Long-Range Load Development

Ladder Testing at 1000 Yards

by Jason Baney

SUMMARY: Repetitive, round-robin Ladder Testing with multiple charge weights can reliably identify those loads which deliver minimal vertical dispersion at long range.

Editor's Note: In this article, Jason Baney explains methods that can help long-range competitors shoot smaller groups, and test more efficiently, saving on components and barrel life. Jason is one of the top shooters at the Williamsport Club. In 2006, shooting a 15.6-lb 6BR, he won the Heavy Gun Division at the Williamsport World Open. Jason describes his Ladder-Test system for finding the optimal load for long-range matches, i.e. the load with the smallest vertical dispersion. With loads validated by ladder-testing, Jason has shot 4 of the 17 smallest 1000-yard Light Gun groups at Williamsport over the last three years. Others using this technique have likewise had great results, in some cases cutting their long-range vertical in half. While the Ladder Test method is primarily used to divine optimal charge weight, it can also be used to find the best seating depth or brand of primer.

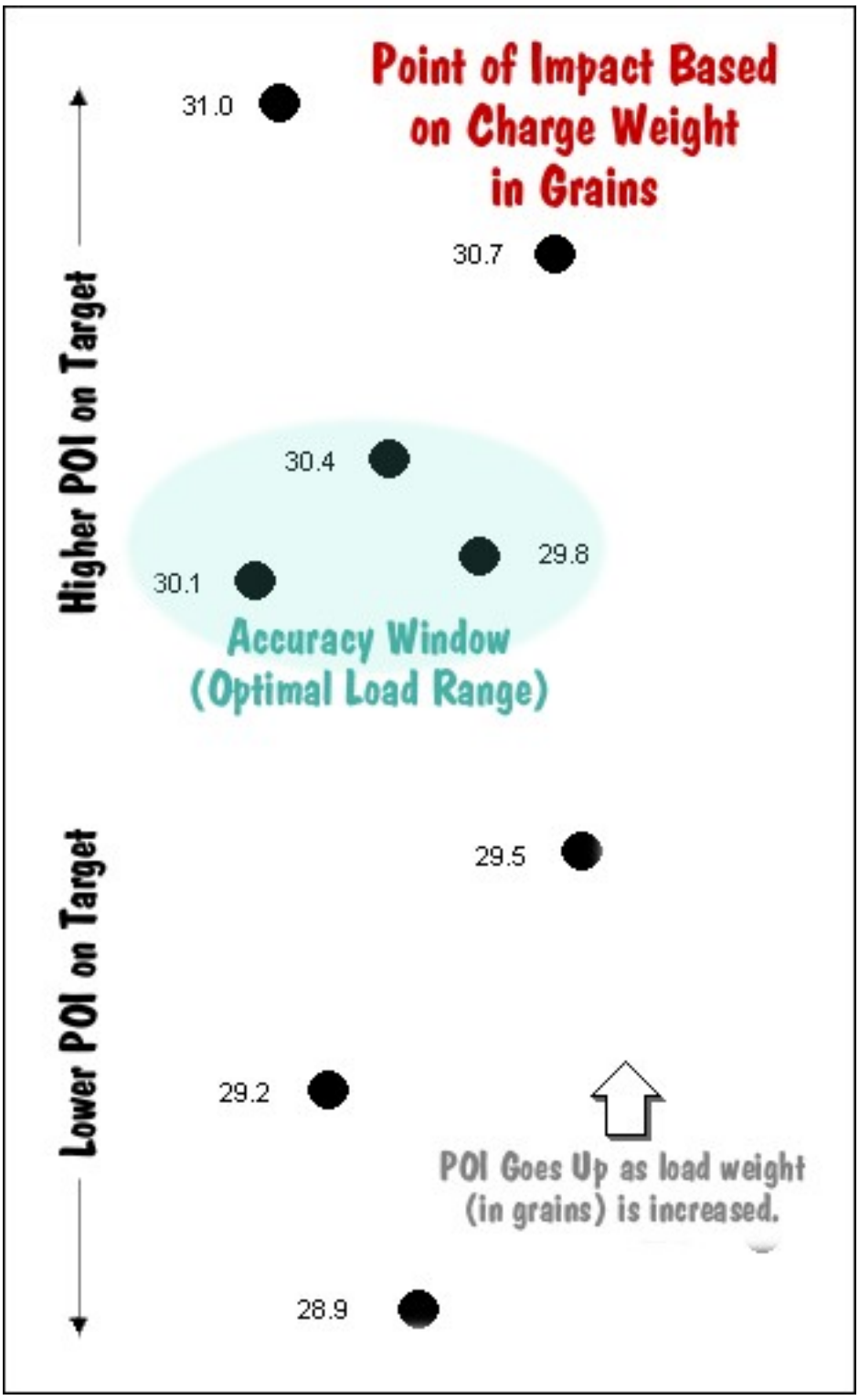
Introduction — Benefits of Ladder Testing

