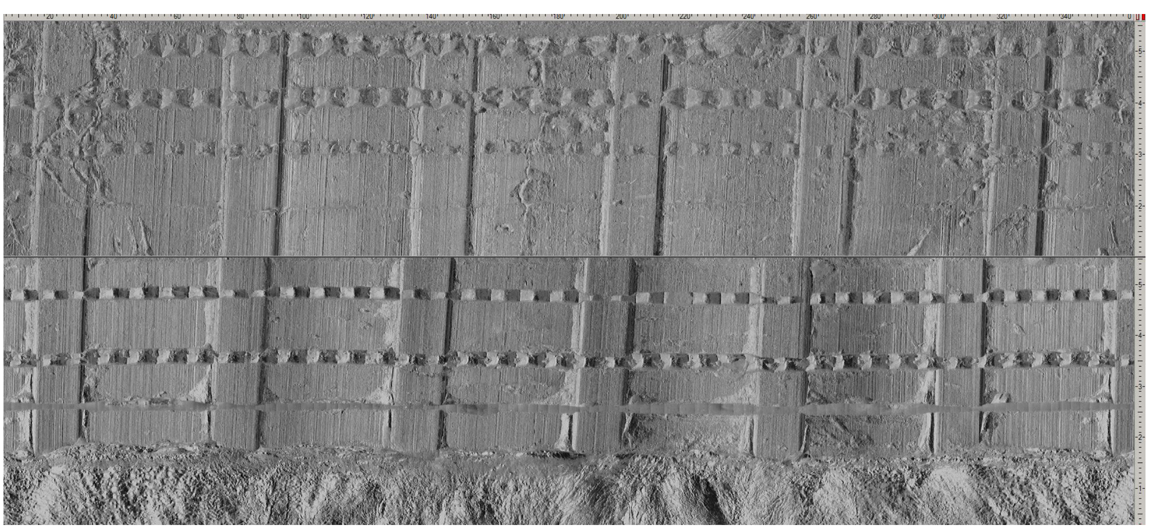

Figure 16: *Evofinder* image of the full bearing surfaces of a lead bullet (top) and a tin bullet (bottom) from the Remington 40X rifle

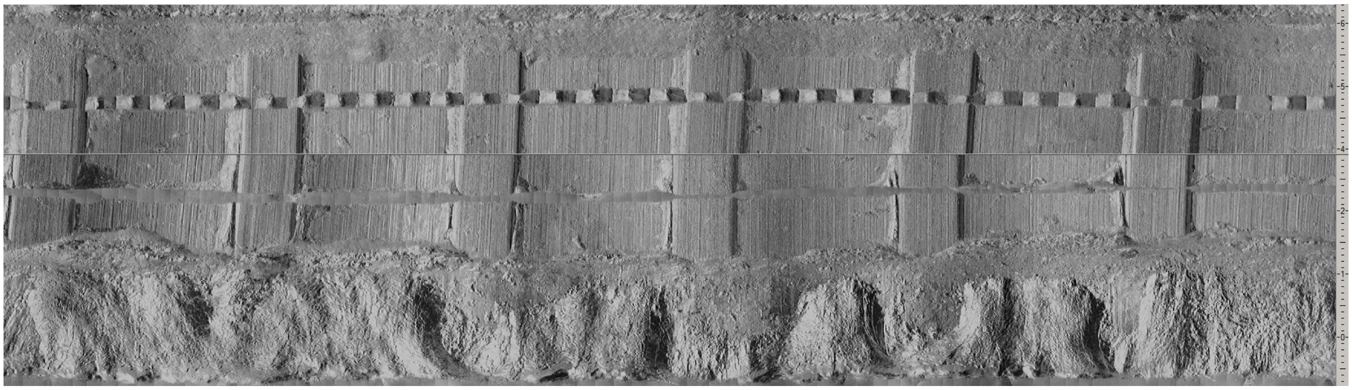

Figure 17a: *Evofinder* image of the full bearing surfaces of two tin bullets from the Remington 40X rifle
Note the extensive gas-cutting at the skirt of the lower bullet

