Reloader Heaven: Instrument Your Rifle, and Toss the Reloading Books. Well, Almost.

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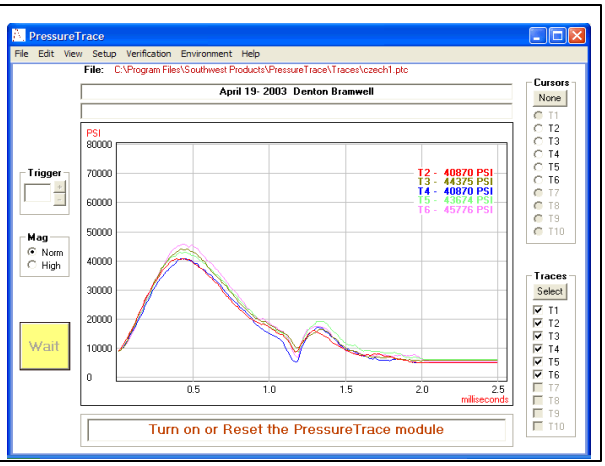
We all know the pressure signs: flattened primers, sticky bolt lift, split cases, etc. But once you start seeing these signs, how much should you back down? Some authors hold that by the time you're seeing classical pressure signs, you can be a long way over the limit. And wouldn't it be better to know before you're over the limit, instead of after? If you want your gun to last a long time, it's a lot better. Fortunately, you can now do your own pressure measurements, without disfiguring your rifle, for a very reasonable cost.

As I've discussed in a previous article, there are three common methods for measuring barrel pressure. Both the CUP method and the piezoelectric method involve drilling a hole in the test barrel chamber. The strain gauge method only requires that you glue a strain gauge to the outside of your chamber. Since the gauge is about the thickness of piece of paper, and about ¼" x ½", it is easily concealed under the stock. Strain gauges are undoubtedly the best of the three for the home reloader.

This is a magazine about hunting varmints, and the example I'm going to show you is from a 1944 issue milsurp M39 Finnish Mosin Nagant. You may wonder if this is an appropriate choice. It is, for two reasons. First, like the wildcats that many of you use, there is very little published reloading data. Second, the Finnish M39 is more of a varmint rifle than you might think. The difference is that in 1939, the varmints worrying the Finns belonged to an invading army, three times the size of their own national army. The tough old Finns used the superior accuracy of their M39 to pick off invaders at long range, and to turn them back.

The hardware is pretty straightforward. You need a laptop computer, and you need the PressureTrace outfit from Southwest Products, www.swproducts.biz, or from RSI, www.shootingsoftware.com. You'll get a strain gauge with connector, to epoxy to your rifle barrel, the PressureTrace interface module, and the necessary computer program. The interface module conditions and amplifies the tiny signal available from the strain gauge, digitizes it, and sends it to the laptop, via a serial cable. Presto! Pressure vs. time curves, and peak pressure readings and statistics for each cartridge fired.

On the far left, a yellow digital thermometer used to measure barrel temperature, then the M39 rifle. The small white box between the rifle and the laptop is the Southwest Products interface. Barrel temperature is an important variable in chamber pressure, so I run most of my tests at a constant barrel temperature of 100^{O}F. I have no idea who the fat guy is.

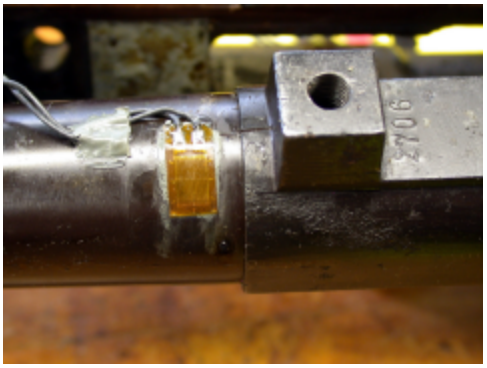


Sample traces, produced by firing milsurp Czech "silvertip" ammunition. At a dime a round, it's attractive for inexpensive shooting, and it's nice to know that the peak pressure is well below the maximum safe limit. We're still debating the source of the little "squiggle" that starts at 1.2 milliseconds.

Installation of the strain gauge is simple, but you do have to carefully follow the instructions. Burt Mitchell, of Southwest Products likes to mount his strain gauges on top of the barrel. I like to put mine underneath, where I can hide them under the forestock. I install a male/female connector in the forestock, just ahead of the trigger guard, so that when I want to take measurements, I just plug in. When I want to remove the barrel and receiver from the stock, it just unplugs from the back side of the same connector. That lets me use a "junker" stock with a male/female connector when I measure pressure in my custom Mauser. When I'm done, I switch it back to its nice walnut stock, and the test lead stores in a small cavity inside the forestock.

