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REGULAR

ARTICLES

- **Cover:** The action in the cover photo was an old one with new side plates, created by the German master engraver, Hendrik Frauehauf. He used the hand tools in the picture in the pre-WWII style of Suhl and Sauer and Son, to engrave this work of art.

- **Cover photograph:** YVDM • **Cover design:** Nadia du Plessis

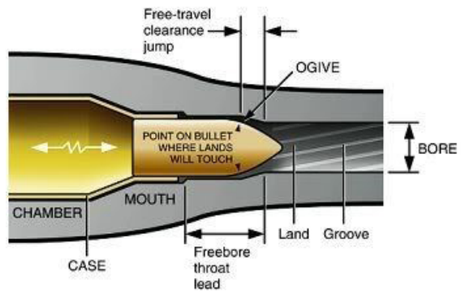
CHRIS BEKKER

Bullet seating depth and its effect on accuracy

The reason why hand-loaded ammunition is far better than factory ammunition is that once you have developed an accurate cartridge, you can constantly reproduce it. Factory ammunition can vary greatly in performance because factory-made cartridges have to be manufactured to general standards to fit all factory-made rifles.

In the context of this article, we assume that your rifle platform is stable and sound, the scope has been fitted correctly, all screws are tight, there are no pressure points on the barrel, the bullet weight is in line with the twist rate of the barrel, and that you are shooting for a best group through a clean barrel.

First of all, clean the barrel of metal fouling before firing for a group size. This simple procedure has turned many a fouled barrelled rife into a respectable 1-MOA hunting rifle. Use a copper-removing solvent and then your preferred solvent for final cleaning.



Chamber Diagram.

Barrel and chamber precision

When the chamber is being cut, its centre must be such that it lies concentrically to the bore of the barrel. I have seen rifles with oval cut chambers and they are bad. This condition cannot, by any means, be rectified. Also, since factory chambers are cut "loose", the bullet never lies 180 degrees with the centre of the bore. Bullet engagement into the rifling of the barrel may upset the bullet's centre of mass to a degree of 'skewness' and so hurts the bullet. This is why custom-made target rifles have tighter cut chambers.

Target or match grade barrels are far more precision-made than mass-produced factory hunting rifles, and so it stands to reason that they will give better accuracy. Their tolerances are much finer, their bores have been lapped to a very fine finish to counter fouling and their perfectly cut crowns concentrically deflect the exiting high-pressure gas, to avoid an induced wobble on the bullet.

Admittedly, factory barrels have improved quite a lot over the last 20 years, but they are still not match grade barrels. The barrel is the heart of any rifle, and if it is a dud, precision loading with match bullets will be to no avail.

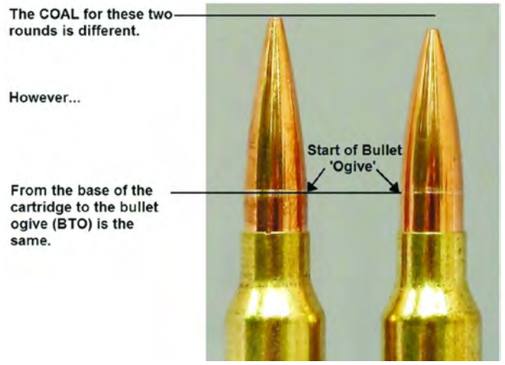
Reloading doctrine

In the context of this article we also assume that you have been following sound reloading practices in terms of case preparation, ensuring that all cases and bullet weights are the same to minimise variances, consistent charge weight in all cases, etc. In all load development exercises, one will have to experiment with different charge weights and is normally the very first thing to do.

Precision reloading is required if you want to shoot your best groups. That in itself demands a separate article to do justice to this aspect as it entails a lot of detail that cannot be dealt with here.

Mass-produced hunting bullets vs match grade bullets

It stands to reason that match grade bullets are made with more care and thus greater precision with more even jacket material, for instance like J4. This ensures that the bullet's mass distribution is more even, so as to avoid what we call "bullet imbalance". Mass-produced conventional lead-core hunting bullets may not be 100% balanced, due to varying thickness of the jacket material, and so it does play a minor role, but it is not a serious impediment for most hunting scenarios at practical hunting ranges. Just be aware that a bullet with inherit bullet imbalance will increase the dispersion on the target.



Two bullets with different ogive shapes, seated to the same CBTO, but having different COALs.

The bullet and its ogive shape

Measuring the Cartridge Base to Ogive (CBTO) dimension is what counts and not the CAOL, as bullet shape in terms of the shape of the ogive will determine how far you can seat the bullet of the rifling.

Bullet shape - secant vs tangent ogive.