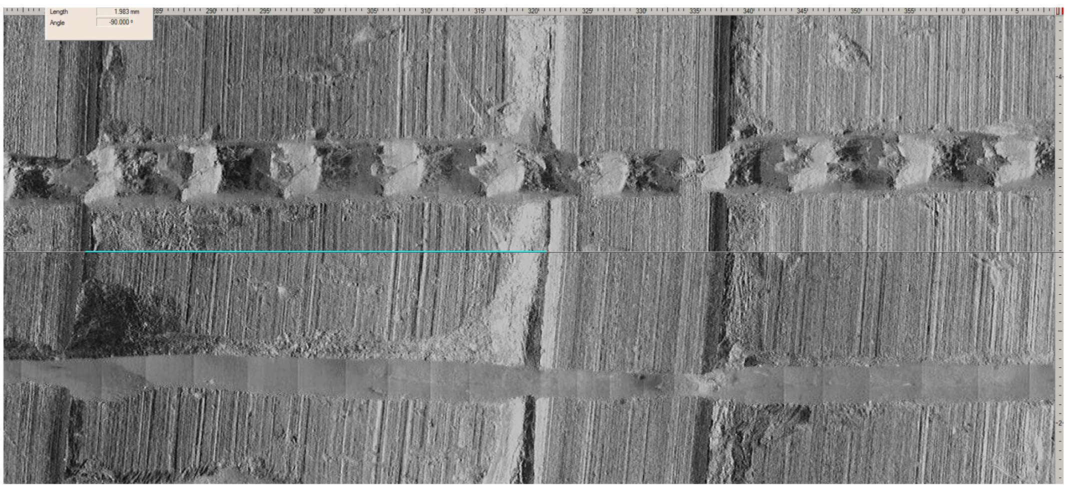

Figure 17b: 150% magnified view of two tin bullets from the Remington 40X rifle with a groove width measurement included
Note: the groove width value is 1.983mm (0.078-in.)

the three types of ammunition previously depicted in **Figure 2**. Three more shots with the same pistol and ammunition were discharged into this witness panel from a distance of 15 feet, so as to only produce bullet wipe. The three close-range GSR deposits and the three rings of bullet wipe from the 15-foot shots depicted in **Figure 18a** were subsequently treated directly with pH 2.8 tartrate buffer followed by the aqueous sodium rhodizonate reagent to produce **Figure 18b**. A careful examination of this latter figure will reveal that only a faint lead-positive response appears in the heavy, grey GSR deposits from the tin bullet, and in the bullet wipe from the distant shot. Closer views of the visible GSR deposits for the *Varmint LF* are provided in **Figure 18c.** These minimal, lead-positive results are likely due to lead from the priming mixture, and possibly 'pick-up' from lead-containing residues in the bore from previous discharges of traditional lead bullets.

This same series of tests was repeated with the Ruger 10/22 rifle with a similar outcome insofar as the sodium rhodizonate test. Lead residues were barely detected, and the soot-like deposits of vaporized tin were somewhat reduced from those produced by the High Standard semi-automatic pistol.

Examination of these vaporous tin deposits under infrared illumination and viewing revealed them to be non-absorptive making them easily distinguishable from carbonaceous deposits.

Regretably, at this time, there is no colorimetric test for tin comparable to the sodium rhodizonate test for lead leaving SEM-EDS as the probable choice for identifying such deposits as vaporized tin.

Observations and Summary

These presently unique .22-caliber bullets from Winchester represent a significant challenge for forensic firearms examiners. These limited tests show that, in some cases, they can be associated with the responsible firearm, but striae engraved on lead bullets failed to correspond to striae imparted to tin bullets discharged from the same firearm. Any hope of accomplishing a definitive comparison for a tin evidence bullet will likely require test-firings with the tin bullets loaded in *Varmint LF* .22LR ammunition. The low weight of these bullets should alert the examiner that he or she is dealing with something very different from a common lead bullet. Making a faint mark on filter paper with the nose of one of these bullets and testing the mark with the sodium rhodizonate reagent will quickly reveal that it is not composed of lead. SEM-EDS analysis will be necessary if verification as tin is required.

Although the muzzle velocity of these relatively light bullets is substantially higher than their lead counterparts, their low ballistic coefficient means that they will lose velocity much more quickly when fired over long distances such as 200 yards or more. This also reduces their maximum range as compared to their lead counterparts. By way of example, the calculated maximum range of the *Varmint LF* tin bullet with a muzzle velocity of 1568 fps, derived from the *Sierra Infinity-6* program, was approximately 1400 yards with a departure angle of 27 degrees. The 40-gr Winchester *Wildcat* bullet with a muzzle velocity of 1257 fps, under the same conditions, traveled just short of 2000 yards with a departure angle of 29 degrees.

