Powder Temp Stability: IMR Enduron vs. Hodgdon Extreme

POWDER TEMP STABILITY: HODGDON EXTREME VS. IMR ENDURON

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The goal of this field test was to quantify the temperature stability of the popular Hodgdon H4350 and Varget powders and compare those to IMR's new Enduron line of powders. To do this we carefully measured muzzle velocities of meticulously loaded ammo over a huge range of temperatures.

This test was conducted by Patrick Middlebrook. Patrick is passionate about the art of precision rifles. He's a great shooter who has competed in numerous local matches, and several national PRS matches. He is also a 5-star handloader. I've learned a ton from him! Patrick has become a good friend of mine (Cal, the author of PRB), and he mentioned wanting to do a powder test. We collaborated on some ways to approach it, and Patrick took it from there. Patrick is a meticulous guy, and he put in the work on this test. I hope you find it as interesting as I did. Thanks Patrick!

94% of shooters finishing in the top 100 in the Precision Rifle Series (PRS) choose to run one of gun powders from the Hodgdon's Extreme Series of powders, like H4350 and Varget (see the data). While those powders may not always produce the fastest muzzle velocities, veteran shooters have learned to trust that Extreme powders will provide consistent muzzle velocities across virtually any environment. That's because the "Hodgdon's Extreme powders perform just as well at 125° as they do at 0°. Using an exclusive extrusion process and exacting quality standards, Hodgdon has created a line of propellants that performs better at hot and cold temperatures than any other powder on the market."

IMR recently released a new line of powders "with Enduron Technology," which is also marketed to have "extreme temperature stability." ... Sounds familiar! These new powders should compete directly with the Hodgdon Extreme Series, which gives shooters more powder options to consider.

I've heard shooters say great things about the IMR Enduron, and some even say it is just as consistent as Hodgdon Extreme. I wanted to investigate these claims, because "consistency" is a must if you want to be competitive. So I decided to test 4 different powders that are ideal for the majority of calibers used in long-range, PRS-style matches:

- **Hodgdon H4350** – This is an overwhelming favorite for mid-sized cartridges like the 6.5 Creedmoor, 260 Remington, 6.5×47 Lapua, 260 Remington, 6mm Creedmoor, 6×47 Lapua, 6XC, etc. Over 70% of the top PRS shooters load their ammo with H4350 (see the data).
- **IMR 4451** – IMR already had powder named "IMR 4350" with a similar burn rate to Hodgdon's H4350, but it lacked temperature stability. So they designed IMR 4451 to burn in the same cartridges *AND* be more temperature stable. Some shooters have told me IMR 4451 allowed them to squeeze a little more velocity out of their rifles, compared to H4350. We can't confirm or endorse those claims, but it might be something to keep in mind when starting load development.
- **Hodgdon Varget** – If you have been to any rifle match and talked about reloading, it would be hard not to hear about Varget. While you may not have seen this powder in person, because it seems to fly off the shelf faster than any other powder ... it does really exist! When Varget was first introduced, it quickly gained popularity among predator hunters and benchrest shooters shooting the 22-250 and 223 Remington. It has also became a favorite powder for those shooting 308 Win, 6.5×47 Lapua, 6mm Dasher, and other mid-sized cartridges. Varget has a faster burn rate than H4350, but there is some overlap between the two in terms of the cartridges that they're ideally suited for.
- **IMR 4166** – This powder has very similar burning characteristics to Hodgdon Varget, and can be used in the same array of calibers. The good news is this powder is easy to find and seemed to have great results in my test.

Why Should I Care About Temp Stabile Powders?

A change in temperature can affect the trajectory or 'flight path' of the bullet in two well-known ways:

1. So long as altitude, barometric pressure and humidity remain constant, an increase in air temperature will cause a flatter trajectory due to a lower air density (less collisions with 'air particles' per unit length of flight path).

