

A Study of Downrange GSR Deposition as a Function of Firearm Type and Ammunition Caliber

A.J. Schwoeble and W.H. Powers

R.J. Lee Group Inc., 350 Hochberg Road, Monroeville, PA 15146

In cases where close proximity to a discharged firearm is an issue and the case firearm is available, test firings can be performed to show the normal distribution of gunshot residue (GSR) on shooters hands, clothing and on either side of the discharged firearm. Naturally everything is relevant to the positions and distance of the firearm to the body and surfaces in the immediate area surrounding the weapon. The small, round insert at the bottom of a cartridge casing is called the primer or percussion cap and contains a paste or mixture of primer compound. There are three components in the primer compound that play a major role in the formation and identification of GSR. They are: lead styphnate (the initiator), which is set off with a sharp blow, as when the firing pin strikes the primer cap, barium nitrate (the oxidizer), which gives up its oxygen readily to burn the fuel, and antimony sulfide (the fuel), which burns at a very high rate. The purpose of the initial burn is to ignite the gunpowder, which propels the bullet. When the primer mix or paste burns, it exits the firearm in the form of a vapor (plume) through any available opening in the weapon (i.e. around the openings of the cylinder walls, trigger mechanism and hammer area in a revolver and from an automatic pistol out of the ejection port, and trigger mechanism). The gases solidify into fine particles, in combinations of lead (Pb), barium (Ba), and antimony (Sb) and settle on the hands, clothing and surfaces in the immediate proximity of the discharged firearm. Large quantities of GSR are also expelled from the muzzle end of the firearm following the bullet downrange. Figures 1 and 2 illustrate the gases exiting an automatic pistol and a revolver upon discharge.

To show the normal distribution of GSR, the test firings are preformed under static conditions. When a firearm is discharged outdoors there are too many variables to consider to make a reasonable estimate of overall GSR deposition distances. Wind, rain, snow, humidity, turbulent air from moving vehicles and high speed thoroughfares are examples of conditions influencing the movement and deposition patterns of GSR. Firearm and ammunition type and caliber also play an important role in quantity and distance of GSR deposition.

A T-shirt target was mounted vertically with a muzzle to target distance of 25 feet. A polyester/cotton runner 4ft x 25ft was placed on the floor to determine the population of GSR particles settling between the muzzle of the firearm and the target. Four firearms were used to demonstrate the downrange deposition of GSR at a distance of 25 feet. A Ruger .22 caliber automatic pistol, a Colt .32 caliber revolver, a Glock .45 caliber automatic pistol and a Colt .45 caliber revolver were the firearms used in the study. Federal FMJ ammunition was utilized in each of the test firings. Three double backed scanning electron microscope (SEM) stub samplers were used to extract particles from the T-shirt targets. The three particle extraction areas were a 6 inch diameter area around the bullet hole, the right side of the T-shirt, top to bottom and the left side of the T-shirt, top to bottom. The particle extractions of the floor runner were taken in 2ft segments from 0-2ft through 22-24ft.

After the particle extraction from the designated areas on the target and floor runner, the samples were placed in the SEM for automated analyses of GSR. The SEM is set to stop the analysis when the detection of three component (Pb-Ba-Sb) particles reaches 100. The maximum run times vary as needed for each sample, as can be seen in the data (Figures 3 through 6). Many of the sample runs timed out when 100 three component particles were detected without analyzing

the total area of the SEM stub (88.5mm²). Other reasons for timing out would include 10,000 total particles being detected, or a run time of 16 hours being reached. Manual examination of the SEM stubs revealed a uniform distribution of GSR particles over the entire sample area, meaning there were many GSR particles present on the remaining unanalyzed area of the sample. In conclusion the Ruger .22 automatic pistol samples analyzed larger sample areas than the other three firearms, but had a lower number of three component particles detected, especially on the T-shirt target. The .32 revolver, .45 automatic and the .45 revolver sample runs timed out at 100 three component particles on all but one sample (18-20ft/ .45 revolver). All 3 of these firearm/ ammunition combinations timed out at 100 three component particles on the T-shirt targets.