It is a proven fact that ogive shape can affect the accuracy of a rifle. The more common "tangent ogive" bullets, like Sierra Match Kings, are less sensitive to seating depth than "secant ogive" bullets and VLD bullets. VLD bullets just have more aggressive secant ogives, and because the curve of a secant ogive bullet meets the parallel part of the bullet quite abruptly, it does not self-align in the throat as well as a bullet with a tangent ogive.

However, both styles can shoot just as accurately, but one is more sensitive to seating depth than the other. Berger makes a projectile called a "hybrid" and this has a long secant nose that then becomes a tangent, just as it meets the parallel part of the projectile. The Tangent portion provides a better alignment into the bore, while the Secant design allows for a very long nose, which gives it a higher ballistic coefficient.

Bullet weight, bullet length and ogive differences

Shooting short bullets in long-throated cartridges, such as the 7x57 mm, 7x64 mm and the 9,3x62 mm, is not ideal, as the bullets are too short to come close enough to the rifling. Typically, these cartridges have been designed to shoot the heavier and longer bullets with higher sectional density. Conversely, the very long and sleek bullets, like VLD bullets, need to be seated so deep into the case that it could fit into standard factory magazines for hunting rifles, and due to their sharp secant ogives, these bullets are still too far away from the rifling – not an ideal situation!

Various .30 caliber bullet brands and weights.

Ideally, a bullet should fit the chamber like a hand fits a glove. What you want, is that the bullet is not seated too deep to rob powder space, but are fully supported by the full neck length in terms of neck-tension to hold the bullet firmly in place, whilst still be adequately long for the bullet to be positioned close enough to the lands for a shorter jump. This is why the traditional bullet weights with tangent ogives fit so well in most hunting rifles. It then follows that each cartridge chambering will have an ideal bullet length from its base to its ogive datum point.

Once fired cartridge cases

When you are reloading, a common starting point is to use once fired factory cases that have been fire-formed in the chamber of your rifle. There are immediate benefits in using a case that has been fired by your rifle and shaped to your rifle's chamber if you opt for neck-sizing, rather than full-length sizing, as it improves bullet line-up.

Bullet run-out

Concentricity is everything in both reloading ammo and the way your rifle has been made and assembled. In this instance, a bullet seated in the case's neck that has ideally no run-out or minimal run-out of less than 1-thou (0.001") and a bullet that lines up perfectly with the bore.

The Hornady Lock-N-Load Ammunition ConcentricityGauge is the first tool on the market to both identify and eliminate bullet run-out. Bullet run-out can be caused by several different variables in the reloading process and can affect the accuracy of loaded ammunition. By identifying bullet run-out and eliminating it, ammunition becomes more consistent, which leads to better accuracy. Just place a loaded cartridge in the tool, roll it and identify run-out on the dial. Once run-out is identified, the dial indicator is used to adjust run-out to zero. This tool will work with both reloaded ammunition and factory ammunition to eliminate bullet run-out.

What is the correct seating depth vis-à-vis the lands or rifling of the barrel?

This is a question that is often asked: what is the proper seating depth for bullets? The truth is there is actually no conclusive answer to this question. Each rifle rig is different from the next one. Various calibres have been chambered to different tolerances and dimensions and even custom throated to suit certain target bullets. It is all about what makes a particular rifle shoot best.

Most target shooters believe that a rifle shoots best when the bullet is near or touching the rifling. We need to be mindful that when the bullet is touching the rifling or lands, it will increase the peak pressure significantly, as the bullet does not have the benefit of some inertia before it hits the rifling, which should be seen as some sort of an

Hornady Lock-N-Load Ammunition Concentricity Tool.

obstacle to overcome. Generally, but not always, we find that if a bullet is too far off the lands that groups open up, and that may be due to a bullet that does not enter the rifling perfectly square or perpendicular, and so got hurt, and which in turn, now causes an unwelcome yaw when it leaves the barrel.

In handloading, we have the ability to play with seating depth or how far we prefer to be off the rifling, which means that we can experiment to find a position of seating depth where the bullet suits your rifle's chamber. Factory rounds are intended to fit all rifles of that particular calibre, and so the bullet jump to the rifling is generally larger to fit the magazines of all brands of rifles to be on the safe side.

Measuring the bullet's distance from the rifling

Before we can experiment with bullet seating depth, we need to determine the cartridge's overall length in terms of where the bullet's ogive contacts the rifling. Several methods can be used to establish this length, but for simplicity, I will confine myself to the oldest and most commonly used method.

One method is to make up a slotted cartridge case with a bullet, seated by hand, in a sized case with no primer or powder. Carefully chamber the dummy cartridge slowly into your rifle so it could push the bullet against the rifling; then extract it slowly without ejecting a flying round. Touching marks should be visible on the smoked or coated bullet where the rifling engraved it.

Cartridge case with a slotted neck.