2. **The same increase in temperature also causes the nitro cellulose based powder inside the cartridge to burn at a higher rate, producing approximately four times the Point of Impact (POI) shift than just air temperature alone.**

Just how much does an increase in temperature affect the powder burning-rate? Some powders are more susceptible to temperature effects than others and will burn faster than others.

– Excerpt from Temperature Effects On Zero on KestrelMeters.com

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"The initial heat condition of your powder will affect the burn rate," I heard Bryan Litz explain at his recent Applied Ballistics Seminar. That means swings in ambient outside temperature can affect your internal ballistics, which will directly affect your muzzle velocity, which will change your bullet's trajectory. **Some powders are more affected by changes in temperature than others. So if your goal is first shot hits and you may shoot in a variety of conditions ... you should care about temperature stable powders.**

Earlier this year, there was a PRS match in Nebraska where competitors had to shoot in the snow, and some of the same competitors will be found in Oklahoma shooting "The Heat-Stroke" match mid-July where temperatures could exceed 100 degrees! I've been at matches where you start off shooting in 50° weather in the early morning, and the day heats up to almost 90° by mid-afternoon. When you have temperature swings like that, the muzzle velocity of your bullet could increase by 50 fps or more ... which could be enough to completely miss a target.

There are so many variables involved in hitting long range targets that we need to always be looking for variables to eliminate. If we can reduce the odds that a load might shoot faster in the heat and slower in the cold, it's a worthy pursuit!

At the Applied Ballistics Seminar in March, Bryan Litz gave his rule of thumb for how muzzle velocities may vary with temperature for different types of rifle powder:

- **Good Double-Base Powders:** 1 fps per degree Fahrenheit
- **Average Single Base Powders:** 0.3-0.5 fps per degree Fahrenheit
- **Best Single Base Powders:** 0.1-0.2 fps per degree Fahrenheit

(For more info on single/double base powders, check out this article by Chuck Hawks.)

Bryan specifically cited Hodgdon Extreme Series powders as one of the least temperature sensitive powders he'd used. He also made it clear that **no powder is completely insensitive to temperature.**

Your muzzle velocity WILL vary based on ambient temperature, regardless of what powder you use. So while we can seek to mitigate that variance … at this point, no powder allows you to completely eliminate it. But, you can minimize the effect by making a wise powder selection.

I've seen many shooters pick a load using one of the Alliant Reloader powders, simply because it gave them the highest muzzle velocity. But, many have found those powders to be very sensitive to temperature. It's unfortunate when you see a shooter at a match that seems to be hammering targets dead center early in the morning, but as the day heats up they start missing more and more targets. They lose confidence in their dope, question their rifle or scope, and generally just spiral into frustration. But, many never make the connection that it could be a poor powder selection that caused their trajectory to change so dramatically.

It's even worse if the temperature gets really hot, because the guys who developed a "warm" load with a temperature sensitive powder will start blowing primers … or worse. If they were already close to max pressure when they developed the load, then any increase in temperature can turn into a dangerous situation. To avoid that scenario, when using a temperature sensitive powder the smart choice is to load down so you'll remain within the range of safe pressures even when the temperature rises. But when you do that, it likely eliminates any muzzle velocity advantage those powders may have provided over those that are specifically formulated to be temperature stable.

The Test

The goal of this test was to quantify the temperature stability of the four powders we're interested in. To do this we're going to measure the muzzle velocities of load ammo for a wide range of temperatures. Let me quickly run through the setup of how the test was conducted.

