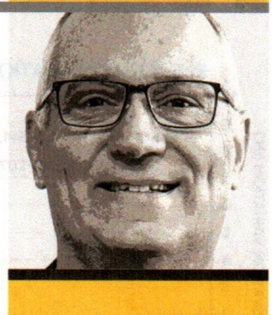
A study of .22 ammunition for ***long-range rimfire*** *shooting.*

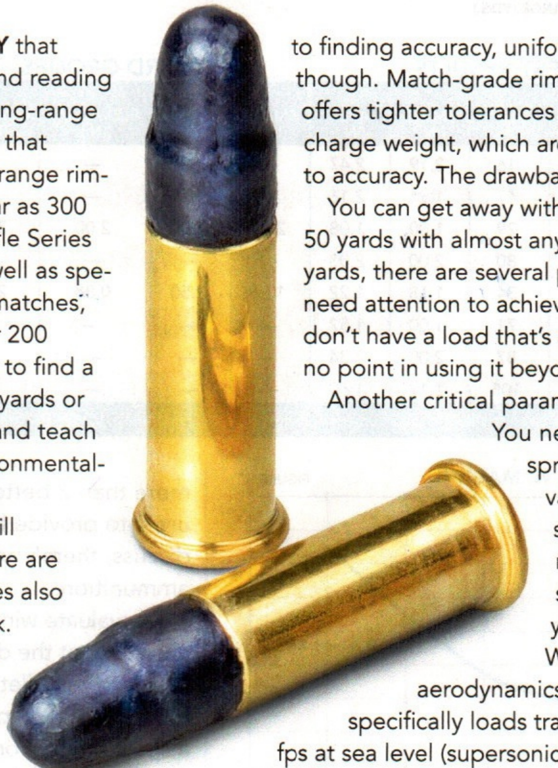


DAVE EMARY

GO LONG!

LOOKING FOR A SHOOTING ACTIVITY that allows you to practice marksmanship, wind reading and long-range shooting techniques? Long-range rimfire shooting is a fast-growing activity that doesn't have to be expensive, and long-range rimfire competitions can test your skills as far as 300 yards! There are rimfire-only Precision Rifle Series (PRS) matches with 300-yard stages, as well as specific National Rifle League (NRL) rimfire matches, for example. Many shooting ranges offer 200 yards, so you shouldn't have to travel far to find a place that allows shooting .22 LR at 200 yards or further. This is a great activity to inspire and teach young shooters marksmanship and environmental-compensation skills.

You likely have a rifle and scope that will work well enough to start. Of course, there are purpose-built long-range rifles and scopes also available, and some won't break the bank. Since the aftermath of COVID-19, rimfire ammunition is once again available in a variety of loads, and much of it is inexpensive. Standard sporting .22 rimfire ammunition currently costs 8 to 16 cents per round. Match-grade ammunition costs 25 to 50 cents per round. (Personally, I enjoy seeing how well I can shoot using low-cost ammunition.) Let's examine some of the technical aspects of ammunition performance and the critical parameters for long-range shooting.



THE AMMO

Shooting a .22 LR cartridge loaded with a 40-grain projectile at 1,250 feet per second (fps) at 200 yards is roughly equivalent to shooting a .308 Winchester round with a 168-grain load at 600 yards. The equivalent when shooting a .22 LR at 300 yards is like shooting a .308 Win. at 1,000 yards. High-quality match-grade ammunition is the shortcut to finding accuracy, uniformity, and consistency, though. Match-grade rimfire ammunition usually offers tighter tolerances for bullet weight and charge weight, which are the primary contributors to accuracy. The drawback is usually its price.

TIME OF FLIGHT VARIATION vs. RANGE: 50 FPS EV FIGURE 1

You can get away with shooting small targets at 50 yards with almost any .22 load. At 100 and 200 yards, there are several performance issues that need attention to achieve predictable results. If you don't have a load that's accurate at 50 yards, there's no point in using it beyond that.

Another critical parameter is velocity uniformity. You need the tightest velocity spread that you can get. This variation is called extreme spread (ES), and it is often responsible for vertical stringing beyond 100 yards.

We need to consider the aerodynamics of .22 LR ammunition, specifically loads traveling faster than 1,116 fps at sea level (supersonic), and loads clocked below Mach 1 (subsonic). The point of impact at longer range depends strongly on the time of flight to the target for each. The common standard-velocity .22 LR load is advertised at a 1,250-fps velocity. Supersonic ammunition is less sensitive to muzzle velocity variations than a subsonic load because the supersonic round has a shorter time of flight and a smaller percentage change in the time of flight for a fixed ES. Let's say we have a 1,250-fps and a 1,050-fps load with the same 40-grain bullet and same 50-fps ES. That 50-fps spread is a 4-percent variation for the supersonic load and a 4.8-percent variation for the subsonic load. This might not seem like much of a difference but consider **Figure 1.** It shows the variation in time of flight for the 50-fps spread for each load. Therefore, time of flight