Exterior ballistic tracking by Doppler radar showed the 26-gr, *Varmint LF* bullets to be stable in flight, even when fired from handguns which left minimal rifling engravings on the bullets.

The terminal ballistic behavior of the tin bullets when fired into two soft tissue simulants produced a surprise; they did not expand despite the presence of a hollow point cavity, their elevated velocity as compared to the Winchester *Xpert22* hollow point bullets, and their similar hardness to that of lead. The reason(s) for their failure to expand is (are) presently unknown.

Close range gunshot residue deposits possess the usual gray to dark gray soot-like deposits which are normally associated with vaporized lead and/or carbonaceous soot. Treatment with the sodium rhodizonate test for lead will reveal very little, if any lead in these deposits because they are largely composed of vaporized tin. As with vaporous lead deposits, the tin deposits are not particularly strongly absorbed by infrared radiation (IR), and contribute very little to IR images of close-range GSR deposits by these cartridges.

Acknowledgements

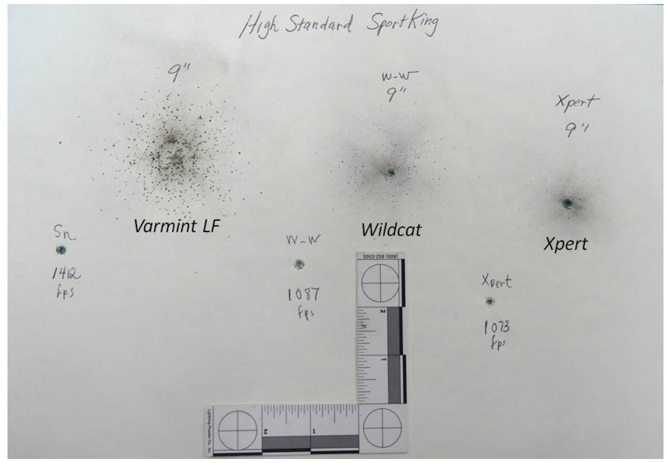

Figure 18a: GSR deposits and bullet wipe from a High Standard pistol

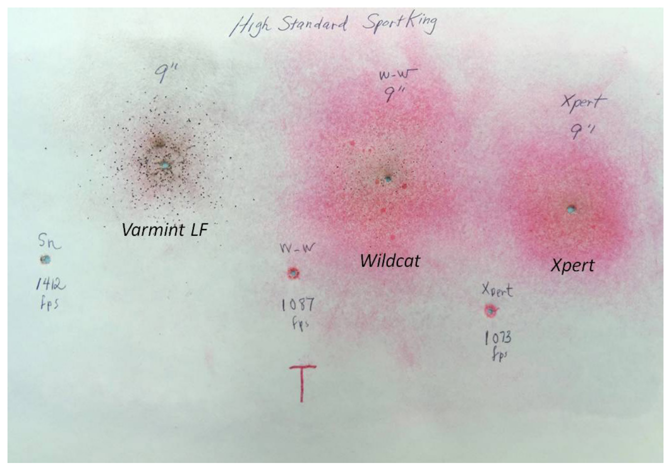

Figure 18b: GSR deposits and bullet wipe after treatment with sodium rhodizonate
Note: the red 'T' is a known lead deposit

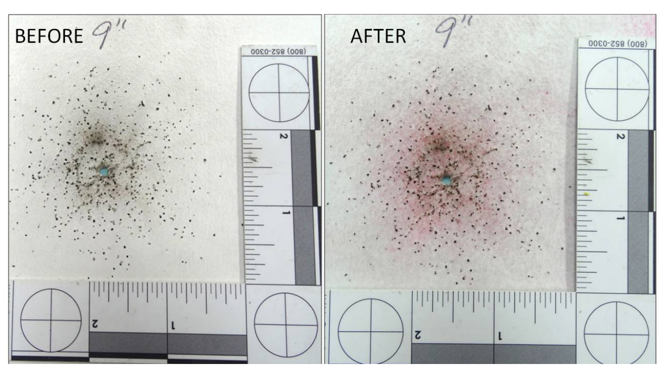

Figure 18c: Winchester *Varmint LF* deposits before and after treatment with sodium rhodizonate
Note: the standoff distance was 9 inches

Thanks are extended to AFTE Technical Advisor, Ed Harris for a current, 50-round box of this unusual ammunition.

Very special thanks and appreciation are extended to Sergey Perunov for his tireless dedication, interest, and participation in this project in which he scanned a large number of fired bullets, only a very few of which were depicted in this article.

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