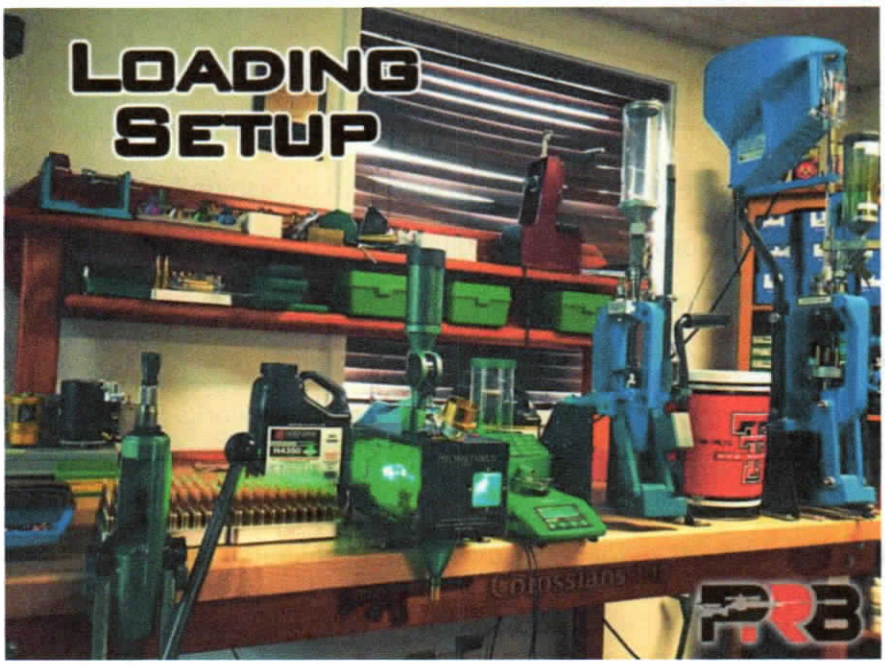
Rifle & Caliber Selection

I wanted to pick a caliber that is widely used in PRS-style matches (see what they use), and that would burn all 4 test powders efficiently. It didn't take long to realize that a wise caliber choice was the 6.5×47 Lapua. There are a multitude of shooters using H4350 and Varget in their 6.5×47's with awesome results. There were also more PRS competitors within the top 100 finishers using the 6.5×47 Lapua than any other cartridge (see the data). I was fortunate enough to perform the test in style, with a full TS Custom rifle build that a friend let me borrow. It had a 22" barrel, which is shorter than average, so your velocities may obviously vary from our results.

Velocity Measurements

I recorded the muzzle velocity of each shot using both a LabRadar Doppler Radar and a MagnetoSpeed Chronograph. The LabRadar is a new type of device that allows you to **measure muzzle velocity within at least +/- 0.1%** of the reading. So if our muzzle velocity is 2,700 fps, the measured velocity should be within about 2 fps of the true muzzle velocity. That's pretty amazing! It actually tracks the bullet out to about 80 yards, taking numerous velocity readings along the way. The muzzle velocities collected proved to be very similar between the two devices, which gave me a lot of confidence in the data. Both of these devices seem to be much more accurate and dependable than traditional light-based chronographs. But to try to mitigate any potential measurement errors, we averaged the velocities collected for each shot from both devices.

Loading Procedure



The ammo was meticulously handloaded with what we believe to be the best equipment available.

Every good load starts with good brass. The availability of quality brass has been such an issue that many shooters choose which caliber of rifle to build based upon what they can find good brass for. Lapua is commonly accepted as the gold standard when it comes to brass quality, and for good reason. Lapua brass is very consistent and tends to last longer than other brands. I've heard shooters getting 20 loadings on 6.5×47 brass (if annealed). Being able to reuse it that many times could mean Lapua is the cheapest brass you can buy! I used brand new Lapua brass and expanded all of the necks with a Sinclair Expander Mandrel to ensure the necks were consistent with no dents. Neck tension is commonly overlooked, but if you want consistent single digit SD's (i.e. your ammo has very consistent muzzle velocities, with standard deviations of less than 10 fps), you'll need consistent neck tension.

Each case was then sized using a Whidden Gunworks Full-Length Bushing Die. The neck was sized to provide 0.002" of neck tension when loading Berger 140gr Hybrid bullet. Match-grade CCI BR-4 Primers were seated using an Accuracy 21st Century Priming Tool, which provides a very good feel and is very consistent. The tool also allows you to fine-tune the seating depth, although I've found my best results come from seating the primer all the way to the bottom.