After several months of waiting on your gunsmith, your shiny new rifle is finally done. You have your dies and brass and youre ready to see what it can do. Now it's time to get to work and find out what load that rifle likes to shoot. Load development can be very frustrating for many people depending on their methodology. It has been frustrating at times for me as well, as I have tried many different approaches over the past ten years or so. This article explains my most advanced and efficient method, which has given me the best results. It may even save you some money, components, and range time.

Does this process work? Absolutely. Using my ladder-testing methodology, I developed loads that produced less than 2" of vertical at 1000 yards (using Berger 105gr bullets) for three shots. CLICK HERE to check out my 1000-yard test targets.

Ladder Test Defined

What is a ladder test? A ladder test is, fundamentally, a method of testing a load combination using continuous increments while looking for a cluster of consecutive shots showing similar points of impact (POI). Usually the powder charge is adjusted incrementally while noting/tracking the point of impact variations in the vertical plane, and looking for plateaus on the target. The idea being that your best load will appear where several sequential, incremental charges impact in nearly the same place on the target. Basically you are trying to visualize a "sweet-spot" in the barrel harmonics by using the bullets impact on a target.



For example, let's say test loads of 29.8 grains, 30.1 grains and 30.4 grains of a particular powder land at nearly the exact same point of impact when firing ladder tests at 500 yards (see graphic at left). That powder charge range will presumably be the optimal load range on which you concentrate in developing your load.

Each incremental step in the ladder test will be referred to as a "rung". Each rung will be comprised of 1-3 rounds loaded identically. When there is more than one shot loaded for each rung, that rung will form a "group". So, a "group", as it is used below, means a set of shots that are all loaded identically (same powder charge and identical load parameters). The term "ladder-group" will indicate a group/cluster of many shots that includes several different rungs, or in other words, a cluster of several groups.

Along with powder charge, **the test outlined below can also help find a rifles preferred seating depth, primer brand, and maybe more.** As long as only one variable is changing with each rung (i.e. powder OR seating depth, not both), then the test procedures outlined below can be applied to more than just selecting the right powder charge.

This similarity in point of impact between sequential shots (looking only at vertical separation and ignoring horizontal POI shifts due to wind) will reveal a powder charge range that should shoot to nearly the same POI independent of velocity differences. Well call this the “accuracy window”. In the example above, the accuracy window would be 29.8-30.4 grains of you test powder (given that all other load variables remain the same). This window may represent about a 30-50 fps velocity spread, yet when groups are fired using loads from each end of the accuracy window at 100, 300 or sometimes even 500 yards, the groups will often overlap even though they are separated by more than 0.5 grains of powder. (NOTE: the graphic above left simulates the results of testing at 500 yards.)

Ladder Test Results: The 3-shot groups within the ladder-test-derived accuracy window on my 6BR all exhibited less than 2 inches of vertical at 1000 yards. A couple groups were actually less than 1 inch vertically! Groups that were not in my accuracy window showed 3-4 inches of vertical–more than double the vertical of the groups within my accuracy window.

