Marksmanship 101: Introduction to Long-Range Riflery

Damon Woodall

Woody’s Hunt & Rifle Club

December 2024

© Copyright 2025 Woody’s Hunt & Rifle Club

Table of Contents

Introduction to Marksmanship 101....3
Chapter 1. What Is a "Good Group?"....4
- Good enough to qualify, but....4
- Generally-accepted baseline for "precision"....4
- Bugholes - accuracy paragon....5
- Conclusion....5
- What's Next....5

Chapter 2. The Rifle Barrel....6
- Barrel manufacturing: Quality, contours, rifling types, etc....6
- Barrel contours....6
- Machining the chamber, tenon, and crown: critical for accuracy....7
- Barrel twist rate....8
- Correct fit of the finished barrel to the action....8
- Correct fit of the barreled action to the stock or chassis....8
- A word about barrel length....9
- Bolt-action and Semi-Automatic Rifles: “Bolt Guns” versus “Gas Guns”....9
- Conclusion....9
- What's Next....10

Chapter 3: Triggers and Scopes....11
- Triggers....11
- Scopes 101....11
- SFP Reticles....12
- FFP Reticles....12
- Turrets....12
- Elevation and Windage Adjustment: MOA or MRAD....13
  - MOA....13
  - MRAD (Milliradians)....13
  - Which to Choose?....13
  - Not Your Grandfather’s Scope: Reticle Complexity....14
  - Scope Rings and Mounts: Not an Afterthought!....14
  - Next Time - Scope Mounting....15
  - Conclusion....15
  - What's Next....16

Chapter 4: Scope Mounting....17
- Tools....17
- Step 1: Make sure your scope rail screws are tight....18
- Step 2: Determine scope position for correct eye relief....18
- Step 3: Leveling the system and completing the mount....19
- Final tightening....20
- A Note About Bubble Levels....21
- A note about “lapping” rings....21
- Conclusion....21
- What's Next....22

Chapter 5: Scope Zeroing....23
- Assumptions:....23
- Prerequisites:....23
- A note about scope reticle adjustment:....23
- Procedure....24

Afterword – Concluding the series....26

Introduction to Marksmanship 101

Over my time as a range owner, I've watched members struggle with hitting steel on the 550-yard range and heard questions about what it takes to consistently hit targets at that distance and beyond.

This booklet is a condensation of five emails sent to Woody's Hunt and Rifle Club members over the first five months of 2024. The information herein will help set expectations when you start investing money into shooting long range or to help you narrow down what's going on with your rifle if you are having problems with consistent accuracy.

It's amazing to me to see someone pull the trigger four or five times and not hit anything except the pile of brass stacking up on the concrete. This is called insanity - doing the same thing over and over and expecting a different result. The more you pull the trigger while not hitting your target, the more it costs you! The primer, powder and projectile are not recoverable. Barrels, especially in popular match calibers like 6.5 Creedmoor, wear out. It's also disappointing to keep missing and your confidence is diminished to a certain degree.

It's important to emphasize that this booklet is directed to members who really want to accurately shoot 500 yards and beyond, using rifles and ammunition up to the task.

I hope you find it useful.

- Damon Woodall
  December, 2024

Chapter 1. What Is a "Good Group?"

I'm starting with, "What is considered a good group?"

Good enough to qualify, but...

I'll start off with what some people call a 100-yard group. Picture #1 below is what I often see, and it does meet the 5-shots-in-4-inches qualification requirement for using the 550 range. I personally call this a pattern, not a group.

Problems literally expand with range. On a 200 yard target, your group is now 8 inches. At 300 yards, 12 inches. By the time you engage a target at 500, it's a 20-inch spread, and that's with no wind. Yeah, you might get lucky and hit it once or twice after firing 10-12 rounds. Hopefully you get the point.

Generally-accepted baseline for "precision"

The next picture #2 is what we call a cloverleaf. The rounds are touching and appear to fall in a 1/2 inch group. Now you have something with which you can reliably engage and hit at distance (shooter skill notwithstanding). Most knowledgeable marksmen consider repeatable half-inch five-shot groups at 100 yards to be a capability baseline for a truly accurate centerfire rifle.

Bugholes - accuracy paragon

The last picture #3 is called a bughole. You can't tell if it has three or five shots (it's five shots). This is the level of accuracy I personally expect from my rifles. Picture #2 above will get it done but picture #3 is the accuracy goal of serious marksmen - It takes a quality setup of equipment and a serious commitment of time from the shooter.

Conclusion

If your rifle shoots a two-inch group and you are happy (or that's the accuracy standard for your rifle and ammunition), great - but don't expect it to hit an eight-inch target consistently at 500 yards when it's only capable of ten-inch accuracy at that range.

This chapter gives you some kind of realism about what to expect when you're zeroing your rifle and begin shooting past 100 yards. Again, this is with no wind, a good fitting rifle loaded with good ammunition, good eye relief, and a good trigger pull.

What's Next

The next chapter will cover gas guns versus bolt guns and the barrel/ bolt combination. The barrel is the most important part of the rifle. Not all barrels are created equally. On any given rifle platform, there are barrels for different purposes as well as different price and quality points. For example, an 8-pound hunting rifle fired 20 times in a year has a different expectation set altogether from an 18-pound match rifle fired 100 times in a day.