With definite rifling marks on the bullet, turn in the seating stem on your seating die a quarter- to a half-turn to seat the bullet deeper. Keep chambering (and if need be, applying a new coat of soot) until there are ever-so-slight marks of the rifling on the bullet. Measure the cartridge length, and that OAL is where that bullet contacts the beginning of the rifling of that rifle.

The importance of bullet seating depth in terms of safety

The overriding concern is always safety. Don't look for trouble by trying to seat too close to the lands!

Always start a little bit further off the rifling - you can always seat the bullet closer later. The reason is that the dimensions of bullets of the same brand and lot are not made the same. They invariably differ in how the ogive is formed, and so they are not consistently similar. Also, seating depth is extremely difficult to keep within a variance of less than .002", even with the best-case preparation routine and the use of competition bullet-seaters.

Adjusting the Seating Depth

Barnes, with their mono-metal bullets, recommends .050" [1.27 mm] of the lands, not as close as .005" [0.13 mm] and that should tell you something. With conventional bullets, it is better to back off .020" [0.5 mm] or .030" [0.76 mm], and work up a good hunting load and vary the seating depth by say .005" closer each time to the lands to tweak for accuracy, even down to .010" [0.25 mm] as a minimum.

Another more conservative rule of thumb that has been recommended as a start was 1mm for conventional lead-core bullets and 2 mm for mono-metal bullets.

Once you figure out where the ogive is in relation to the rifling, you will need to decide, as a starting point, how far to back off from the rifling, and at this point, you can start to adjust the seating depth of the bullet and load your first rounds – perhaps 4 lots of 5 rounds each with different charges, but all of them with the same seating depth.

Having shot your groups and examining the accuracy obtained, you can now decide which lot gave you the best group, and should you be happy with the group, then you can again load the same charge but vary your seating depth – typically getting 0.005" closer to the rifling and go from there. Keep on adjusting the seating until you find the bullet seating depth that gives the best accuracy in your rifle.

The magazine can be a limiting factor

Also, your loaded bullet should be at least .030" shorter than the magazine length for smooth functioning. Many a time your magazine becomes the limiting factor. This is nowadays more prevalent with long sleek bullets such as Berger's VLD bullets that are being used in hunting rifles with standard magazines rather than single-shot target rifles for which VLD bullets were designed.

My advice is that Semi-Spitzer bullets with tangent ogives are more preferable for hunting rifles out to 400 yards. They do offer enough sleekness or a high enough ballistic coefficient. VLD's come into their own at extreme ranges such as in a 1,000-yard competition matches. Since tangent ogive bullets are more forgiving in seating depth variation, Berger Bullets launched a newer "Hybrid" design, which has a tangent ogive where the ogive meets the bullet bearing surface, that switches over to secant profile as the ogive starts to narrow.

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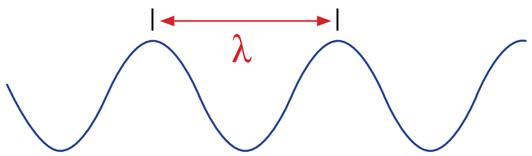
The effect of playing with the seating depth

By varying the seating depth until we find the best distance from the rifling, what you are doing is to make the bullet exit the barrel at the "sweet spot" in much the same way that barrel-tuners work. A bullet that exits the muzzle at either a peak or valley of the harmonics curve will be consistently more accurate than one exiting on the way up or down from the peaks. This is how it was explained to me:

The moving bullet causes a "whipping" motion to the barrel, even though it is impossible for the eye to see this phenomenon. This is the barrel's harmonic response to the forces imparted on it. Shorter and thicker barrels are affected less than longer and thinner barrels, but they all exhibit this behaviour. We need to recognise this effect on accuracy, being important to those who want to maximize their rifle's accuracy.

By adjusting the seating depth of the bullet, the chamber pressure is changed, as well as the distance that the bullet must travel before it exits the muzzle. These factors will affect the barrel's harmonic response, as well as at what point in the vibration pattern the bullets leave the muzzle.

Barrel vibrations that travel from the chamber after ignition, to the muzzle, then back and forth like waves on a pond, are what is called "barrel harmonics." To put it differently, barrel harmonics is about a barrel flexing slightly when the rifle is being fired. When flexing is consistent it will increase the accuracy of your load. The induced vibration propagates as a wave, beginning at the chamber and extending up the barrel to the muzzle end; then it reflects down the barrel. When the wave reflects back, the peaks from the forward moving wave will, at various times, overlap the troughs from the rearward moving wave. At that point, it is called a "node" and at that time, the vibration of the barrel is minimized. With all the actions and reactions that are flexing the barrel, fast and slow rounds will exit the muzzle at different angles.