Several people have previously published their version of a ladder test; I have no doubt their methods work for those shooters. However, I have enhanced and modified the commonly-used ladder test to make a unique procedure that has delivered very good results so far. Results have been repeatable with the same rifle, and other shooters who have used my method with their rifles have achieved similar success. The objective of this test is to extract the smallest groups possible from a chosen load combination. In my case, the ladder test is used to optimize loads for long-range (600-1000 yard) Benchrest competition, where ultimate precision is required. Though this process was developed for long-range Benchrest, it can be easily applied/adapted to shorter ranges, and to non-benchrest rifles and disciplines.

New Tricks — Enhancing the Classic Ladder Test

Target Marked by Colored Bullets

I have added a few twists to existing ladder-type tests that help establish the accuracy window rapidly with no ambiguity of test results. The first and most important modification is **round-robin firing** of the test rounds. That means one shot is fired from each test group before the second shot of any “group” is fired. Round-robin firing serves to balance out wind, light, and other atmospheric conditions by “spreading out” the conditions throughout the whole ladder-group. Basically, it creates no bias towards any one load because you won’t have one load fired in one condition and another fired in different conditions. In the final stage, all test shots are fired in the same time frame, testing 5 different loads simultaneously. This method also seems to address the psychology of shooting, and eliminates a problem that most people have. There is no anxiety as you try to make that tiny 3-shot group into a tiny 5-shot group. You only have to concentrate on firing each shot consistently, because the ladder-group will look like a

mess until you get close enough to see the colored holes (prior to shooting, I color-mark the bullets as explained below).

Round-robin firing has been used by others, but not in this same manner. *Most of the round-robin fired rounds in my method are shot at the same point of aim (POA) instead of shooting each group at a different target. This requires only one setup of the rifle on the sandbags*, so the rifle/sandbag/shooter relationship (angle/contact area/shooter position) is kept as identical as possible between all shots. The rifle doesn't deviate from its initial setup to shoot subsequent groups. This consistent gun placement helps remove one variable: inconsistent shooter and/or rifle positioning within and among groups. Throughout each stage of testing, this process will result in 10-30 shots fired at the same POA.

LOAD DEV STAGE I: Establishing a Practical Maximum

I have divided my load development process into three stages that progressively define the best long-range load. A chronograph should be used during all three stages if possible. Shooting over the chron is essential in Stage 1 so you can establish velocity of the test loads. Also vitally important in all three stages (as well as general reloading), is keeping good records. RECORD EVERYTHING! All velocities and test conditions should be recorded.

The ladder tests will ultimately progress up the target as you shoot faster loads. So, it is important to *always start low on the target with the slowest loads*, and be sure to have plenty of paper to catch all shots as they climb higher. I recommend color-marking your bullet tips so you can easily distinguish bullet holes from different loads. Mark each bullet ahead of the ogive. The marker ink transfers to the

target paper when the bullet passes through, leaving a colored ring around the hole. Clean, unused target paper is helpful, especially at longer ranges. Use a single aim point, low on the target, to assure that all test shots land on CLEAN PAPER. This will allow the colors from the bullets to be more visible. In case you happen to land a shot somewhere that obscures the color from the bullet, a cotton swab with a little isopropyl rubbing alcohol touched to the bullet hole should show you the color. (CLICK HERE for Video demo of swab technique.)

Pressure-Testing Loads (10-25 shots)

This round of testing should be fired at 100-500 yards depending on range availability, rifle accuracy and the shooter's preferences. The purpose here is simply to find the maximum powder charge that could be used for a given load combination, in a given rifle. Once the maximum safe powder charge is established, you can work backwards from there to find the best load. In addition to establishing your maximum safe pressure, Stage 1 can also serve to fireform new brass to give more accurate and consistent performance in Stages 2 and 3. The same 20-30 pieces of brass can be used for all stages if desired.

For this stage, you will want to test 8-10 powder increments to make sure you start low enough to be safe, and end on a high enough powder charge to assure you have found the maximum safe pressure. Fewer increments could be used if you are more familiar with the load combination. There is no need to work in increments smaller than 1% in Stage 1. So, on a 6BR, you would use 0.3 grain or larger increments, and on a 6.5-284, 0.5 grain or larger increments etc. You will use larger charge increments in this stage than in the following stages.