Chapter 2. The Rifle Barrel

In this chapter, we will be focusing on the rifle barrel itself. I'll break down and describe what is important for a barrel, as part of a rifle "system," to provide accuracy.*

Regardless of price point, four factors are critical for consistent accuracy:

- Quality of the barrel blank itself, especially the rifling
- Machining the barrel: chamber, tenon, crown
- Correct fit of the finished barrel to the action
- Correct fit of the barreled action to the stock or chassis

You can have the most expensive rifle you can afford, but, if any one of these factors is improperly addressed, accuracy will suffer.

It is appropriate to consider the rifle's trigger as a critical part of the rifle "system." I will address triggers in the next chapter. For purposes of today's discussion, let's assume that the trigger simply and correctly does its job: release spring tension to fire the chambered cartridge, without affecting performance of or being affected by other rifle components.

I'll also touch on the comparison of semi-automatic "gas guns" to bolt-action "bolt guns" in terms of long-range accuracy. A good barrel is critical to both.

Barrel manufacturing: Quality, contours, rifling types, etc.

Like anything else, the very best barrels take more time to produce using more expensive materials and processes than inexpensive ones. I'm not going into the pros and cons of cut versus hammer-forged versus button rifling. Any of these methods can produce accurate barrels.

The bigger gun companies machine their barrel blanks (and other major components) in-house, using materials and methods appropriate to the price point. Smaller gunmakers are likely to outsource their barrels and/or other major components.

Barrel contours

The barrel contour - the amount of taper between breech and muzzle - on any rifle is very important and, along with length, should always be considered first in any purchase or custom build.

---

* Accuracy also requires quality ammunition. The finest, most accurate rifles in the world cannot make cheap, bulk-produced ammo shoot well. That's another discussion.

For reference, the diameter at the breech end of most centerfire barrel blanks is 1.20 inches before machining.

Rifles intended to be carried long distances - like most hunting rifles - usually have thin, heavily-tapered barrels with a muzzle diameter of 1/2 to 5/8 inches and a finished weight of around three pounds. Such “pencil barrels” can be accurate, but they are intended to be fired only a very few times at once. They will heat rapidly, often resulting in groups opening up and/or the group “walking” away from point of aim. Such thin-barreled rifles, with a total wright typically under ten pounds with optic, may well have sufficient accuracy to reliably hit targets 500 or more yards away, but are not intended for more than half a dozen shots in quick succession.

Barrels with larger contours are thicker and heavier, with muzzle diameters up to the unfinished diameter of 1.2 inches and weighing over seven pounds. Heavy-contour barrels are more rigid and heat up more slowly. These properties enhance accuracy and allow longer shot strings without group spread. That’s why it is common to see centerfire match rifles, which are usually fired from a bipod or rest, weighing twelve to fifteen pounds with an optic. Rifles tipping the scale over 20 pounds are not unusual.

Carbon-wrapped barrels can be lighter. I’m focusing on all-steel barrels here.

Machining the chamber, tenon, and crown: critical for accuracy.

Precise cutting of the ***chamber*** is critical to accuracy. Even a tiny machining flaw, especially in the chamber’s neck or throat, can destroy accuracy or cause fliers - the occasional round that turns a cloverleaf group into a disappointment. It is very frustrating to shoot three or four rounds into a cloverleaf and the fifth one lands an inch away.

The ***tenon*** is the part of the barrel that mates to the rifle’s action. Proper machining of the tenon is critical to headspacing, which is the front-to-back fit of the cartridge in the chamber. There’s nothing magic about this. It’s simply paying attention to detail.

The ***crown*** is the finish of the muzzle. It’s more important than would seem obvious. Poor machining or nearly-invisible damage from something hitting the muzzle can cause trouble. I’ve seen a rifle shoot terribly, then a simple re-crowning of the barrel turned it into a tack driver. Again, nothing magic.

Barrel twist rate

“Twist rate” is the rate of spin put on the bullet by the rifling, specified as inches per revolution. A rate of 1:10 means the bullet will spin one complete revolution for every ten inches traveled.

Twist rate is out of scope for this series because it really isn’t an accuracy factor unless bullets unusually heavy for a given caliber are being used.

Top: Unfinished blank in “Heavy Varmint” contour, one of the heaviest.

Bottom: Finished barrel in “Medium Palma” contour, an intermediate weight.

Correct fit of the finished barrel to the action

The finished barrel tenon must precisely match up the rifle’s bolt for optimal accuracy. Again, there is no magic here. It is simple machining, but precision machining has a cost in time or equipment.

Correct fit of the barreled action to the stock or chassis

Once the barrel is installed on the action, the barreled action must be correctly mated to its stock. Any amount of looseness or flex will degrade or destroy accuracy.

For traditional wood or synthetic stocks, bedding the action in an epoxy-based material to eliminate gaps and increase rigidity provides best accuracy.

Many of you have seen or own rifles with aluminum “chassis” stocks. A chassis is supposed to provide a stable, rigid mount without bedding, but some excellent gunsmiths still recommend bedding for best performance.

Whether or not part of the barrel itself is bedded along with action depends on the barrel. Thin-contour barrels often benefit from bedding. Thick, heavy profile barrels are generally “floated” in the stock or chassis.

A word about barrel length

The length of a given centerfire barrel has no practical effect on its accuracy, but length definitely affects velocity.