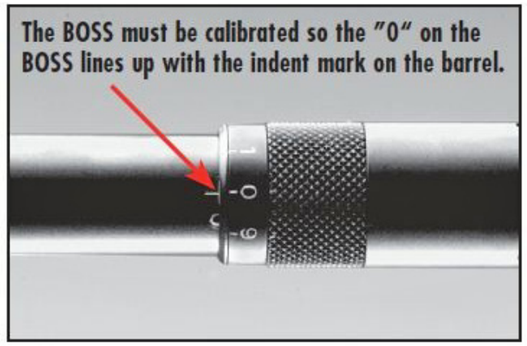


Amplitude – showing the barrel at the highest and lowest vertical point, as reflected by a sine wave showing the barrel deflection from the bore centreline, which runs through the middle of the wave.

When a round is fired, a harmonic wave travels through the barrel, and it is not just the consistency of this wave that is important, but the wave has to be at a "node" when the bullet leaves the barrel. This harmonic wave is the end or nett result of all other interrelated aspects like changing the charge, the bullet weight, the brand of the case, the type of primer and the closeness of the bullet to the rifling.

Consistency is the name of the game. If you could tune your load so that the bullet leaves the muzzle at a point in the muzzle's vibration where it changes direction (the "node), it is moving the slowest, even actually stopping, before changing direction and it is therefore much more forgiving. Tuning your loads to take advantage of these points in the barrel's harmonics will give you tighter groups.

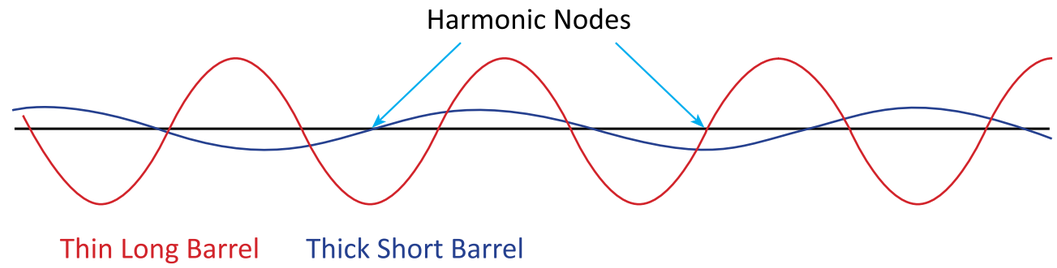
Barrel tuning can be manipulated in other ways also, the way **Browning's BOSS** system does it. The cylinder at the muzzle can be turned in and out until its weight changes barrel vibrations for best accuracy. The idea is to have the bullet exit the muzzle at the split-second the muzzle stops between vibration cycles. We also have the **Limbsaver De-Resonator**, a rubber-like collar that slips over the barrel, which works much like the BOSS system by adjusting its position until you obtain maximum accuracy.



Browning Boss System – by moving the BOSS device along the barrel changes the vibration frequency. The "Sweet Spot" is when the bullet exits the barrel at the top or bottom of the vibration wave, which is the time when the barrel experiences the least motion. The Sweet Spot varies with bullet weight and charges weight.

You may have observed that most three-shot groups will exhibit a triangular shape. This is caused because as the barrel vibrates through its "circular arc", one bullet may, for example, leave the muzzle at 12 o'clock, another at say four o'clock and the third for instance at eight o'clock. The larger the arc of the barrel, the less accurate the rifle will be, and the larger the triangle. As a rule, the thinner and longer a barrel, the more it is affected by the vibrations. This is the reason why a heavy and thick match barrel seems to shoot more consistently than a standard factory sporter barrel, and is also easier to tune.

A shorter barrel of the same diameter will have less amplitude to its arc of movement. What you are in effect doing when tuning the barrel is to change the vibrational length of the free-floated forward end of it, causing the vibrational arc, or circular vibrations of the barrel, to get smaller and smaller. As the arc gets smaller, the groups are getting tighter. Even though the bullets may still be leaving the muzzle at 12, four or eight o'clock, the diameter of the arc has been lessened, so the triangle gets smaller and the shots start to cut each other.



The Use of a chronograph can only compliment your load development

Many people develop their loads with the use of a chronograph, whereby they measure velocity and track extreme spreads and standard deviations with the intention to minimise velocity spreads to get the loads as uniform as possible. The main value of a chronograph is to provide velocity consistency of your load, especially for longer ranges.

Another important aspect is to calculate your VC ratio (Velocity Charge ratio) to see if your load is within the recommended minimum and maximum pressure range as given in Reloading manuals. You could also check the effects of changing temperature conditions and barrel warming, etc. Needless to say, it allows you to model trajectories and that you could calculate the Point-Blank-Range (PBR) of your load.

In the follow-up article about achieving better accuracy, I will discuss shrinking your groups with the so-called ladder-method of developing a good load where we look at barrel nodes again.