I then used the Prometheus Gen II Powder Scale to throw all charges. I have checked the Prometheus several times on a high-end Sartorius analytical scale, and each time it confirms what I already know: the Prometheus is accurate down to a single kernel of powder! The Prometheus isn't cheap (starts around $3,800), but if you reload as much as I do, it can save a ton of time, and allows me to go to the range instead of sitting around loading all day. I loaded each case at what I knew would be a mild to medium load, in order to avoid pressure spikes. None of the loads were "tuned" for the specific rifle we were testing with.

When using Berger bullets, everything tends to be very uniform … but never perfect. For PRS-style matches, I don't find sorting Berger Hybrid bullets in any form or fashion helps me put more rounds on steel. I've experimented with "improving" Berger bullets by pointing them and weight sorting them, but it had virtually no effect on my groups downrange. I did see my BC improve slightly by pointing. So if you're looking for every last advantage you can get, pointing may be worth your time! But I didn't do that in these tests. I seated the Berger 140gr Hybrid bullets using a Whidden Gunworks Bullet Seating Die, which have proven to provide very consistent and repeatable seating depth.

At the end of all this, I had a box of 25 loaded rounds of 6.5×47 Lapua ammo for each of these powder charges:

- 39.5 grains of Hodgdon H4350
- 39.5 grains of IMR 4451
- 36.5 grains of Hodgdon Varget
- 36.5 grains of IMR 4166

Freezing & Heating The Ammo

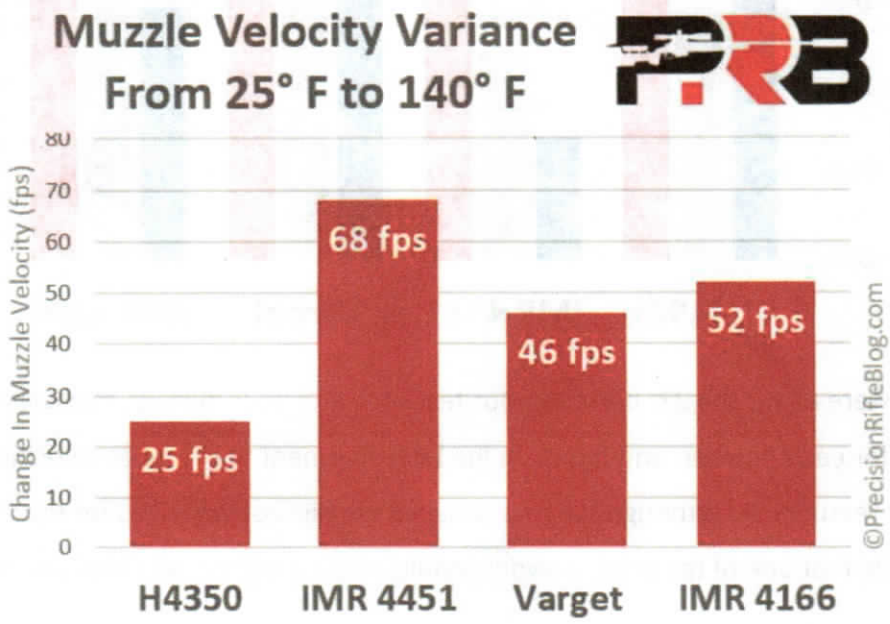
10 loaded rounds from each group were **brought down to 25° F** by placing them in an iced down cooler (mixture of dry and regular ice). They sat in the cooler for 4 hours to ensure they were evenly acclimated to the temperature. A thermometer was placed in the cooler with them to measure what the final temperature ended up being.

Another 10 loaded rounds from each group were **brought up to 140° F** by exposing them to a heating blanket. This might sound excessive, but if you leave your box of ammo out in the sun or on the dash of your truck … it can get up to this temperature. I brought the heating blanket to the range with me, and let all the cases heat up for 2 hours as I prepared the test. Once again, a thermometer was placed alongside the cases to measure the final temperature.

The remaining 5 loaded rounds from each group were used as the control for this experiment, and they were kept at the **ambient temperature of 65° F**.