Most factory-built centerfire sporter rifles have 22-24 inch barrels. The velocity printed on many factory cartridge boxes is usually derived in a 24-inch test barrel. Depending on caliber and a nominal barrel length between 20 and 28 inches, each inch of length change generally adds or subtracts 50 feet per second of velocity.

Bolt-action and Semi-Automatic Rifles: “Bolt Guns” versus “Gas Guns”

I shoot both. This is my experience. The controversies around their accuracy potential can go on for hours so I’m not going there. I’ll just say that my ARs are as accurate as my bolt guns.

In my experience there are only three are so manufacturers that assemble gas guns which can shoot and hold a cloverleaf group or better. You have to consider the AR platform was designed as a military rifle. A saying you might have heard is they are “minute of man” accurate. Most ARs are chambered to fire ammo manufactured anywhere in the world and keep working despite the crud that builds up from the gas being blasted through the barrel and back to the bolt. They aren’t made to be match rifles. They are made to be reliable in conditions that would choke the tight tolerances of a competition firearm.

But the AR and similar platforms are very adaptable and versatile and have come a long way. With today’s CNC milling machines and manufacturing processes, the AR platform is capable of excellent accuracy. You my have heard that bolt guns are more accurate than gas guns. Not necessarily. I own many ARs in many different calibers and 80% of them shoot bug holes, the rest shoot clover leafs. I won’t keep one that doesn’t. I’m not going to waste time and money on ammo on a rifle that “won’t shoot” to that level of accuracy.

Early on as a newbie shooting 3-Gun competition, I found that I was struggling with targets past 200 yards, especially after a course of fire that started with shooting paper targets before engaging at longer distances. That’s when I began learning what goes into a quality barrel as part of a precision system assembled by a skilled gunsmith. Bolt gun or gas gun, the principles described above are critical to both. A hot barrel is not your friend.

Conclusion

It doesn’t matter how little or how much you spend on a rifle. The barrel, action, and stock must be right, and you must use quality ammunition.

I’ll end this installment with this: it is fair to say almost all manufacturers’ bolt-action rifles should shoot a one-inch 100-yard group out of the box theses days with good quality ammo.

Common AR-platform semi-autos should shoot a 2-2.5 inch group with match-grade ammunition. The highest-quality ARs can match bolt-action accuracy.

What's Next

Next time I'll briefly discuss triggers and will go into depth on scopes, mounts and what you should consider before buying either.

Chapter 3: Triggers and Scopes

In this chapter we will be focusing on triggers and scopes. As discussed in the previous chapter, the barrel is the first component that has to be right. Second is the trigger and third is the optic.

Triggers

There are basically two types of triggers: single-stage and two-stage. I personally shoot a single-stage trigger, which is the most common. When you place your finger on it and apply pressure, it releases and fires. A two-stage trigger has slight movement rearward until you start to feel resistance, then additional pressure is applied until it releases and fires.

The choice between them is a personal thing. When I place my finger on a trigger and mentally and physically apply slight pressure, I want it to have a clean break with no creep or overtravel. Unfortunately, the single-stage Jewell triggers that I've always used in my bolt guns are no longer available. They are all set by my gunsmith at 1.5 pounds and they feel like ounces. Unless you are shooting a benchrest-type format, anything under that is dangerous in my opinion.

There are so many triggers on the market that it can get confusing. I'm not a fan of triggers that you can adjust. There are too many components with these styles of triggers and I stay away from them. Again it's a personal preference. The important thing is your triggers need to break clean, meaning it releases without you mentally and physically knowing. Hopefully this makes sense. If your rifle can shoot a 1/2-inch group but your trigger pull is crap, you'll end up with crazy flyers. It's critical that your trigger isn't gritty feeling and you aren't snatching it to make it fire. I'll also add that I see a lot of new shooters positioning their finger on the trigger incorrectly. Your fingertip needs to be centered. The easiest way to explain this is that the tip of your finger should be centered on the trigger and no further back than the rear of your fingernail.

Scopes 101

Most riflescopes purchased today are variable power, so magnification can be adjusted. While fixed-power scopes are still available, our discussion applies to variable power scopes.

There are two types of variable-power riflescopes: First Focal Plane (FFP) and Second Focal Plane (SFP)*.

- The reticle (crosshair) of an FFP scope is located in front of the magnification lenses. With this arrangement, the size of the reticle as seen in the eyepiece changes when the scope's magnification is changed.

* Less commonly called Front Focal Plane and Rear Focal Plane

- With SFP, the reticle is located behind the magnification lenses. The size of the reticle in the eyepiece stays the same regardless of the magnification setting.

There are pros and cons to both depending on what type of shooting they are used for.

SFP Reticles

SFP scopes are commonly used in hunting or just plinking around with a 22. They are less expensive to produce than a comparable FFP scope. They give a great field of view. They're often intended to "set and forget" with screw-on caps over the turrets' adjustment dials.

If the reticle has subtensions or Bullet Drop Compensator (BDC) hash marks (holdovers), you must know the manufacturer's designated magnification (usually the highest) for them to be correct. The center of the crosshair does not change on the target with magnification change, but the hold over marks will be incorrect if you're not at the magnification the manufacturer recommends.

