

WHITE PAPER REPORT REGARDING ELEVATION EFFECTS ON SPORTING AMMUNITION

It seems that nearly everyone who is passionate about shooting and hunting --especially long-range, precision shooting-- will tell you that elevation effects ammunition. The specific effect is that your rifle's zero will change and shot groups will expand. What many shooters do not understand however, is the cause of these effects. Understanding the cause will not only make the shooter more knowledgeable but also more effective. To understand the cause then, we need to examine the root of the problem and ask *why* does elevation effect ammunition?

The answer is simple. As you might guess, various environmental factors play a role. They are air density, temperature, and humidity. By increasing elevation we decrease air density (relative to that found at sea level) and decrease air temperature. The latter factor, humidity, is effectively inconsequential and will be dismissed from further discussion. Air density and temperature, on the other hand, demand further investigation.

The reason temperature changes (reduces) as elevation increases is because there are fewer air molecules to excite, absorb and retain heat from the sun. In essence then, reduced air density accounts for the reduced temperatures witnessed at higher elevations. Simple enough right? In fact, we could go so far as to say that air density --and not really elevation-- causes the observed shift in zero and expansion of shot groups. But how?

One way is the effect of temperature on the burning rate of powder. Today's modern shooter however will find this inconsequential as an increasing number of temperature-compensated powders are becoming available. The use of these powders does not negate all the effects of varying air density though. As noted earlier, decreased air density simply means there are fewer air molecules. Besides effecting thermal dynamics, the scarcity of air molecules also means sound travels more slowly. This effectively shifts what is called the "transonic region"... the region along a bullet's flight path where it breaks the sound barrier as it decelerates. The transonic region is no small matter to a bullet. Looking at the mach-drag coefficient graph (figure 1) we notice a pronounced spike in drag that peaks where mach = 1.0. Mach, of course, is the speed of sound regardless of the exact velocity of sound.

To compare apples with apples, let's put mach and the transonic region into familiar shooting terms. The speed of sound ranges from 970-1120 fps at elevations of 10,000 feet to sea level, respectively. For the average shooter, most rounds will be fired from sea level up to perhaps 8,000 feet in elevation. In this case, the speed of sound ranges from 1000-1120 fps. The transonic region is roughly 70-110% of mach. For the shooter this means 700-1100fps at 8,000 feet in elevation or 784-1232fps at sea level. Let's simplify this to be conservative and make it easier to understand. Therefore, let's just say the transonic region is 700-1200fps. Now, when is your rifle's bullet travelling through the turbulent transonic region? It obviously is going pretty slow and consequently occurs at long range. In fact, when I referred to an ammunition makers ballistics tables I found only the .30-30 Winchester and .458 Winchester Magnum entered the transonic region at ranges <500 yards. All other rifle cartridges passed through the transonic region at ranges of 500 yards or beyond. Let's be realistic here folks. How often do you shoot your .30-30 beyond 400 yards...or even beyond 200 yards? How much of our shooting occurs beyond 500 yards with a .30-06? The transonic region for a burner like the .220 Swift is perhaps 700-800 yards (the manufacturer's table did not even supply data beyond 500 yards). Ok, I have probably made my point...yes, I will concede that air density does effect a bullet. However, the effect takes place at such long range that it may be ignored by nearly all shooters all the time!

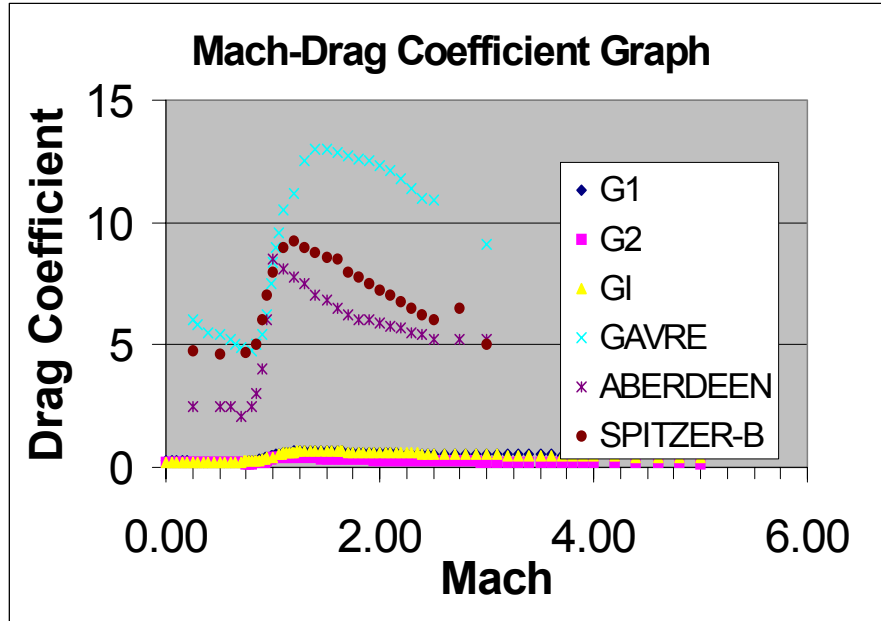


Figure 1.: Mach-drag graph and transonic region "spike".

How does varying air density effect your rifle's zero? Primarily, this is associated with the change in velocity due to temperature. The expansion effect on your shot groups can be attributed primarily to the thinning atmosphere and at long range, the transonic region.