Powder Test Results

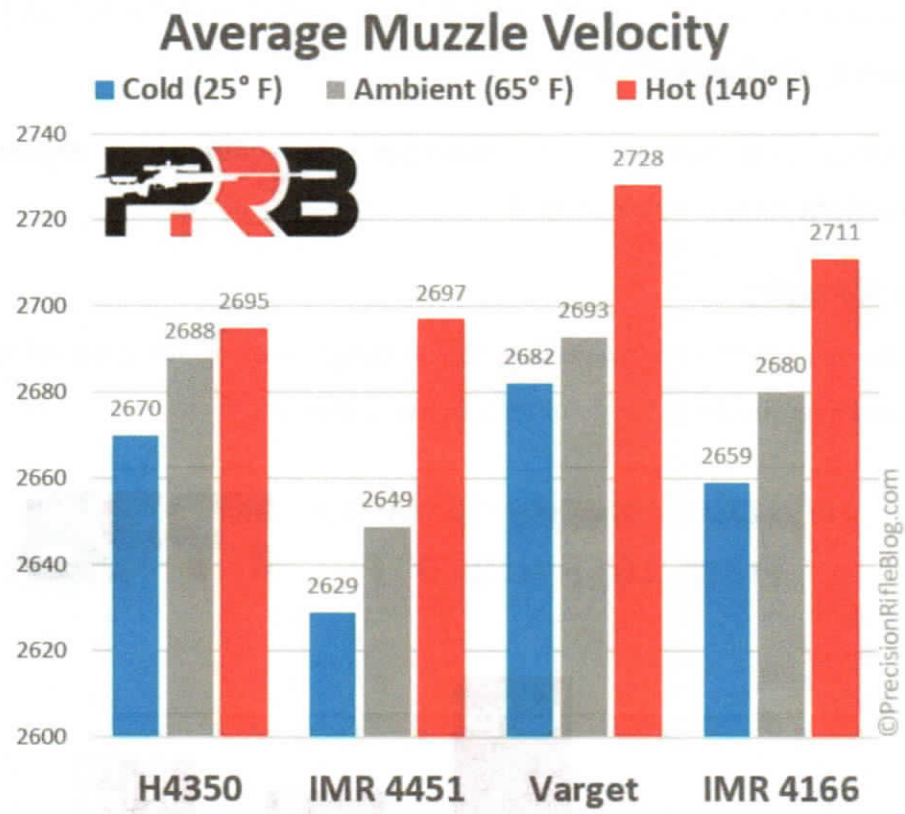
We'll view the results in a few different ways. Let's start by simply looking at the overall variance in muzzle velocity we measured over the entire range of temperature extremes:



You can see Hodgdon H4350 had the least variance in muzzle velocity, with just 25 fps over the 115° swing in temperature! That is very, very low. Hodgdon Varget was the second least temperature sensitive powder in this test, with 46 fps of variance in muzzle velocity between temperatures of 25° F and 140° F. IMR 4166 performed very similar to Varget, and proved to be fairly insensitive to large swings in temperature. IMR 4451 had the largest swing in muzzle velocity of the powders tested, but keep in mind just 68 fps over 115° F swing is still a good performance.

If we would have included powders like Alliant Reloader and others, which are notorious for large swings with temperature … you would see much larger numbers on this graph. We didn't include those, because honestly … we're only personally interested in using powders that are temperature stable. We already know those aren't, so there was no sense wasting time and barrel life on them. **I just wanted to put the results in context; all four of these powders outperform most others out there.**

Here is a view of the underlying data, which shows the average muzzle velocity for each group of ammo:

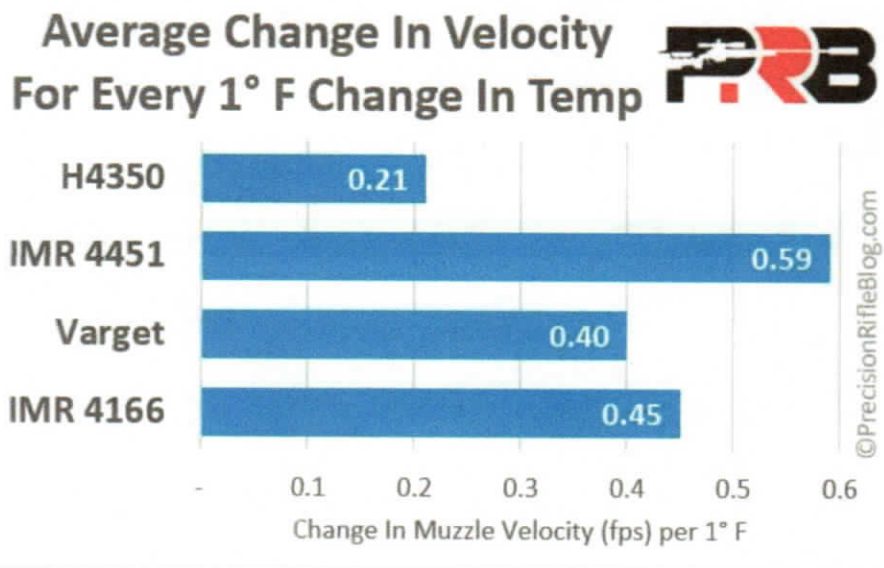


Remember these were all for the 22" barrel on our test rifle, and your mileage may vary. We also just picked safe loads for each powder, and didn't do load development to see what velocities for each powder would be at max pressures. So although Varget produces the highest velocities for the loads we tested, it's more than plausible that one of the other powders could achieve higher velocities and still be within safe

pressures. Our goal in this experiment was simply to quantify how much the muzzle velocities of the powders varied with respect to temperature.

One thing you might notice in the chart above is that the variation in velocity does NOT appear to be perfectly linear across the full range of temperatures. By that, I mean the change per degree from 20 to 65 might be smaller or larger than the change per degree from 65 to 140. That may be surprising, but it's something I've heard a couple industry pros notice as well. That's why I'd suggest you test your own loads at various temperatures, and document what you find. **The Kestrel Elite Weather Meter with Applied Ballistics allows you to enter a table of muzzle velocities for different temperatures, and it will automatically use that data to infer your initial muzzle velocity for the current conditions.** That is a pretty cool feature, and as far as I know it's the only ballistics engine that provides a way to automatically account for this type of variable. But it's only valuable if you have good data to support it.

And here is one more view of the results, which shows how much the average change in muzzle velocity for every one degree of temperature change across the full range of temperatures.



The results were interesting, to say the least! Both company's claim their powders perform better than this experiment indicated … and that could be the case in different conditions. I did notice both Hodgdon and IMR used Winchester primers in their tests. I chose CCI BR-4 primers, because they provide world-class standard deviations with my handloads, and because top shooters I trust have always recommended either CCI or Federal. It's interesting that at every match I've been too, I've never heard of anyone using Winchester primers. *(Note: Hodgdon and IMR appear to be sister companies of Winchester Powders, so that could have influenced their choice.)*

Many accomplished shooters put a big emphasis on using a temperature stable powder, but could we as shooters have overlooked the importance of a temperature stable *primer*? Perhaps a test for another day!

I will note that the H4350 loads in my test had an average SD of 6 fps! The Varget load also had a single digit SD. I did not get single digit SD's with both IMR powders, but they were still respectable. I'm sure I could fine tune the loads for any of these powders and achieve fantastic results.

It seems like we can conclude that this lot of H4350 is measurably more temperature stable than the new IMR Enduron 4451. In fact, Hodgdon H4350 had about half the variance of any other powder tested. IMR 4166 performed very similar to Hodgdon Varget, when it comes to temperature stability. That's great news for those shooters struggling to find Varget in stock! I wouldn't hesitate picking some up and developing a load tomorrow. In a time when it seems like good powders are always "Out of Stock, No Backorder," it's great to have a few more options!