# The Los Angeles Silhouette Club

## Lubricating Cast Bullets

By: Glen E. Fryxell



OK, I'm going to ask a stupid question. What does bullet lube *do*?

I'll bet most of you answered that bullet lube lubricates the passage of the bullet down a rifled bore, to eliminate galling of a soft metal as it traverses a hard metal cutting edge. Well, yeah, I suppose that's true enough, but that's not all it does, nor is it necessarily even the most important job that it does. Let's assume for the moment that lubrication is the sum total of its job -- is the lube on a given bullet lubricating the passage of the bullet that carries it, or the bullet that follows after it? Another way that I've had this question posed to me was, should the lube groove (s) be on the front of the bullet (where they could lube the passage of that bullet), or towards the rear of the bullet (where they could leave a healthy lube film for the next bullet in line)?

Part of the problem with this line of reasoning is that it assumes that the lube is delivered to the bore by simple bullet/barrel contact and smearing, and hence the lube can only lube that which is behind the reservoir (lube groove). Looking at things in this manner results in a fairly simplistic, almost static picture (hard surface, soft surface, slippery stuff in between), and the firing of a revolver shot is a very dynamic process. What *else* does bullet lube do? Or perhaps more accurately, what else is done *to* the bullet lube?

Let's just set the record straight, lube is not simply smeared from the lube grooves onto the bore, nor is lubrication the sole function of bullet lube.

There were a couple of excellent articles published a few years back in The Cast Bullet on lube pumping mechanisms. In a nutshell, the conclusions were that bullet lube was pumped to the bore surface by 3 different mechanisms -- compression, linear acceleration and radial acceleration. In compression, the force applied to the base of the bullet causes the compression of the bullet's core underneath the lube groove, resulting in expansion of the core diameter and shrinkage of the lube groove width. Both of these factors results in the reduction of the volume of the lube groove itself, and hence compress the lube and force it to the bullet/barrel interface. There is solid physical evidence supporting this mechanism (especially in rifles). The linear acceleration mechanism is pretty straightforward -- the inertia of the lube at rest causes it to be forced towards the rear of the lube groove as the bullet is accelerated forward by the burning powder. When the lube encounters the beveled (or radiused) rear face of the lube groove, it is once again forced to the barrel surface. In the third lube pumping mechanism, radial acceleration, as the bullet begins to spin faster and faster as it progresses down the barrel, at some point sufficient radial acceleration (think "centrifugal force") is generated to overcome the viscosity of the lube and it gets flung off of the lube groove surface and outward onto the barrel. All three of these mechanisms come into play when any cast bullet is fired, although the magnitude of each will vary significantly with the application (e.g. .38 target wadcutter vs. .30-06 or .45-70 hunting load), and will be dependant on velocity, pressure, alloy hardness, bullet diameter, etc. Indeed, the magnitude of each will vary for any given shot, depending on where the bullet is in the barrel -- linear acceleration will be dominant early in the shot, compression will take over as pressure peaks and radial acceleration will become more significant as the velocity increases.

Delineation of these mechanisms provides a significant level of understanding in terms of cast bullet shooting and design, as well as bullet lube formulation. However, these mechanisms still have the bullet serving as nothing more than a brute-force paintbrush, slapping on a fresh coat of grease of the bore for the next bullet in line. This is all well and good, but it is an incomplete description of the process. I believe that there is another mechanism operating, one that accentuates a second and perhaps even more important role that bullet lube serves.

Back in the 50s and 60s, some very knowledgeable Handloader's performed extensive tests to understand what made the best bullet lube and why. One of the more notable efforts in this area was the work done by E. H. Harrison of the NRA Technical Staff. These results were originally published in the American Rifleman, and were subsequently reprinted in "Cast Bullets" by E. H. Harrison, and available through the NRA (buy this book if you don't already have it!). The most important property of the lube formulation was found not to be the inherent lubricity of the mix, but rather its flow properties (we will return to this shortly). It is interesting to note that Mr. Harrison was singing the praises of moly loaded bullet lubes back in the 1950s. It seems "the wheel" has been rediscovered…

Why are flow properties important? Most barrel tolerances are generally good to less than .001", where can the lube flow *to*? As the bullet undergoes the violence of being engraved by force, if there is *any* slippage or variation in groove/land width, this will result in there being a gap between the trailing edge of the land and the groove engraved in the bullet's face. Gas molecules are very, very small things, and at the temperatures and pressures of burning powder they're buzzing like an angry swarm of hornets.