Burt used a more dainty connector than the one shown here. By the time I met Burt, I had already been doing pressure measurements for about a year. Since the PressureTrace connector is so small, you might mount the strain gauge on the side of the barrel, with the connector in a small pocket cut in the top of the stock.

In any event, the strain gauge should not be allowed to rub against the stock.



The strain gauge is glued to the barrel, at about the midpoint of the casing. The gray blob to the left is a dab of JB Weld. It prevents me from accidentally yanking the wires off the strain gauge.

This is the old style connector I was using. The one Southwest Products supplies is quite a bit smaller, which is an advantage. Burt was able to supply the parts to make an adapter, so I can use my old strain gauges on my new system.

In my first installation, I mounted the connector a few inches forward of the trigger guard. That was a bad choice. There is this thing called "recoil" that happens when a gun goes off, and if your hand is behind the connector, it's very bad for the connector.

Southwest Products supplies a special "crazy glue" type adhesive with their system. The regular stuff you get at the hardware store will not work well. I mounted mine with JB Weld, which has the advantage of curing slowly. A roll of the thumb to press the gauge down firmly, followed by a taut piece of electrical tape to hold the gauge down snugly while the adhesive cures, help ensure a good adhesive joint.

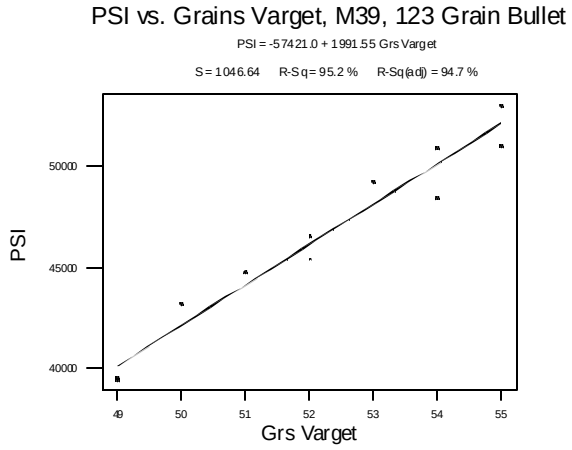
You should put the strain gauge about in the middle of the cartridge case. Actually, I put mine a trifle farther forward. It gets it away from the corner that is left when the threads are cut in the barrel. It may just be a personal prejudice, but the physics of edges and corners tend to be a little squirrelly, so I moved the gauge away just a bit.
Once your gauge is in place, and the adhesive has cured, all you have to do is supply the OD and ID of the barrel, at the point you mounted the gauge, and the gauge factor supplied with the strain gauge, and you're ready to take measurements. If you're instrumenting several barrels, the software will save all this information for each one.

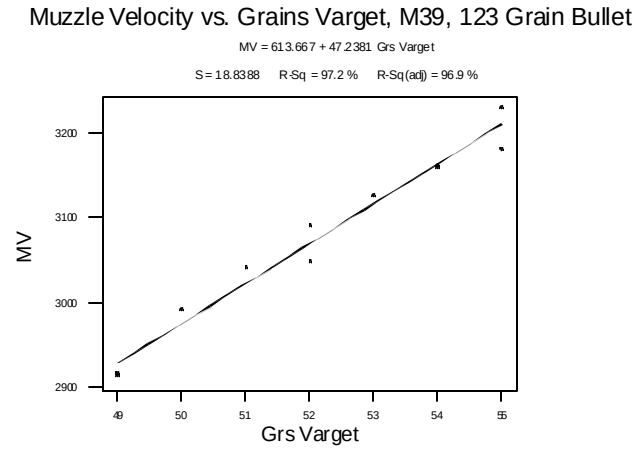
The system makes load work-up a snap, and a lot safer. A good example came along when I decided to see what the old Finn would do with 123 grain bullets designed for the SKS.

I started with what I was sure was a safe load: 49 grains of Varget. I tested loads at 49, 50, and 51 grains, and quickly found two things. First, I was far below the 52 KPSI limit that I feel is safe for my old Mosin. Second, a grain of powder increased pressure by about 2 KPSI. So I estimated that my upper limit was around 55 grains. You can use the LINEST function in Excel, or just plot points by hand, and estimate the line with a straightedge. Most careful "eyeball" estimates are surprisingly close to the ones done with fancy math. I also did the same with muzzle velocity data from my Shooting Chrony. I usually do two shots for each powder charge.

With that knowledge in hand, I made two cartridges at 52, 53, 54, and 55 grains, and recorded data for them. Sure enough, the data fell right in line, and 55 grains brought me out right around 52 KPSI, and 3200 fps. The accuracy of the Finnish M39 is legendary.

With 3200 fps, who says it isn't a varmint rifle? Do you think that iron sights might be a limitation?