FFP Reticles

In an FFP scope, the reticle's size changes as the magnification changes. This means that reticle subtensions (hash marks) change too, so magnification settings don't affect how holdover is applied. If you are considering shooting past 300-400 yards you should consider a FFP scope. A few scope models offer the option to choose FFP or SFP. FFP will be more expensive. It's worth the extra spend.

Turrets

A word about turrets. If you shoot a lot of long range, you'll be adjusting your scope constantly, especially its elevation. Inexpensive SFP scopes with capped turrets simply are not intended for this kind of use. You need large, clearly-marked turrets intended to be turned with the fingers. See the photos for examples.

An inexpensive Second Focal Plane (SFP) scope with capped turrets. Meant to "set and forget."

A popular First Focal Plane (FFP) competition scope. Constant adjustment is expected.

Elevation and Windage Adjustment: MOA or MRAD

Riflescope elevation and windage adjustments are made in either Minutes Of Angle (MOA) or milliradians (MRAD or just “mils”). I’m not getting into detail about the definitions and math involved with each. It’s enough here to describe how they are used with riflescopes.

Newcomers to precision rifle always ask, “Which is better?” Neither is “better.” They are simply two different ways of measuring elevation and windage. Once you understand a little about them, which you choose comes down to preference.

MOA

“MOA” is the old standard. On an MOA scope, each “click” of the turret will move the reticle some fraction of a Minute Of Angle, usually 1/4 MOA. High school geometry shows us that a one-MOA adjustment translates to 1.047 inches at 100 yards, so it’s convenient to say that a 1/4 MOA adjustment is a quarter of an inch. But that’s at 100 yards. It’s half an inch at 200. A full inch at 400. As you learn more about long range marksmanship, you will learn to stop using inches in making your shot corrections. You use angles. If your shot misses the mark at 200 yards by an inch, you won’t say “I need to correct by one inch.” You’ll correct by half an MOA, or two clicks on your MOA scope. There is an image below which shows how this works.

MRAD (Milliradians)

MRAD, often abbreviated as “mils,” has appeared more recently as a common scope adjustment. On an MRAD scope, each “click” of the turret is 1/10 of a milliradian, or “mil.” At 100 yards, a “mil” of angle translates to 3.6 inches, so a 1/10 mil adjustment is 0.36 inches at 100, 0.72 inches at 200, 1.08 at 300, and so on.

Which to Choose?

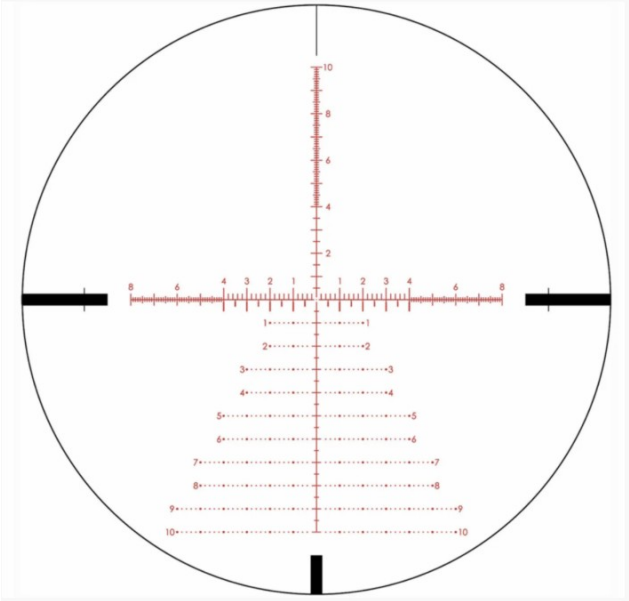
MRAD scopes are easier for most people to use under time pressure than MOA, even for those who learned to shoot with MOA scopes. All my scopes are MRAD. I personally find that, when engaging multiple targets, the smaller numbers are easier for me to remember when on the clock. Neither system is superior when it comes to accuracy.

When shooting MOA, you do have to be aware that each click is a 1/4” MOA. If your dope doesn’t fall exactly on the number you should click up. At this point there is no need to get into a lot of detail with each one. I shoot MRAD because that’s what everyone I shoot with shoots. It’s easier to call corrections when everyone is on the same page.

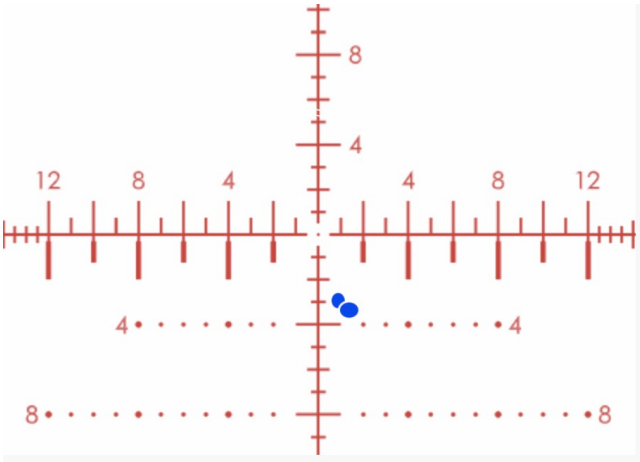
Again, we do not call corrections in inches. We call them in tenths of a mil or quarters of an MOA. A tenth is a tenth, a quarter is a quarter, at 100, 500, 1000, 2000 yards. We never use inches as a correction measurement. See the photo below.