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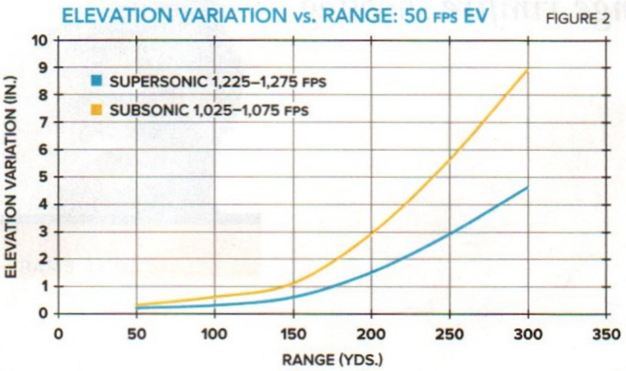
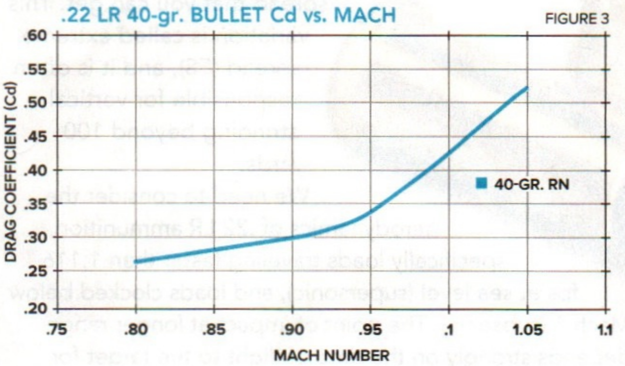


50-YARD AMMUNITION TEST RESULTS / **100-YARD GROUPS**

AMMUNITION	AVG. VEL. (FPS)	EV (FPS)	SMALL (IN.)	AVG. (IN.)	SMALL (IN.)	AVG. (IN.)	ELEVATION (IN.)	WINDAGE (IN.)
CCI Clean Subsonic	1,074	16	2.19	2.47	—	—	—	—
CCI Clean Supersonic	1,173	47	1.94	2.16	—	—	—	—
CCI Green Tag	1,047	29	1.00	1.08	2.88	3.00	2.00	3.00
CCI Mini Mag	1,229	80	2.00	2.03	—	—	—	—
CCI Pistol Match	1,064	34	1.18	1.22	1.56	2.50	0.88	2.50
Federal Auto Match	1,170	71	1.00	1.52	—	—	—	—
Remington Golden	1,183	87	2.00	2.34	—	—	—	—
Remington Subsonic	1,000	105	1.19	1.60	—	—	—	—

Note: Tested using a Ruger American Rimfire Long-Range Target equipped with a Bushnell Engage 2.5-10x44mm riflescope.



correlates strongly to the elevation's point of impact. As you can see from the plot, the subsonic load is more susceptible to time-of-flight variations due to the variations in muzzle velocity.

Figure 2 shows the corresponding elevation variation of the round's impact compared to range for the 50-fps ES. The subsonic load is sensitive to muzzle-velocity variations. You can get away with a lot at 50 yards, but velocity differences between shots will catch up to your potential effective range after that. At 200 yards, subsonic ammunition has about twice the elevation variation for a fixed extreme spread as supersonic ammunition, and it stays that way beyond that. If it were only as simple as finding ammunition with a low-velocity spread!

You must also have ammunition that is accurate. Looking at the graphs, you might think to simply use supersonic ammunition. However, due to the higher probability of bullet distortion — along with the messy aerodynamics as a bullet transitions from supersonic to subsonic speeds — rarely do supersonic loads shoot as accurately as subsonic loads. It's hard to find accurate supersonic ammunition with low ES. It's easier to find subsonic ammunition that's accurate and produces more consistent velocities. This is why most .22 LR-match ammo is subsonic.

Let's compare a supersonic load that shoots 1.2 inches at 50 yards with an ES of 55 fps and a subsonic load that shoots .75 inch at 50 yards with a 35-fps ES. The accuracy of the subsonic load is 1.6 times better than the supersonic results. The ES of the subsonic load is 1.43 times better than the supersonic load's, too. These two factors added together are 3.03 (i.e., 1.6 plus 1.43). In this example, the subsonic load is expected to outperform supersonic loads at long range. The combination of ES and accuracy of subsonic loads should exceed a factor of more than 2 better than supersonic ammo based on Figure 2 to provide better performance. As I'll continue to discuss, there's another good reason to shoot subsonic ammunition.

To evaluate wind drift of .22 LR, as well as trajectory, we must look at the drag coefficient (Cd) versus Mach number for a rimfire bullet. **Figure 3** shows the Cd for a 40-grain round nose (RN) projectile generated by the U.S. Army in a spark range. For calibration, 1,250 fps is Mach 1.12 and 1,050 fps is Mach .94 at sea level.