Depending on preference, you want to load 1 or 2 rounds at each powder charge along with several sighters/foulers at the lowest charge to assure enough shots to zero the scope and align the chronograph. Sighters/foulers will serve several purposes during testing. You can use them to adjust your scope zero. They will also be used to foul a clean barrel, as well as warm up a dirty barrel for testing.

Sticking with the 6BR example with 105 Berger VLDs and Reloder-15, a good Stage 1 test window would be: 27.5-31.5 grains: 27.5, 28.0, 28.5, 29.0, 29.5, 30.0, 30.5, 31.0, 31.5 grains. This window will give a very safe starting point as well as assure that maximum safe pressure is established at the upper end. With most rifles, you will probably stop well before reaching 31.5 due to pressure signs. If pressure signs occur while shooting increased charge weights, STOP SHOOTING!

If you load one round at each charge, I'd suggest that all be fired at the same aimpoint consecutively, as fast as possible while still recording results and maintaining accuracy and good form. If you load 2 rounds per charge, you may want to split it up into two separate ladders and let the barrel cool between each ladder. Shoot the first ladder low to high until max safe pressure is reached, then let the barrel cool and repeat. Even though this is just a pressure-testing stage, the resulting ladder-group can still give useful information, and give an indication of where the accuracy window may lie.

WARNING: Always start with the LOWEST charge and work up to the heavier powder charges. Pay attention to increasing bolt lift force, as well as inspecting every case as it comes out for signs of

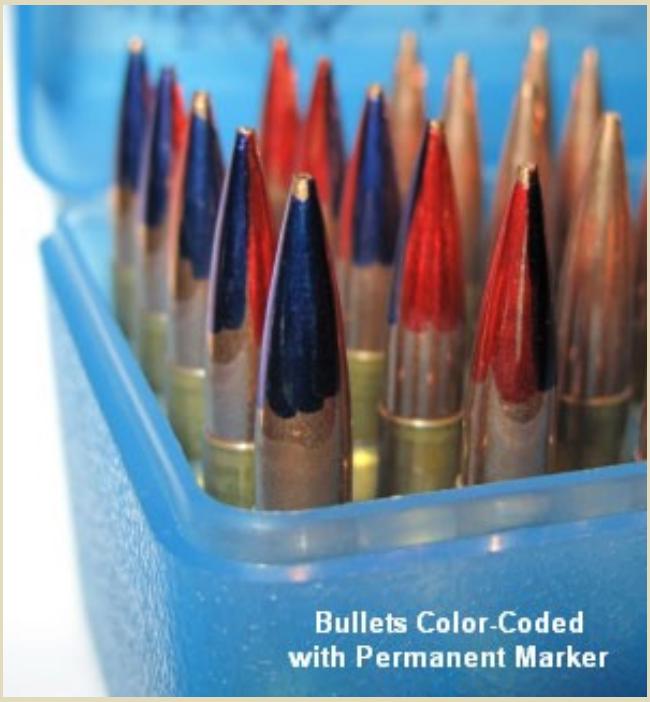
pressure (Primer cratering, casehead extrusion into ejector hole etc.) If pressure signs occur, discontinue the ladder at that point and do not go higher than that powder charge.

Interpreting the Results

Upon firing the ladder, let's say that the 31.0 grain load is starting to show minor indications of pressure and the 31.5 grain load has primer cratering and ejector marks–tell-tale signs of too much pressure. Now we know how high we can go before we hit worrisome pressure. This will determine what we test in Stage 2.

Managing Test Targets — How to Keep Track of Shots

When doing round-robin ladder tests, you normally direct all your shots at the same point of aim. This of course will leave dozens of identical-size bullet holes on the target. How are you going to keep track of all the bullet holes, and discern which holes correspond to which loads? Here's how you can do that.