Not Your Grandfather's Scope: Reticle Complexity

A new shooter's first look through a quality long-range riflescope can be very intimidating. Instead of a simple crosshair, the reticle may have a confusing variety of other marks and numbers. Their purpose is to give you the information you need for holdover, windage, shot correction, and even determining range to an unknown-distance target. A "Christmas tree" reticle has a lot to offer once you fully understand its potential. You will gain confidence and increase your accuracy once you understand how to use it. Do not let it get in your head. I do not recommend a BDC reticle past 300-400 yards.



Here is an MRAD "Christmas tree" reticle, shown at a low magnification setting. With an FFP scope, increasing the magnification will also zoom in on the reticle.



Here is the same model scope with an MOA reticle at high magnification.

The blue dots represent two shots. To call a correction, we would say "up 3 and left 1." With 1/4-MOA increments, this would be 12 clicks up, 4 clicks left. We would not convert anything to inches.

Scope Rings and Mounts: Not an Afterthought!

One of the most common problems we see when folks are having trouble shooting good zeroing groups is loose rings or one-piece mounts. Again, I buy once and cry once when buying rings or mounts. They stay with the scope if you decide to get rid of the gun. I know from experience that going cheap on them will cost you in the long run. You waste ammo, time, and barrel life chasing accuracy when loose or cheap misaligned rings or mounts don't hold the scope tightly in place.

When we see problems with rings, it's often because the owner went to a gun store to purchase a scope and had the store mount the scope in whatever rings the store wanted to use. The selection of rings at most stores falls into the $35-45 range and are considered to me as low recoil rings. The minimum "serious" price point should be $100-125 (examples are Vortex, Warne, Seekins, etc.). Like all things in this sport, there are unlimited choices on everything that attaches to the rifle.

About rings versus one-piece mounts: I use rings on my bolt guns and one-piece mounts on my ARs. Rings provide the most flexibility in how they are spaced on the scope and rifle rail and the height of the scope above the rail. One-piece mounts offer a general higher scope mount, quick-release, and other options that work well for the AR platform.

About mounting height: Your scope should be mounted so that your head and neck are comfortable when your eye is correctly positioned behind the scope and your cheek is correctly supported by the comb of the stock. If you have to strain your neck to get low enough to see through the scope, it's too low. If your cheek is not comfortably but firmly supported by the stock, the scope is too high.

There is an old saw that the scope should be mounted as low as possible over the barrel. Forget that, especially when most LR stocks have adjustable combs. Buy rings a little too high so you can adjust the comb. If you rings too low, you're stuck with an uncomfortable mount that will have you miserable at the end of a long shooting session.

Next Time - Scope Mounting

In the next installment in this series, we will be going through the proper way to mount your scope on your rifle to ensure you have confidence when you get to the range. If you are that shooter that lets the gun store set up your scope, then the next email will be very helpful. It really doesn't cost a lot to be set up to handle mounting it yourself and know that it is going to be right. Scope mounting is a skill you'll use over and over and over in this hobby.

Conclusion

When it comes to glass, I tell folks to buy once and cry once! Your rifle may not shoot good groups, you may want another caliber, or you just want something different. The scope can be moved to the new rifle. You should invest in good glass. While usable scopes can be had for less, good quality starts at around $800. Many of the competitive shooters at Woody's run scopes in the $1200-3000 range. The very best scopes can cost $4000 or even more. The most notable quality that the highest-price scopes offers over less expensive ones is performance in challenging light conditions.

I hope the first three installments in the Marksmanship 101 series have given the new long-range shooter something to consider before just jumping into buying something that will be regretted soon after. Please be very careful as a new LR shooter shopping at a gun store. Some stores do have knowledgeable staff in the LR discipline. Most, especially chain stores,

do not. The problem is that new shooters don’t know what questions to ask, and it costs them dearly. I wish I had gotten some guidance early on about the many pros and cons of everything firearms related. It would have saved me a lot of time and money.

LR shooting is not cheap! If you are budget minded, take time to gather knowledge and have patience to save beforehand rather than just buying something to try out. You will be rewarded later with a smile on your face.

If you are cheap then you are not ready for LR shooting. Not to be rude, but it’s like showing up at a drag race and your 8 cylinder motor is running on 7. You’re not going to finish well!

What's Next

As I said, I'll describe how to correctly mount a scope on a rifle. Maybe other goodies as well.

Chapter 4: Scope Mounting

In this chapter, we will be discussing scope mounting and proper eye relief. We discussed proper scope height in the last installment, so we start here with the assumption that your rings or one-piece mount are of the right height.

When you engage targets at long range, the scope's vertical reticle must be perfectly vertical (plumb) through the rifle's bore to the ground. If not, you'll have a built-in offset of the bullet's trajectory to the scope's line of sight.

The steps below mount your scope with correct eye relief and the reticle properly leveled.

Tools

Mounting a scope requires only a few items which you may already have. For those tools you don't have, trust me: if you seriously pursue precision rifle, invest in them and you will use them over and over.

