Velocity-To-Charge Ratio: A Good Way To Work Up Safe Loads

January 04, 2011 By Lane Pearce

A couple of situations have occurred recently that reminded me of the fact you can always learn--or relearn--something new and significant related to safe handloading practices. I thought I'd share them with you.

First, how many reloading articles have you read that contain the standard mantra "start with the minimum charge listed and work up as pressure signs indicate it is safe?" So what exactly are these "pressure signs?" Sticky bolt lift? Leaking primer pocket? Flattened primers? Swollen case heads?

Actually, when any of these indications are evident, you've surely already exceeded safe pressures--hopefully without having caused permanent damage to you or your rifle.

There is a better way to work up a safe load. While most of us can't measure pressure, we can readily measure bullet velocity. The only special equipment you need--an accurate chronograph--is well within the means of most handloaders.

I first read about the velocity-to-charge (V/C) ratio several years ago in a loading manual published by the Somchem Ballistic Laboratory in South Africa. Simply stated, it's the bullet velocity divided by the propellant charge weight. The author was Johan Loubser, who is now the ballistician at Western Powder in Montana.

I met Loubser nearly 10 years ago in the Accurate Powder booth at the SHOT Show. The South African native struggled to effectively communicate with this ol' Southern boy. Eventually, he was successful in teaching me a few things about reloading. Fortunately, when Western Powder acquired Accurate a few years ago, my friend was part of the package.

Before immigrating to the U.S., Loubser was the ballistic specialist at Somchem's lab near Cape Town. The company's loading booklet included Loubser's insights on various ballistic performance parameters in addition to the usual load recipes. Promoting the quantitative premise of "if you don't measure it, you can't manage it," he offered a relatively simple method to help shooters assess handload performance

First, assemble five rounds using the minimum powder charge suggested by your reloading manual. Next, fire them to determine the average velocity. Then calculate the handload's V/C ratio and compare it to the V/C values derived from recommended load data in your loading manual. Of course, you must compare apples to apples--same powder type, equal barrel length, same weight bullet, etc.

If the calculated V/C for your handload is higher as compared to the ratio derived from the load manual data, then your ammo/firearm system is generating higher pressures. You may hit the maximum load for your rifle before reaching the maximum charge weight indicated by the manual. Conversely, if the V/C ratio is lower, your system is operating at relatively lower pressures. In order to achieve maximum velocity, you may have to exceed the recommended maximum powder charge.

Loubser stated the average V/Cs for charge weights within the recommended start and max range should be almost constant. As you increase the charge further, both pressure and velocity change from a relatively linear to an exponential progression. He refers to this as the dynamic V/C range (see the graph on page 28). When the dynamic V/C exceeds 1.5 times the average V/C, pressures have become unstable, and you should back off the powder charge.

I reviewed an earlier column on developing a safe .30-06 handload using Alliant Reloder 19 and a 180-grain Sierra GameKing bullet. I've modified the chart to add the average and dynamic V/C values for each test load and retained the velocity and pressure data for reference. As you can see in the accompanying chart, the average V/C numbers are stable as the dynamic values bounce around some.

Then I averaged both sets of V/C data. The results suggest that most shooters should be able to safely handload this cartridge. Loubser refers to the venerable .30-06 as "one of the forgiving cartridges" because the average V/C for ammo loaded even with different bullet weights does not vary significantly.

Lesson learned? Physics is physics; it takes so much work to accelerate a bullet to a certain velocity. Pressure multiplied by area equals force, and force times distance equals work. So, practically speaking, achieving maximum velocity with a specific bullet in the same or similar system requires essentially the same pressure. Just remember: You should not exceed maximum velocities, and you should always stop if the usual obvious pressure signs become evident.

Other Lessons RelearnedWinchester recently introduced a new spherical propellant called Supreme 780. It is intended primarily for loading large-capacity magnum rifle cartridges. Hodgdon Powder Co. distributes Winchester propellants and provides appropriate load data via its online Data Reloading Center. I received a sample for testing and evaluating a few months ago, and I've tried it in several recent loading projects.

During a typical session at the range, I bring three or four rifles along to test-fire. After firing one or two groups with one, I set it aside to cool and select another to fire another batch of handloads. I rotate through the firearms so none is subjected to excessive conditions. I relearned something recently during a typical range session.