1) The simplest and least expensive option is to color-code your bullets to distinguish each rung in the ladder. Using a Sharpie or other permanent marker, mark each BULLET ahead of the ogive (see photo). The marker ink transfers to the target paper when the bullet passes through, leaving a colored ring around the hole. One important point here is to make sure the target is clean white or off-white colored paper. I often use the reverse side of a 1000-yard Benchrest target with an orange dot as an aimpoint. You want all of the color-coded rounds to land on a clear section of the paper. Try to avoid targets with other colors, especially black, as the color from the bullet will be obscured by the color of the target. You can even use multiple colors on one bullet. So far, I have found that red, green and blue, and combinations thereof, have worked the best

2) Another option is to video-record the target during your shot strings, or use a wireless camera and video monitor system to watch the target in real time. Be aware, however, that you need to manually log each shot, if you are watching "live" and not recording the test session.

3) When fired at about 500 yards or less, another option is to have someone watching thru a spotting scope to plot the shots in sequential order. This can work well with maybe 6-10 shots, but things can get messy fast when you can no longer pick out the most recent shot among the growing cluster of bullet holes.

LOAD DEV STAGE II: Defining the Accuracy Window

Stage 2 should ideally be fired at 300-500 yards or more. From Stage 1, we saw that we probably want to stay below 31.0 grains of powder. Now that we know where the rifle and load combination achieves max pressure, we can work backwards from that "practical max" to find the most accurate load while maintaining the most velocity with the chosen set of components. Stage 2 will serve to find the accuracy window at which the rifle/load combo should shoot the smallest groups at long range.

For this stage, you will load 3 rounds per charge, covering 6-10 charge weights in about 1% increments. Like the other stages, *be sure to have several sighters/foulers loaded at the lowest powder weight*. This will give you three separate ladders that, when shot correctly, should each show a similar plateau of the shots as they climb up the paper.

Shooting Three Ladders to Reveal Accuracy Window (25-35 Shots)

Usually you will want to shoot the three ladders separately, letting the barrel return to nearly ambient temperature between ladders. If you do this, you will still want to use the round-robin method, but with a twist. *This time you would shoot the first ladder "low to high," (lowest charge to highest charge) then the second ladder "HIGH to LOW", and the third ladder "low to high" again*. This will serve to even out the barrel temperatures at which each round is fired. If the ladders are shot separately, a new aim point should be used for each ladder. Color-coding the bullets with permanent marker will help identify each shot if you don't have someone to spot and record the location of each shot as it is fired.

Continuing with our example, and our data from Stage 1, you would load 3 rounds of each of the following powder charges: 29.2, 29.5, 29.8, 30.1, 30.4, 30.7, 31.0. This will assure that we see what is happening right up to our maximum as well as about 150 fps below that. So, in this case, you would have 21 record rounds (3 rounds at 7 charges), and at least 6 sighters/foulers, for a total of 27 rounds. "Record rounds" in this case will be the rounds that are actually being tested. In a match, they will be the ones that "count" for score. In other words, these are NOT your sighters/foulers.

Editor's Note: Seating depth can have a huge effect on accuracy. In his own tests, Jason started with a seating depth (.020" into lands) known to provide excellent accuracy with the Berger 105gr VLDs in his barrel. If you are working with a new cartridge (or new barrel) for the first time, it may be wise to do some conventional testing at 200-300 yards to determine optimal seating depth. Try 3-shot groups with the same powder charge, but different seating depths. This can help "dial-in" one major variable before you proceed to 1000-yard ladder testing to find the optimal load. Basically you want to determine a good ballpark seating depth (either in the lands or "jumping") before you start extensive long-range testing. As Jason explains however, you can use long-range ladders to

refine your seating depth once the load accuracy window is established.

Ideally, I would shoot a couple sighters/foulers before each individual ladder and let the barrel cool between ladders. Foulers should be shot at a different POA than the record rounds, to avoid interfering with the ladder-group. So, the first ladder would be shot from 29.2 grains up to 31.0 grains. The second ladder shot 31.0 down to 29.2, and then the third ladder would be shot like the first. If you want to shoot all 3 ladders consecutively instead, you would shoot them "low to high" and repeat 2 more times. Shooting that way will assure that no 2 rounds loaded at the same charge are fired back-to-back. When firing all 3 ladders consecutively, it would be best to shoot all the test rounds at the same POA while using permanent marker to color-code each charge.