Figure 1. Plume observed around revolver



Figure 2. Plume observed around automatic pistol

22 Cal					
Sample	Sample ID	Area Analyzed	3 component	2 component	1 component
T-shirt Right Side	1007414	88.516	13	215	1357
T-shirt Left Side	1007415	75.871	2	146	874
T-shirt Bullet Hole	1007416	82.193	0	70	299
22-24 Feet	1007417	69.548	71	686	2051
20-22 Feet	1007418	41.649	91	1884	6105
18-20 Feet	1007419	28.194	33	2685	5424
16-18 Feet	1007420	43.047	51	1892	5802
14-16 Feet	1007421	53.193	73	1580	5805
12-14 Feet	1007422	47.758	69	849	5143
10-12 Feet	1007423	70.339	69	921	3288
8-10 Feet	1007424	70.339	77	956	3781
6-8 Feet	1007425	75.871	47	692	2355
4-6 Feet	1007426	41.342	100	773	3899
2-4 Feet	1007427	57.693	75	939	4403
0-2 Feet	1007428	64.701	100	745	4537

Figure 3. Area analyzed and particles found on samples taken form Ruger .22 caliber automatic

32 Revolver					
Sample	Sample ID	Area Analyzed	3 Component	2 Component	1 Component
T-shirt Right Side	1007342	21.99	100	101	826
T-shirt Left Side	1007343	30.901	100	107	910
T-shirt Bullet Hole	1007344	9.406	100	118	731
22-24 Feet	1007345	3.655	100	243	1475
20-22 Feet	1007346	2.334	100	186	1271
18-20 Feet	1007347	2.599	100	188	1201
16-18 Feet	1007348	2.162	100	132	1010
14-16 Feet	1007349	1.896	100	121	999
12-14 Feet	1007350	4.058	100	188	1338
10-12 Feet	1007351	4.106	100	193	1290
8-10 Feet	1007352	4.995	100	176	1416
6-8 Feet	1007353	1.392	100	202	1245
4-6 Feet	1007354	1.327	100	231	876
2-4 Feet	1007355	2.739	100	142	525
0-2 Feet	1007356	5.055	100	153	765

Figure 4. Area analyzed and particles found on samples taken form Colt .32 caliber revolver

45 Revolver					
Sample	SampleID	Area Analyzedmm2	3Component	2 Component	1Component
T-shirt RightSide	1007322	30.39	100	179	991
T-shirt Left Side	1007323	25.202	100	173	826
T-shirt BulletHole	1007324	11.751	100	240	1332
22-24 Feet	1007325	16.797	100	491	3382
20-22 Feet	1007326	9.415	100	586	4794
18-20 Feet	1007327	8.725	85	476	4133
16-18 Feet	1007328	7.926	100	531	4722
14-16 Feet	1007329	6.48	100	362	3013
12-14 Feet	1007330	8.224	100	480	4237
10-12 Feet	1007331	7.757	100	328	2646
8-10 Feet	1007332	9.173	100	339	1910
6-8 Feet	1007333	3.278	100	404	1689
4-6 Feet	1007334	1.934	100	353	1311
2-4 Feet	1007335	5.023	100	433	1169
0-2 Feet	1007336	15.488	100	359	1524

Figure 5. Area analyzed and particles found on samples taken form Colt .45 caliber revolver

Glock 45					
Sample	Sample ID	Area Analyzed	3Component	2 Component	1 Component
T-shirt Right Side	1007388	64.607 mm ²	100	125	172
T-shirt Left Side	1007389	37.115 mm ²	100	77	146
T-shirt Bullet Hole	1007390	28.721 mm ²	100	91	145
22-24 Feet	1007391	10.798 mm ²	100	363	610
20-22 Feet	1007392	7.744 mm ²	100	273	394
18-20 Feet	1007393	4.374 mm ²	100	258	271
16-18 Feet	1007394	4.049 mm ²	100	187	185
14-16 Feet	1007395	4.634 mm ²	100	218	236
12-14 Feet	1007396	5.943 mm ²	100	231	283
10-12 Feet	1007397	6.359 mm ²	100	208	256
8-10 Feet	1007398	2.387 mm ²	100	121	149
6-8 Feet	1007399	2.475 mm ²	100	130	100
4-6 Feet	1007400	0.605 mm ²	100	107	53
2-4 Feet	1007401	4.227 mm ²	100	158	110
0-2 Feet	1007402	11.737 mm ²	100	110	291

Figure 6. Area analyzed and particles found on samples taken form Glock .45 caliber automatic