Spring Fling

New valve springs worth 20hp or more!

COMP Beehive™ valve springs reduce harmonics and weight.

Performance is all about pushing the envelope. As camshafts become more aggressive in the search for more power, these lobes make life increasingly difficult for valve springs. This may seem like a problem only for drag racers spinning stratospheric-rpm small-blocks, but this situation applies even to everyday street engines. Valve float and loss of valve control can happen even at conservative engine speeds.

Mass Hysteria

The valve spring's only job is to control the valve. This means that the valve should open and close only when the camshaft signals the valve to do so. Roller cams drastically increase acceleration rates, especially compared to flat-tappet lifters, which means that the valve spring must control a mass that is now moving much quicker at the same rpm. That might seem like a simple thing, but keep in mind that the rocker-arm ratio also multiplies the acceleration rate of the valve. On the opening side of the lobe, the valve accelerates up to its greatest speed and then must start decelerating back to zero velocity at maximum valve lift. Then, the valve must begin to close, accelerating up to a given speed and then back to zero again as the valve closes. All of this has to happen very quickly, especially at high rpm.

All of this sounds fairly simple–and for stock engines, it is. But as we add variables like increased valve train weight and engine speed, the situation changes drastically. As engine speed increases, the valve must open and close in a shorter period of time. What is easily accomplished at 3,000 rpm must be completed in half the time at 6,000 rpm. At 6,000 rpm, an intake valve must open and close 50 times a second! Again, if the valve spring is designed, installed, and used properly, this is usually not a problem. But consider what happens when we add weight into this equation with a larger valve. Simple physics tells us that heavier objects require more force to accelerate, just like a heavier car requires more horsepower to accelerate. Adding larger valves means the valve spring must control additional weight, more than likely at higher engine speeds.

Here's the rub. Bump the valve spring pressure up to increase control, and that additional load pushes down on that little piston inside the hydraulic lifter. At higher engine speeds, the acceleration loads are so great that the lifter is no longer able to maintain the oil in the lifter cavity, pumping the lifter down. This creates excessive lash and lost valve lift that quickly kills power. So, there is a limit to the amount of valve spring pressure we can apply to control this heavy valve train. Of course, we could bolt in a new mechanical roller camshaft, but that's an expensive solution. Since we can't increase the spring load with a hydraulic lifter, the more elegant solution is to reduce valve train weight.

Weight Watchers

Racing-engine builders have known for decades that lighter valve train components allow higher engine speeds without loss of valve control. The key is to reduce weight on the valve side of the rocker arm, because the rocker multiplies the lobe acceleration rate by the rocker ratio. This is the idea behind titanium retainers, valve springs, and ultra-lightweight titanium valves. All of these are excellent ways to reduce the mass of the valve train parts that must be accelerated, but they are also very expensive, and for the most part, race-only solutions. But let us consider the valve spring itself.

For several years, GM has employed a beehive-shaped spring in the LS1 engine. This spring's ovate or oval wire provides more lift without increasing the spring height. It also has a variable rate, meaning that when first compressed, the spring operates with a lower spring rate and progressively becomes stiffer as the smaller-diameter windings compress into the larger coils. Most importantly, the beehive shape reduces the weight of the spring. This is a critical point, because coil springs must use a certain amount of their pressure to control themselves. So, if we reduce the mass of the spring, more of the spring pressure should be available to maintain control of the valve, and it may be able to accommodate a higher engine speed. The beehive shape also uses a radically smaller and lighter retainer. This is important because we're reducing the mass at the top of the spring, which reduces lateral leverage as well. Keep in mind that the top of the spring travels much greater distances and is subjected to greater accelerative forces than the bottom of the spring.

This is the new PN 26120 beehive spring from COMP Cams® that we used in the 454 H.O. Rat test. Note that the top of the spring is smaller, which reduces spring weight, and drastically reduces the weight of the retainer. This allows more of the spring load to control the rest of the valve train as opposed to using that load to control the spring.

Valve Float

Before we go any further, it's important to define what we mean by loss of valve control. This is most often referred to as valve float because the common misconception is that the lifter launches itself off the nose of the cam. While this can and does occur, the more common result of a loss of valve control is when the valve bounces as it approaches the seat. Generally, this will happen to the intake valve first because of its greater weight. This results in a loss of engine power because cylinder pressure is pushed back into the intake manifold instead of remaining in the cylinder. The biggest problem is identifying when the power loss occurs, because it may happen a few hundred rpm earlier than what is considered normal for a given application.

Classic valve float is usually accompanied by a dramatic loss in power and an obvious misfire, but most engines are already suffering power loss from valve float before it becomes audibly noticeable. This is what happened to our big-block and why our engine picked up significant power at the top end of the curve.

Don't Freq Out

Most springs are rated for a certain load at a given installed height. That load is the pressure imparted on the valve to control it. Historically, load has been the main factor in matching a spring to a valve train, but given all the variables of rocker ratios, valve train weight, pushrod deflection, and a couple of dozen other items that affect valve operation, it's easy to see that matching a spring to a cam lobe and valve train requires much more data than just a load rating. Much of this has to do with what is called a spring's natural frequency.

Weighing the individual components quickly identifies the advantage that the conical spring has over the standard single spring. As our sidebar illustrates, the top half of the conical spring is 57 percent lighter than its PN 911 counterpart.