After all of the shots have been fired, each of the three separate ladders or the one large ladder-group of 21 shots should reveal clustering of consecutive shots/charges (in the vertical plane). In other words, the vertical progress of the shots up the paper should plateau as 2-3 consecutive shots/charges exhibit minimal vertical separation.

So let's say the shots at 29.8, 30.1 and 30.4 grains landed within 3/4" – 1" of each other at 500 yards (that is ?" – 1" in the vertical plane) and there was no other clustering of consecutive shots evident in the rest of the ladder-group. This will be your presumed "accuracy window," and is where Stage 3 will concentrate: between 29.8 and 30.4 grains of powder.

LOAD DEV STAGE III: Confirming the Best Load

This stage will serve to solidify what we have learned so far. Stage 1 showed us our maximum safe load, and Stage 2 helped point to the most accurate load that maintains maximum velocity. The next step is to retest the accuracy window at longer range to further define its upper and lower end, confirming what load the rifle prefers. When all testing is done, you should have a reliable (and repeatable) load window that will yield minimal vertical at long-range. In the video below, I show how my "accuracy window" repeated precisely during two different shooting sessions.

Does the process work? Take a look at the photo below of 1000-yard ladder tests shot during two test sessions (one week apart) with my own 6BR. You can see how different loads clearly produced different vertical dispersions, and how the best loads showed the least vertical in both sessions.

Final Long-Range Ladder Testing (20-25 shots)

Stage 3 consists of 15 record rounds and whatever sighters/foulers you need for zeroing the rifle at 500-1000 yards. The best distance to conduct this test is the distance at which you will be using the load. If your game is 1000-yard Benchrest, it would be best to shoot it at 1000 yards. For 600-yard Benchrest, run the test at 600 yards. Ideally, this test should be shot with fairly calm conditions. I always try to do this test on summer evenings. The best time is about two hours before dark, before

the temperature really starts to drop. When the temperature drops too much, the ground begins to give off mirage from the heat built up during the day. Wind, as always, must be taken into consideration as well. If it is windy enough to easily push a shot off of your target paper, it may be a good idea to shoot on a different day.

In this final stage, you will load 3 rounds each of 5 different powder charges, and several sighters/foulers at the lowest charge weight. This time, increments should be 1% or less of the total load. Don't forget to color-code each charge using permanent marker. To confirm the accuracy window, you also need to test charges on either side of where you suspect it to be. To continue with our example, the accuracy window established in Stage 2 was 29.8-30.4 grains of powder. So, for this final test, you could load 29.5, 29.8, 30.1, 30.4, and 30.7 grains of powder. This will flank the suspected accuracy window with one "rung" on each end. You could also run Stage 3 using smaller increments if desired. In this example, you would run: 29.7, 29.9, 30.1, 30.3 and 30.5 grains of powder. This still flanks the suspected accuracy window, but with smaller steps. I have used both methods, and both worked well and produced the same end result.

The 2-3 charges/rungs that exhibit the least vertical within each 3-shot group, as well as minimal vertical climb between each 3-shot group, will define your accuracy window. You can expect to be able to load anywhere within that window, and get similar accuracy. **The 3-shot groups within the accuracy window on my 6BR all exhibited less than 2 inches of vertical at 1000 yards.** A couple groups were actually less than 1" vertically! That is 3 shots of the same load with about 1 minute of time between each shot. The 1 minute between each shot is due to the round-robin firing method. Groups that were not in my accuracy window showed 3-4" of vertical, or more than double the vertical of the groups within my accuracy window. Realistically, all of the groups fired in Stage 3 with my 6BR exhibited competitive performance (under 4" of vertical at 1000 yards), but those within the accuracy window were half that value. After seeing those results with my 6BR, it is very possible that there are many people out there that can get better groups out of their current load components by just altering their powder charge a little.