- Gun vise to hold your rifle. A rifle-mounted bipod and rear bag also work fine if they can hold the rifle in place.
- A small bubble level to level the rail. You can also use the level function on an iPhone by opening the "Measure" built-in app and selecting "Level." Android phones have a leveling app available but I am not familiar with it. A member compared readings from his iPhone level with an expensive engineering level and found the two to match. You can also buy scope leveling kits that include multiple bubble levels. If you get one of these, be sure to test the levels side by side on the same surface. If the bubbles don't match, do you really want to trust them?
- An inch-pounds torque driver is strongly recommended to insure even tightening of screws to recommended specification. The Wheeler FAT Wrench (photo) is popular and inexpensive - prices vary widely, but your target purchase price (without tax) for the basic kit is $50, no more than $60. The basic kit comes with a few flat, Phillips, Allen, and Torx bits - you will almost certainly need additional sizes. Be aware that the more "advanced" kits with more bits are overpriced unless you need a variety of rarely-used sizes. Buying smaller bit kits separately is usually the best approach.
- Blue Loctite thread locker is optional for mounting your rifle's picatinny rail but I personally recommend it.

Step 1: Make sure your scope rail screws are tight

If your rifle has a picatinny rail, make sure of three things:

1. It is the correct rail for your rifle. A rail that doesn't precisely fit your rifle's receiver will never hold the scope securely enough for accuracy. This sounds like a silly thing to have to confirm, but believe me - it isn't.
2. It is mounted securely. This is where I advise using blue Loctite - ONLY on the rail screws, NOT on any of the ring screws. Not everyone agrees with using Loctite - but the rail is the number one thing we see loose, followed closely by the scope rings and stock or chassis mount bolts. Something being lose is the last thing you should be worried about.
3. DO NOT put Loctite on ANY ring screws!

Step 2: Determine scope position for correct eye relief

Now we will position the scope for correct distance, or eye relief, within the scope's eye box (image below). Place your rifle in your gun vise or on your bipod and rear support to begin. It doesn't have to be perfectly level at this point, but close is good.

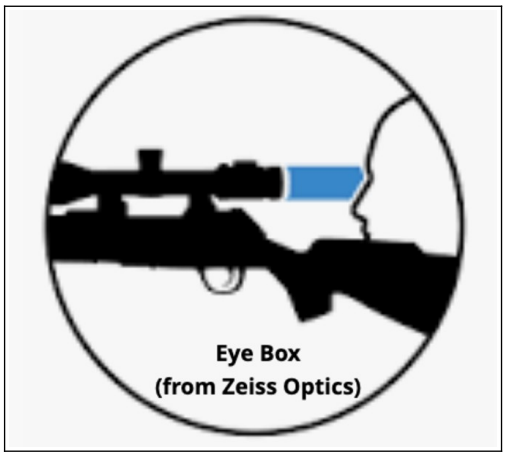
1. Mount the lower ring halves and tighten the screws just enough to hold the rings securely in case you need to move them.
2. Place your scope in the lower rings and secure it with the upper halves, leaving screws loose enough to move the scope but tight enough to keep it from falling.
3. Mount the rifle to your shoulder as if shooting. Doing this on a table or bench is easiest but usually puts the shooter's head further back than shooting prone. If your stock has adjustable length of pull, you may want to extend the stock about an inch so that you have more room for adjustment when shooting from other positions.
4. Looking through your scope, you should see a complete image with no "shadows" or blackout. With your head comfortably supported by the stock, move the scope back and forth in the rings until you achieve that "edge to edge" image.
5. To fine-tune your eye relief adjustment, do this:
    - Lift your head from the stock.
    - Close your eyes.
    - Drop back into your mount and open your eyes.
    - Do you see the clear, complete image without moving your head? If not, move the scope until you do. You want your eye to fall naturally in the middle of the eye box for best flexibility when shooting from different positions.

Now check the scope's position between the rings. Ideally, with correct eye relief set, you want the scope centered in the rings. Realistically, this seldom works out.

- The ring edges should be 1/8 inch or more from the scope's objective bell, turret assembly, and magnification adjustment ring. You may need to move one or both rings on the picatinny rail to achieve the best spacing while maintaining correct eye relief. Tightening rings placed too close to the bell, turrets, or magnification ring can cause damage.

- With receiver-mounted rings or one-piece mounts, you may need to compromise the scope's position a little, or use the stock's length-of-pull adjustment.

Finally, with eye relief established and rings positioned correctly, make note of the rings' positions on the rail and the scope's position in the rings. Put a temporary witness mark on the scope and one lower ring to enable easy front-rear alignment during final leveling.

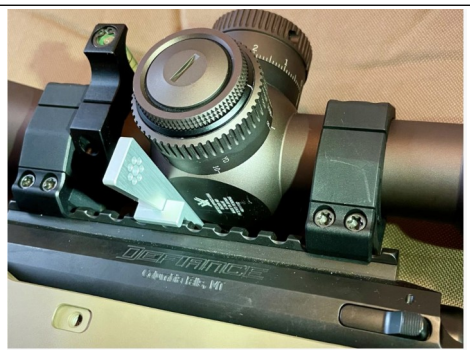


Step 3: Leveling the system and completing the mount

Now we want to level the scope - that is, ensure that the vertical reticle is plumb through the bore's axis - and tighten everything down.

Leveling on a picatinny rail

A common practice for leveling a scope mounted on a picatinny rail is to level the flat bottom of the turret assembly to the rail. This is done by placing the scope loosely in the rings, then use feeler gauges, cards, or something like an Arisaka leveling tool (photo) to insure the base of the turret assembly is perfectly parallel to the rail. The possible problems with this approach are that not all scopes have a flat turret assembly base or, while rare, the vertical reticle may not be absolutely perpendicular to the turret base.