I experienced a hangfire. If you've never experienced one, it's when you can discern a perceptible delay between squeezing the trigger and the gun going "bang." Well, this ignition anomaly will typically occur if you use degraded or incompatible primers. Degraded primers can be caused by improperly storing them or by contaminating them before reloading. In my case, I simply used a standard primer instead of a magnum to ignite a relatively large charge of Supreme 780.

Actually, only 60 percent or so of the initial batch of test loads hangfired. A couple of the groups were pretty good, but the chronograph data indicated unstable/irregular ignition. When I reloaded those cases again, I used the same components, but this time I switched to a magnum primer. Back at the range, the hangfire problem was eliminated by the extra oomph of the magnum primer, recorded velocities increased slightly, and the calculated standard deviation dropped precipitously.

On another occasion, I was reminded what you should always do when switching components in a handload. Every manual says to reduce the maximum charge weight at least 5 percent and then incrementally increase toward the maximum load cautiously. I forgot to do this and, thankfully, just experienced an unexpected event with no personal or equipment damage.

I'd worked up a handload for my .257 [Weatherby](#) Vanguard rifle. Of course, by the time I'd reached my accuracy/velocity objectives, I had run out of powder. I checked my magazine, found another 1-pound container, and prepared to reload another batch. Then I decided to assemble just five rounds to verify performance before loading several boxes. I didn't think it was necessary to start low and work up because I had tested this specific recipe several times already with no surprises.

On the first shot, bolt lift was snugger than usual. The same results accompanied the next four rounds. The chronograph tape indicated average velocity was nearly 100 fps faster than my previous experience. Obviously, this powder lot was a bit faster than the lot I had loaded before. I backed off a couple of grains, worked up only a half-grain more, and stopped. My new batch of handloads perform about the same as my earlier pet load did but with 1.5 grains less propellant.

Just before I wrapped up this month's column, another incident occurred worth relating. I was mildly charging some .260 Remington handloads with IMR-4064. If you're not familiar with this propellant, it's a long, skinny-grain stick powder that can bridge in your powder measure or funnel and prevent a full charge from entering the case, and the next charge will be topped off by the leftover from the last case. I always visually inspect each case after charging, so I caught the under- and overcharged pair of cases in the tray before seating the bullets. When you're using powders of this kind, it's not a matter of if it will happen; it's a matter of when. The only thing you can do is be vigilant at all times.

Practically speaking, of course, you're never too old to learn--or in my case, relearn--something about handloading.

Velocity-To-Charge Ratio Revisited

In last October's issue, I described an empirical method one could use when working up a new handload. Apparently I didn't do a good job explaining how to apply it because I received several inquiries from interested but puzzled readers. Let me make amends by emphasizing the key aspects of this handy scheme:1.) You must chronograph your handload's average velocity.2.) You calculate the V/C ratio by dividing the average velocity of a batch of test loads (at least 10 rounds) by the propellant charge weight. For example, .30-06 cartridges charged with 57.3 grains of Reloder 19 should deliver approximately 2,700 fps in a rifle with a 24-inch barrel (according to Sierra's 5th edition reloading manual). The V/C ratio is 2700 Ã· 57.3 = 47.1.3.) Dynamic V/C ratio is the increase in velocity resulting from each grain the propellant charge is increased. For example, if you step up the powder charge by 1/2 grain and the average velocity increases 32 fps, then the dynamic V/C is calculated as 32 Ã· 0.5 = 64.4.) As you work up your hand-load, you should compare the dynamic and average V/C values for each increase in charge weight.

Using the values from 2.) and 3.) above, the ratio of the dynamic to average V/C is 64/47.1, or 1.36. If the dynamic value exceeds 1.5 times the average V/C ratio, you must repeat the specific test load to verify the value. If so, the data suggests your handload is surely approaching the maximum limit, so you may choose to proceed cautiously if there are no other indications of excessive pressure.5.)

If the average V/C ratio is lower than the value calculated using published load data, your handload/rifle system is less efficient than the one used to develop the load manual's data, so you may have to exceed the recommended maximum charge weight to achieve the corresponding maximum velocity. Do so carefully in small steps while watching for obvious pressure signs. Conversely, if your loads exhibit a greater V/C value than the published data, your system is apparently more efficient, and you may reach the maximum velocity listed using less than the corresponding maximum charge weight shown in the manual. Never try to exceed the maximum velocity. The laws of physics regarding energy conversion are quite rigid. If your bullets chronograph even 50 to 100 fps faster, then you're surely exceeding maximum safe working pressure.