Distance Variances in Ladder Results

Thousand-yard Ladders will show different patterns than those shot at closer ranges. At the closer ranges you will often see overlap of groups from consecutive rungs on the ladder. In other words, groups from 2-3 consecutive rungs (i.e. 29.8 grains, 30.1 grains and 30.4 grains), may partially, or entirely, overlap each other vertically. Much of this will depend upon the precision ability of the test rifle. The bigger your groups, the more likely they will overlap. At 1000 yards, with four rifles so far (6BR, 6×47 Lapua, 6.5-284, 284 Win), I have not observed this overlap even when testing 0.2 grain intervals.

What you will see at 1000 yards is reduced vertical climb between each group of consecutive charges that are within your accuracy window. Also, the resulting 3-shot groups within this window (i.e 29.8, 30.1 and 30.4 grains) should display less vertical within each group than the groups outside your accuracy window.

Fine-Tuning Other Variables with Ladder Testing

Once you've found the optimal powder charge with your ladder test, if you wish, you can use the same process to optimize seating depth, neck tension, primer brand and so on. (Further testing isn't always necessary, but may be beneficial.) For seating depth, you could either change the seating depth to a different length, then re-shoot the test with varying powder charges, or shoot an "overall length ladder". Instead of varying the powder charge with each rung, the overall length would be varied. You would still use 3 rounds at each of 5 rungs, but each rung would be a different seating depth and the powder charge would remain constant. This would test 5 seating depths at the same time. This process can also be used to test primers of several brands. You could either switch to a different primer and re-shoot the powder charge ladder, or use a constant powder charge and each rung would then use a different primer. This would allow you to test 5 different primers at one time.

CONCLUSION — This Method Is Proven in Competition

This load development method was used to refine my 1000-yard match load for my 6BR. That rifle has shot 4 of the top 17 smallest light-gun groups at Williamsport since I have been using it there (2006, 2007 and 2008 seasons). Out of about 20 matches total, including 3 World Open Matches at Williamsport, my 6BR has produced six, 10-shot groups under 6.0 inches at 1022 yards.

I have been asked many times how I develop a load for 1000-yard Benchrest. Until recently I had no set method so could not really answer those questions. The process I have laid out has worked well for me. It has also worked well for other shooters at Williamsport who have done it as prescribed. I am making no claims that this is the "perfect" or the "only" way to develop a good long range load. I am simply presenting a process that I have developed that I think most scientifically, and without ambiguity, results in the best load for a given combination of components. Another goal with this process was efficiency. In other words, there is minimal component expenditure, minimal barrel life wasted, and minimal range time required. This process has accomplished these goals fairly well.

Tips for 1000-Yard Shooting & Long-Range Testing

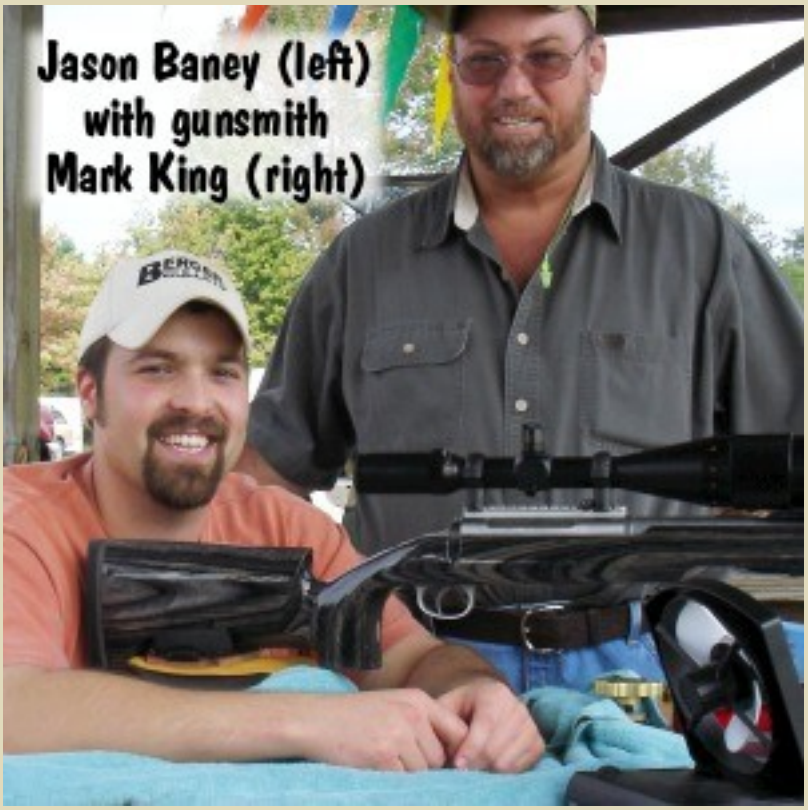
Find a Friend to Spot for You
When running the test at 600-1000 yards, it is best to have a helper along to watch shots go down range to assure the wind has not pushed you off of the target paper during the test. The spotter can either spot impacts, or watch the bullet trace to make sure that the shots are not getting blown off the paper. You can actually do this yourself if the impacts can be seen in the berm at 1000 yards. One problem when spotting for yourself is that it will take a few seconds longer between each shot. Spotting for yourself may also be more difficult with heavier recoiling rifles.