If your case has enough capacity, eventually you'll reach a point where, as you add powder, you get more pressure, but not more muzzle velocity. It is prudent to operate below the point that this effect becomes very noticeable.

The $64 question is, how accurate are the results? Are they just relative, or are they absolutely calibrated?

Part of the answer is that the results are very repeatable. With a proper installation, you should be able to get the same answer over and over again, about as precisely as the folks

who publish reloading data. This is expressed as the σ_e. or standard deviation of the random error in the measurement system. As nearly as I am able to estimate, from tests and from published data, the Southwest Products device is much more repeatable than the old CUP system, and about on a par with the best data the piezoelectric system can produce.

The digitization in the interface is an 8 bit system, which means that you can represent 256 levels of pressure. The total range of the system is about 80,000 PSI, which, in turn means that each level is a bit over 300 PSI. That is probably getting pretty close to being the limiting factor in system resolution, and that's not bad resolution. It also means that if you're shooting closely matched ammunition, you'll see the same peak pressure numbers popping up again and again.

How about absolute calibration? That one's a little more sporting.

I spent a very pleasant half hour on the phone with Ron Reiber, of Hodgdon, finding out how they maintain their absolute calibration. You won't duplicate their system at home. They go to impressive lengths to ensure accuracy and repeatability, but, even so, I couldn't find anything in their system that lets them say definitively how much calibration error their system has. About all you can say is that they have gone to extraordinary lengths to minimize their calibration error, and it is surely so small as to be insignificant.

What you have to rely on at home is the accuracy of each of the elements in the system. The "gauge factor", or how much the resistance of the gauge changes for a given amount of applied strain, is supplied to three significant digits. That's not going to be a big source of error. The gain of the amplifiers in the interface module is also easily determined to about the same accuracy. The potential source of error that is hard to nail down is any inaccuracy in the equation that is used to convert strain to PSI. However, that equation has been around for a long time, and has been pretty well investigated.

My conclusion is that the strain gauge system gives you excellent repeatability, and the absolute accuracy is probably decent. But nobody can tell you how decent.

A good "benchmark" is to shoot several types of commercial ammunition, note the peak pressure, and stay below that. I carefully disguised myself, and slipped into an out-of-town sporting goods establishment, and bought a box of Winchester Super X, and some Federal Premium "high energy" ammo for my 30-06. It just didn't seem right to shoot "store bought" ammunition, but I did it anyway, for the sake of science. These two registered 51.9 KPSI and 58.9 KPSI, both completely plausible figures for 30-06 ammunition. The Federal Premiumhad quite a bit of variation, and gave me very slightly sticky bolt lift on a few of the extra zippy rounds. So, in that rifle, I stay enough below 58.9 KPSI to provide a margin of safety for hot days, and feel that I have a more reliable indicator than conventional pressure signs.

What WON'T work as a basis of comparison is to whip up a batch of ammo that has a published PSI or CUP number. That data is taken in a barrel cut to minimum dimensions, and the pressure is going to be…. what? Perhaps 2-3 KPSI higher than what you'd see shooting the same ammunition in a "typical" rifle. Also, Hodgdon uses special test powder, which is right at the center of the specification for that powder. The powder in your jar may be a little hotter, or a little cooler. The good news is that the data you gather with your own strain gauge, on your own rifle, and your own powder, won't have these biases in it.

If your handloads are "too hot", it is unlikely that you'll immediately scatter parts of your rifle across the range. Your rifle will just age far faster than it would with a more conservative load. My theory is that it's best to shoot loads that are a little conservative. If your gun won't deliver the speed and power that you want, it's better to get a bigger gun than to prematurely age the one you have.

Conclusions:

1. The strain gauge system offers the careful user a highly repeatable measurement system for developing loads, without disfiguring your firearms.
2. The absolute accuracy of the system is probably pretty good, but nobody can say how good. In that case, it is wise to use it as though it gave only relative answers.
3. Installation is a breeze. The hardest part is waiting for the adhesive to cure. Even the "crazy glue" requires a day.
4. Results from the system are indicative of pressure in your own rifle, not a minimum dimension lab barrel.
5. Simple linear regression, or the LINEST function in Excel, or even just manually fitting a line to your data, will give you a useful estimate of how much pressure increases for each added grain of powder. That makes load work-up very easy. With 6-10 rounds, I usually know how much powder is safe, and how the load performs over a range of safe values.
6. The system is attractive to handloaders who want their gun to last. The strain gauge gives you a pressure indicator that is informative over the full range of pressures your rifle will "see". You don't have to exceed your gun's limit, and then back down in order to test a load, and you don't have to rely on pressure signs that may not appear until you're far past a prudent limit.
7. The price of a complete system is about on par with a moderately priced scope, and, once you have the basic system, adding more strain gauges isn't a budget buster.