Typically, for many reasons, a handloader gets an itch to develop a load for a favorite rifle using a new propellant he hasn't tried before. I started out loading for my .270 Winchester with Hodgdon's surplus 4831. At only a dollar a pound, I didn't mind the dealer scooping it out of a 50-pound keg and pouring it into a small paper sack. Later, I discovered IMR-4350 might be a suitable option. It was twice the price of 4831 but came in a sturdy can that stored on the bench better, plus I thought it might launch the bullets faster and maybe even straighter. I checked out DuPont's load-data sheets and made up some test loads. An electrical-technician friend had recently designed and fabricated a homemade chronograph for me. It was crude and cumbersome to use, but it measured bullet velocities, and as an engineer, I could always use more data.

Looking back at my records and comparing them to the old DuPont recipes, the average V/C for my Winchester Model 70 was 52, whereas the V/C for the DuPont data was 54. As the powder charge increased, the average V/C remained almost constant, and the dynamic value was stable, i.e., increasing essentially linearly without abrupt change. However, according to the V/C theory, because the ratio for my handloads was lower than the DuPont V/C ratio, my handload/rifle system was somewhat less efficient.

In hindsight, I could have safely bumped those early handloads to even greater velocities. I would have had to load more powder than the maximum IMR-4350 charge weight recommended by DuPont, but the groups were near MOA, and another 100 fps wasn't that attractive considering I'd surely be eroding safety margins.

Of course, with the plethora of new cartridges and propellants introduced during the last decade, the situation might arise when you want to develop a handload for a new round with a well-known propellant or even a new one before any published data is available. In fact, I've recently tested handloads for two new rifle cartridges with both conditions. I have enclosed a set of charts that gives the details.

[Hornady](#) recently introduced two new rifle cartridges--the .300 and .338 Ruger Compact Magnums (RCM)--and Ruger introduced two new Model 77 Hawkeye rifles chambered for these short magnum rounds. So I purchased a stainless, synthetic model chambered in .338 RCM and decided Winchester's 760 propellant might be suitable considering the relative case-to-bore capacity (expansion ratio). Later, I ordered a matte-blue, walnut-stocked Hawkeye in .300 RCM. At the same time, Alliant was touting its new Reloder 17 as an ideal short-magnum propellant. Its burn rate was advertised as similar to 4350, so I ordered a couple pounds in order to develop some test loads in the .300 RCM. But there was no Reloder 17 load data.

The experience obtained while testing handloads in the new RCM cartridges meant I could also safely develop Reloder 17 handloads using the V/C ratio method. I considered the following factors before assembling any handloads: Always start with a reduced charge, but not too low--at least 85-percent case capacity. For larger cases, you can increase the powder charge in 1/2-grain increments. Use Magnum primers if you are loading spherical powder (not in this case) and/or if the charge weight exceeds 60 grains (as it does here) to help ensure consistent ignition. Seat the bullet about 0.030 inch off the lands if the resulting cartridge overall length will still fit and reliably feed from the magazine.

Using The V/C Method						
Bullet.	Powder (Type)	Powder (Grs.)	Velocity (fps)	V/C Ratio	Dynamic V/C	Dynamic V/C vs. Avg V/C
.300 RCM						
Hornady 165-gr. SST	Reloder 17	60.0	2830	47.2	---	---
Hornady 165-gr. SST	Reloder 17	60.5	2855	47.2	50	1.1
Hornady 165-gr. SST	Reloder 17	61.0	2892	47.4	74	1.6
Hornady 165-gr. SST	Reloder 17	61.5	2930	47.6	76	1.6
Hornady 165-gr. SST	Reloder 17	62.0	2968	47.9	76	1.6
.338 RCM						
Hornady 200-gr. JSP	W760	59.5	2492	41.9	---	---
Hornady 200-gr. JSP	W760	60.5	2555	42.2	63	1.5
Hornady 200-gr. JSP	W760	61.5	2599	42.3	44	1.0
Hornady 200-gr. JSP	W760	62.5	2645	42.3	46	1.1
Hornady 200-gr. JSP	W760	63.0	2680	42.5	70	1.6
Hornady 200-gr. JSP	W760	63.5	2707	42.6	54	1.3
Hornady 200-gr. JSP	W760	64.0	2723	42.5	32	0.8
Hornady 200-gr. JSP	W760	64.5	2752	42.7	58	1.4
Hornady 200-gr. JSP	W760	65.0	2781	42.8	58	1.4