Warm up the Barrel before Record Fire
With benchrest rifles, I never shoot “record rounds” (those that you are actually testing), on a cold barrel. I usually shoot a few shots to zero the scope and foul the barrel, then let it cool and follow up with 1-2 sighters to warm the barrel and confirm zero, followed immediately by the 15 record rounds. Now with hunting and tactical rifles, I try to test from a cold barrel because that is how the rifle will be used. Basically, you want to simulate the conditions in which the load and rifle will be used.

Use your Accuracy Window Parameters to Tune for Temperature
Once your accuracy window is established, the data can also be used to maintain top accuracy in

temperature extremes. Powders react differently to temperature swings, but most if not all will create more pressure at higher temperatures and less pressure at lower temperatures. Some, like Hogdon's Extreme powder, will not be affected as much as most others. With careful recording of notes, you can see what velocities will be at different temperatures, as well as the velocity change per 0.1 grain of powder. You can then use this information to adjust your load based on ambient temperature. Your aim is to maintain a velocity that was within your original accuracy window. This practice has worked well for me, but requires you to have a good idea of the expected ambient temperature when you will be shooting.

Choosing Components for Optimal Long-Range Accuracy



The first thing any reloader needs to do, when working on a new load, is to select the best components for the intended use. This includes brass, bullets, primers, and powder. (Note, in choosing bullets, you also need to consider seating depth and neck tension. For example, if you have a very short freebore the ideal bullet might be different than if you have a long throat.)

Most who have been reloading for a while can settle on their ideal list of components fairly easily. For those that are not sure what might be the best combination, there are many resources available to help with these decisions. Gunsmiths, competition shooters, reloading manuals, and the internet (including AccurateShooter.com), are all great references. You may even make a decision based on components of which you already have a good supply. While consulting these resources, also get a feel for the powder charge range you want to test.

There are several other things to keep in mind when deciding on components for a new load. What is the rifling twist? Is there a combination that is consistently working good for match shooters (i.e 6mmBR with Varget or Reloder 15 and CCI450 primers)? Should you stay away from "slightly compressed" or "almost compressed" loads to avoid the

“zone of uncertainty” where some charges are being compressed and some are not?

Here is an example of preferred components (and settings) that I selected for my 1000-yard ladder testing with my 6BR:

” Lapua cases – Good availability and consistent quality.

” 105 Berger VLD – Suited to 1:8.5” twist barrel and good results from other shooters.

” Reloder 15 – Good velocity for pressure, and has won many matches in 6BRs.

” CCI 450 Primers – Experienced long range 6BR shooters recommend them. The hard cups handle high pressures better than some other brands.

” 0.0015” (1.5 thousandths) neck tension – This setting avoids sensitivity of lighter tension and bullet damage with heavier tension.

” 0.020” “into the lands” seating depth – Preferred starting point (at the time) with VLDs.

TOPICS: Jason Baney, Williamsport, Original Pennsylvania 1000-yard Benchrest Club, 6BR, 6mmBR, 1000 yards, Long-Range, 1000, 1K, Ladder Test, Ladder Testing, chronograph, BC, Ballistic Coefficient, Drag, velocity, bullets.