Even a gap between the trailing edge of the land and the engraved groove of the bullet of only .001" will leave enough room for over 50,000 of these gas molecules to line up "shoulder to shoulder" and still not bump into the outer boundaries of the gap. The point of bringing all this up is to show how easy gas leakage is through this sort of defect channel, even though at first glance it appears to be quite small. In addition, there are similar (somewhat smaller) channels on the grooves and lands, left over from the machining processes that gave rise to the rifling, and these defects also contribute to potential gas leakage. Gas pressure rises much faster than the bullet is accelerated, so therefore as the bullet's surface is ravaged by the lands and gas leaks past the base band, the lube reservoir becomes pressurized, with the gases entering from the rear and pushing forward. This rapid pressurization forces the lube to flow into the defect channels in the engraved driving band in front of the lube groove, sealing off the gas flow and limiting the damage due to gas cutting. If the cast bullet is appropriately sized, then this controlled injection forms a floating pool of lubricant that follows the bullet down the barrel, lubricating the bullet/barrel interface and sealing the high-pressure gases. Kind of a ballistic stop-leak, if you will.

This is why some of the new hard lubes perform their best at higher pressures. Gas leakage into the lube groove melts the lube, and the liquid lube then gets forced into the microscopic defect channels ahead of the groove. Some of the commercial hard lubes work just fine at 800 fps and 1300 fps, but at intermediate velocities or say 1000 fps, they lose some of their shine. At the lower velocities/pressures there are few demands placed on the lube, and these can be addressed by simple frictional smearing of the lube displaced from the lube groove by the land. As the pressures/velocities rise into the intermediate range (+P level, 20,000 psi, 1000 fps) however, the mechanisms outlined above can't pump the hard lube to the bullet/barrel interface fast enough to keep up with the lubrication/sealing demands of the system, resulting in leading and poor accuracy. As pressures/velocities climb into the magnum level (35,000 psi, 1300+ fps), enough hot gases are injected into the lube groove to melt some or all of the hard lube, allowing all of the lube pumping mechanisms outlined above to come into play, resulting in effective lubrication. These high-pressure gases also cause the molten hard lube to be injected into the defect channels in the forward driving bands, thereby sealing off gas cutting. Lube pumping and high-pressure injection cannot take place efficiently until a hard lube melts. For a soft lube, it's not necessary to melt the lube for this injection to happen, the soft lubes are capable of flowing from the start, which is why they lubricate cast bullet revolver loads effectively across the entire range of velocities from 600-1500 fps. The commercial hard lubes are well-suited for magnum revolver and rifle cast bullet velocities.

Undersized cast bullets leave a gap between the bullet and barrel, leaving them unable to restrict this pressure-induced lube flow. As a result, the lube very quickly gets blown out of the barrel in front of bullet, leaving the bullet "naked", un-lubricated and unprotected. This phenomenon is especially problematic with the hard lubes; once molten, the low viscosity liquid lube gets blown out rapidly if the bullet is undersized. Concerning the flow properties vs. lubricity issues cited above, E. H. Harrison explored the use of molybdenum disulfide (aka "moly") as a bullet lube back in the 1950s. He found that dry moly was inadequate as a bullet lubricant for .30-06 loads at 2000 fps, but that when it was incorporated into a more traditional grease/wax lube formulation, that it worked quite nicely indeed. By incorporating moly into a soft lube, the desirable flow properties of the lube are maintained, as is the ability to leave behind a moly coating on the barrel. This moly coating serves to protect the bore from oxidation, in addition to serving as a lubricant, preventing adhesion of leading deposits. More recently, a lot of work has been done looking at hard-cast bullets dry coated with moly, and this has been found to work nicely for routine handgun velocities in the 800-1000 fps range. These observations reinforce the conclusion that simple lubrication is sufficient at lower velocities, but as pressures and velocities climb, the role of bullet lube is also that of a fluid gasket to seal the bullet/barrel interface.

In summary, bullet lube is pumped from the lube groove to the barrel surface by compression, linear acceleration and radial acceleration. In addition, lube is injected forward during the firing process, as the result of high-pressure gas leakage into the lube groove. This injection process forms a floating fluid gasket around the bullet, and serves to limit gas cutting and is a kind of ballistic stop-leak. Hard lubes must first melt before they can be pumped or injected by any of these mechanisms. By incorporating Moly into the mix, the lube delivered to the barrel surface can serve to prevent adhesion of future leading deposits by passivating the steel surface.

- Glen E. Fryxell



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