.22 LR 40-GRAIN RN 10-MPH WIND DRIFT TABLE 1

RANGE (YDS.)	1,250 FPS (MOA)	1,050 FPS (MOA)
50	2.9	2.1
100	5.4	4.1
150	7.6	6.0
200	9.6	7.9
250	11.6	9.8
300	13.5	11.7

This may seem counterintuitive, but a subsonic .22 LR load is subject to less wind drift than a supersonic load. The drag on the bullet, which is the effect that the atmosphere has on a bullet to slow it down, or "drift," drops rapidly below Mach 1. It becomes somewhat stable at about Mach .94. Initially, the drag for a short period of the supersonic flight is much higher than for a subsonic bullet. What happens near the muzzle has more effect on a bullet's drift downrange than what happens near the target. The supersonic bullet, which has a higher initial drag for a given wind value, gets a bigger push from the wind initially than the subsonic load. Therefore, it drifts more. This is a good reason for finding a good subsonic load for shooting .22 LR. **Table 1** shows the wind drift of a supersonic and subsonic 40-grain load in a 10 mph crosswind at sea level; you can see why I suggest that shooting rimfire at long-range is a great way to practice wind reading; the .22 LR round drifts a lot!

When evaluating ammunition, I typically test rimfire loads at 50 yards for accuracy and use a chronograph to calculate muzzle velocity and ES figures. For accuracy testing, I always single-load ammunition to the chamber by hand to eliminate damage to the soft-lead bullet's profile, which can occur when chambering ammo from a magazine. Usually, I get the best accuracy from a subsonic load. Then, I search for the load with the best ES figure. Don't ignore supersonic ammunition, though! If you have an accurate supersonic load, take it out to 100 yards and see how it shoots beyond the transition through the sound barrier. In fact, test them all to see which performs the best in your gun. For long-range shooting, weighing the cartridges to get them all the same weight can provide decreased elevation variances; weight doesn't make as much of a difference for typical .22 LR shooting. After this test, it's up to you as to how much time you want to spend measuring other ammunition parameters as described in "Consistency," my March 2023 column. Typically, shooting match-grade ammunition provides better results. Hence, with a good-shooting rifle and load, repeatable hits on a 6-inch target set at 200 yards is achievable. Wind will be your nemesis.

The only trajectory information that can be found on .22 LR goes to 100 yards. I usually use the online ballistic solver found at jbm.com. Beyond trial-and-error, having a good idea of where to start for scope come-ups saves time and money. Atmospheric conditions are also a consideration, so a weather meter that gives temperature and pressure is essentially required for accurate trajectory calculations. My weather meter is a Kestrel (kestrelballistics.com). A supersonic load goes subsonic around 45 to 50 yards. At 300 yards, about 85 percent of the flight is subsonic, which can be seen in the Cd vs Mach number curve from **Figure 3**. Realizing that most of the .22's flight is subsonic, we need a drag function that will match the Cd curve as close as possible — especially subsonic. The GI (i.e., the Ingalls drag function that's available in the JBM solver) matches better than about any other drag function I could find. **Figure 4** shows a 40-grain .22 LR bullet's Cd versus Mach number and several popular drag functions. My own shooting experience has demonstrated that a GI BC of .120 is accurate. This varies a little depending on the specific bullet shape.

I calculated the BCs from the Cd data results using a GI BC of .120; G1 of .126; and G6 of .087. Again, I use the GI BC with the JBM solver, which has given me accurate results. I would stick with either the GI or G1 BC for trajectory calculations. **Table 2** shows the 300-yard sea-level trajectory for supersonic and subsonic 40-grain loads with a GI BC of .120 and a 100-yard zero.

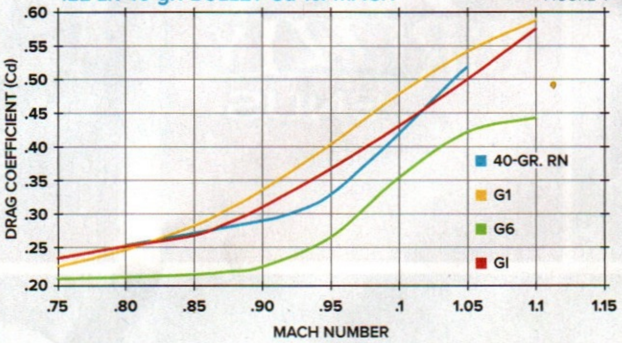
The quality of ammunition matters more when shooting at ranges beyond 50 yards where "match grade" proves its worth.

TO BE CONTINUED …

Part 2 of this topic details long-range rimfire shooting even further. Next, I will focus on equipment, including rifles and scopes. We will also examine my recent results from testing several currently manufactured .22 LR options. G&A

.22 LR 40-gr. BULLET Cd vs. MACH

FIGURE 4



.22 LR 40-GRAIN RN SEA LEVEL TRAJECTORY

TABLE 2

RANGE (YDS)	ELEVATION (MOA)		WINDRIFT (MOA)	
(FPS)	1,250	1,050	1,250	1,050
50	5.2	7.2	2.8	2.1
100	0.0	0.0	5.3	4.1
150	-7.2	-9.2	7.5	6.0
200	-15.6	-19.6	9.5	7.9
250	-25.1	-31.2	11.5	9.8
300	-35.5	-43.8	13.4	11.7