Arisaka leveling tool

Universal leveling steps

The steps below level the rifle, then the scope reticle, independently of one another. You will need some level or plumb reference like a rope or heavy string hung from a support, the corner of a building, a carpenter's level mounted on a support, etc. For best convenience, start these steps with the rifle, supported in its vise or on bipod and bag, pointed toward your reference at a distance to which your scope can focus.

1. Holding your rifle in place using your vise or bipod and rear support, level your rifle's picatinny rail on all axes using your leveling tool of choice. If you have no rail or other surface on the receiver you can use to establish plumb, eyeball it as best you can.
2. Check the witness marks you made in step 7 above to confirm correct eye relief. Make sure the rifle's rail is not bumped from level.
3. Now you want to carefully point the supported rifle at your level or vertical reference, keeping the rifle level. Looking through the scope, rotate the scope in the rings until the reticle is perfectly aligned with your reference, making sure you also watch your witness marks to maintain correct eye relief. Your scope is now level with correct eye relief. Putting fine witness marks on the scope and rings make it easier to see if the scope moves out of adjustment as screws are tightened.

Final tightening

Now you want to complete the mounting process by tightening the rings' screws.

1. Consult the manufacturer's torque specifications for both the rings and the scope. They should be very close. I recommend using the lower of the two if there is a difference. Also, the rings' base screws, which hold the lower halves to the rail or receiver, will have a much higher tightening torque than the ring half screws. DO NOT put Loctite or oil on the screws!
2. Tighten the screws in a crisscross pattern per the manufacturer's guidance so tightening is applied evenly. Here is where having an inch-pounds torque driver is so valuable. If you overtighten the ring screws, you can severely and permanently damage the scope. If you overtighten the rings' base screws, you can strip them. But if you don't tighten sufficiently or evenly, the scope can move just enough to destroy accuracy, and eventually the whole assembly will come loose.
3. Using your witness marks, verify everything as you go! It's easy to bump things off level or plumb. Just tightening the screws will turn the scope in the rings if not done very evenly. Verify against your reference! Go back and correct if level or plumb is disturbed.
4. Once you're done, you may want to put permanent witness marks on your scope and rings to make remounting far easier and faster. More importantly, misaligned marks will tell you the scope has moved. Of course, permanent witness marks can become problematic if you sell the scope, change rifles, etc. Your call.

A Note About Bubble Levels

As I said earlier, it's critical that your reticle be perfectly level when you aim and break the shot. We've mounted the scope so that it's correctly aligned with the rifle's bore. But what about when we're actually shooting? How do we know the rifle isn't canted (tilted)? Some shooters attach a bubble level to the scope (photo) or the receiver that the shooter can see while aiming. There are also electronic levels that flash red or green lights to show level.


Scope-Mounted Bubble Level

Should you get one? It's a personal choice.

A note about "lapping" rings

You may encounter advice to "lap" your rings before mounting your scope in them. In short - if you purchased quality rings, you don't need to worry about lapping, let alone do it or have it done. Period.

Lapping is a process to remove high/low spots in the rings and insure they are aligned. The purpose is to make sure the rings do not put uneven forces on the scope tube when they are tightened.

Quality rings are sold in matched pairs and may even have serial numbers. They do not need to be lapped. Buy once, cry once, don't worry. If you buy cheap $35 rings, lapping may be the least of your problems… or the worst.

Conclusion

This whole process takes me maybe 15 minutes and there are always ten ways to skin a cat. Others may do it differently, but if it works and the scope is mounted right, it doesn't matter. Even if it takes 30-45 minutes or two hours, mounting the scope yourself and avoiding wasted ammo and range time because the scope is wonky is time well spent.

I'm not knocking any gun shop but I'm sure someone reading this, or someone you know, has left the store, gone to the range, could never get the rifle shooting right, and finally found out later something was loose. You can't complain if it was free service they offered… hopefully your scope is not scratched, but for sure your ammo and time are lost. Follow these steps and use the right tools, and your scope will be mounted right. I leave my witness marks on all my scopes. If I drop my rifle or by some chance something comes loose, the marks will tell me if the scope has moved in the rings.

What's Next

Next time, we will go over bore sighting your rifle and zeroing using less than 12-15 rounds. I don’t use any gadgets someone sells to bore sight, and you won’t need one either.

Chapter 5: Scope Zeroing

In this last installment of my Marksmanship 101 series, we will discuss my method for zeroing your riflescope without burning a pile of ammo or purchasing gadgets. All too often, someone buys a scope, has the store mount it, and shows up at the range with no idea at all how to go about zeroing it beyond turning the turrets. I've seen guys like that burn boxes of ammo and still be unable to zero on and reliably hit a softball-size target at 100 yards.

You should be able to establish a good working zero with as few as 10, no more than 15 rounds fired.

Assumptions:

- Use a 100-yard starting zero for centerfire rifles. Hunters may want a 200-yard zero, but it's much easier to bore-sight at 100 yards. In this day of ubiquitous ballistic calculators, the zero range really doesn't matter.
- Use a 50-yard zero for .22LR and other rimfire.
- You're working with a capable long-range rifle system mounting a quality scope with at least 9-12x magnification.

Prerequisites:

- Your scope is mounted and leveled as described in the last Marksmanship 101 installment (Chapter 4).
- Solid, stable front and rear support for your rifle. Many members use a bipod and rear competition support bag like a GameChanger. Others use a standalone front rest and rear sandbag. If they are stable enough, front and rear sandbags can work just fine. It really doesn't matter as long as the rifle is supported well enough that you can keep the reticle centered on a 1" bullseye at 100 yards.
- A full-size IDPA/IPSA B-27 target or similarly-sized (24" x 45") paper and 2-3" orange pasters.
- If your riflescope is not capable of "seeing" bullet holes in your target at your chosen zero range, you'll save a LOT of time by having a spotting scope or other optic on hand so you do not have to keep walking out to see impacts.

A note about scope reticle adjustment:

- First, read your user manual for instructions for adjusting your specific scope's turrets in the zeroing process. Don't just assume you mount the scope on your rifle and start turning the knobs. Especially with high quality scopes, there are "zero stop" mechanisms in place which will limit elevation turret adjustment unless you follow instructions. Also, some scopes have "infinite" zeroing capability allowing adjustments smaller than its "click" graduations - IF you follow the directions. Others will adjust only

to the measure of a single “click,” in which case your group average impact may fall a fraction of an inch from exact center. READ THE MANUAL before you try to zero.

- Second, it is imperative that you know how far each “click” of your turret moves the point of impact at your zero distance! Your scope’s box or manual will specify adjustment increments in Milliradians (MRAD) or Minutes of Angle (MOA). Most MRAD scopes have 0.1 MRAD increments; most MOA scopes have 1/4-MOA “clicks.”

- If you are serious about learning long-range shooting, you will read and understand the “Scopes 101” section in “Chapter 3: Triggers and Scopes. You learn to make corrections in angular measurements (MRAD or MOA) - NOT in linear measurement (inches).

- However, as a temporary shortcut or for scopes lacking reticle subtensions, here is a translation of angular to linear measurement at common zero ranges to simplify the zeroing process. You will reference this table in step 2 under “Fire sighter shots” below.

  <u>At 100 yards:</u>
  - Each “click” of an MRAD scope moves impact 0.36 inches (0.1 MRAD increments).
  - Each “click” of an MOA scope moves impact 0.26 inches (1/4 MOA increments).

  <u>At 50 yards:</u>
  - Each “click” of an MRAD scope moves impact 0.18 inches (0.1 MRAD increments).
  - Each “click” of an MOA scope moves impact 0.13 inches (1/4 MOA increments).

<u>Procedure</u>

<u>Boresighting:</u>

1. Set up your target with the paster centered on it. Use 100 yards for centerfire, 50 yards for rimfire.
2. Bolt-action rifle: remove the bolt. AR or similar gas gun: separate the upper from lower receiver and remove the BCG from the upper.
3. Do the actual bore-sighting: position the rifle or upper on your support so you can get behind it and sight through the barrel bore. Move the barrel until you can see the paster on the target. Once you have accomplished that, stabilize the rifle/upper with the paster centered in the barrel bore.
4. Now look through your scope. Using the zeroing directions in the scope’s manual, adjust your elevation and windage until your reticle is centered on the target dot.
5. Verify that the paster is centered in the barrel bore AND the reticle is centered on the paster.
6. Repeat steps 3-5 as needed.

Your initial sighter shots will hit the paper if you have carefully followed these steps.

Now reassemble your rifle and set it up on your front and rear support. The front support should be about midway between the trigger guard and front of the fore-arm. Make sure nothing is touching the barrel when you fire. You certainly should not have the barrel resting on your support.

Fire sighter shots:

1. Fire 2 shots (insure that the scope is level). These rounds should land very close together on the paper, but most likely some distance from the target paster's center. (Note: the further apart your shots land, the more difficult it is to establish a good, reliable zero.)
2. Adjust windage to move your group toward center. Using the size of your target paster as a reference, calculate how many "clicks" of windage are needed to center the 2-shot group. Remember to move your turret in the direction you need to move your impact.

   For example, if your group is two paster's width left of center and your paster is three inches in diameter, you need:
   - MRAD: (2 x 3 / .36) = 17 clicks right
   - MOA: (2 X 3 / .26) = 23 clicks right
3. Repeat steps 1-2 until windage is centered.
4. Perform steps 1-3 for elevation.

Finish Up

I can generally get a rifle impacting 1/2-1" from center of a paster in 10-12 shots. After letting the barrel cool, it's time to fine tune to shoot bug holes on your point of aim by adjusting one or two clicks either way.

Again, some scopes' mechanisms may force you to accept a zero that is a small fraction of an inch away from perfect center. Don't waste time, ammunition and barrel life chasing a perfect zero. As you gain experience, you will learn that environmental conditions and your own skill may affect your "absolute zero" on any given day.

Afterword – Concluding the series

I hope the Marksmanship 101 series has shed some light for those members that have had concerns about taking the plunge into LR shooting. This isn't bragging but Woody's has some of the best LR shooters on the east coast. When you do go to the range and see a member who is making consistent impacts on what they are aiming at and they look comfortable doing so, that's the person to ask a few questions. Don't overwhelm them, but do ask and let them enjoy their time. As many of you know, they will often take time and effort to help you gain knowledge and maybe save you time and money.