Spring Specs

Spring	Free Length	Outside Dia.	Seat Load	Open Load	Coil Bind	Weight Spring	Ret.	Locks
911-16 Single wire w/damper	2.34	1.525	130 @ 1.900	340 @ 1.350	1.200	117	3[illegible]	7
26120 Beehive™ spring	2.50		160 @ 1.850	355 @ 1.300	1.085	98	7	7

We compared the top half weight of each spring plus the weight of the retainer to illustrate the additional mass of the normal valvespring versus the beehive spring. We added the weight of the retainer to half the weight of each spring. This really isn't fair to the beehive (the weight would actually be less because the top half of the spring would be lighter), but the difference between the two systems is still significant:

½ wt. 911 spring + retainer + locks = 99 grams

½ wt. Beehive™ + retainer + locks = 63 grams

This is a 57 percent increase in mass that the standard spring must manage compared to the beehive spring.

Cam Specs

We equipped the 454 H.O. Rat motor used for our test mule with a COMP Cams® Xtreme Energy hydraulic-roller camshaft (PN XR-282HR) using factory hydraulic-roller tappets.

	Advertised Duration	Duration (@ 0.050)	Lift	Lobe Separation Angle
Intake	282°	230°	0.510 in.	110°
Exhaust	288°	236°	0.510 in.	

At a given rpm, any valve spring will hit a frequency where it will naturally vibrate or resonate like a tuning fork. When this happens, the spring loses much of its ability to maintain control over the valve. This is why most single-wire valve springs come with a flat wire damper. This damper is designed specifically to dampen the spring's natural frequency, especially when the spring resonates at an rpm where the engine spends time. Dual or triple springs use the friction between the inner and outer springs to perform this damping action.

The beauty of the beehive spring is that its conical shape and variable rate creates numerous, yet less dramatic, natural frequencies, which makes it much less susceptible to a loss of control. There's much more to this concept that would take volumes to discuss (and frankly we don't pretend to understand all of it anyway), but it's enough to say that the beehive spring takes advantage of the physics of its design to give it much more control.

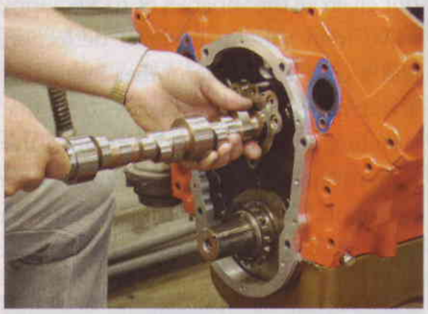
Beehive™ Buzz

COMP Cams® now offers new valve springs that take advantage of this conical-shape technology to complement our favorite engines. One of the engines we have always had difficulty controlling is a big-block Chevy outfitted with a set of hydraulic-roller lifters. This is due in large part to the weight of a typical big-block valve train, which uses large, heavy, 3/8-inch-diameter valve stems. We've experienced mild valve float as low as 5,500 rpm on a hydraulic-roller-cammed 454 H.O. engine.

To prove this point, we bolted up a GM Performance Parts 454 H.O. big-block to Ken Duttweiler's dyno and outfitted it with a COMP Cams® Xtreme Energy 282 hydraulic-roller cam, along with a set of World Products Merlin Jenkins oval-port iron heads equipped with a set of COMP® single-wire valve springs (PN 911), which are the standard springs recommended for this cam. We outfitted the rest of the engine with an Edelbrock Performer RPM Air Gap intake, a 750-cfm Holley mechanical-secondary carb, and an MSD distributor sparked by a 6AL box.

Dyno man Ed Taylor performed the dyno test, equipping the Rat motor with the COMP 911 springs. At around 5,500 rpm, the engine went into serious valve float and would not rev past this point. Given the cam's duration and lift, it should have made power at least up to 5,700 rpm, but clearly the engine was limited by valve-control difficulties.

COMP then sent us a set of brand-new PN 29120 Beehive™ springs designed specifically to address this valve-control problem on the Rat motor. As you can see by the accompanying

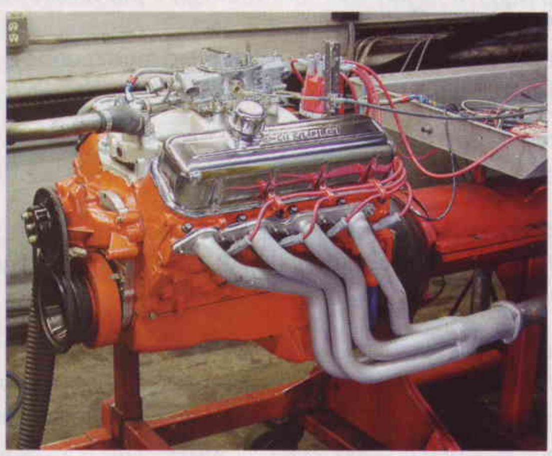


Roller camshafts tend to tax valve springs because of fast acceleration rates. This, combined with load spikes from valve train deflection can really put the hurt on a valve spring if it is not carefully matched to the rest of the valve train.

Testing a valve spring in a load tester like this digital machine will accurately test the spring's load capacity, but it tells us nothing of the spring's characteristics in dynamic situations. As our dyno test indicates, the beehive springs' reduced mass may be worth more than it appears in terms of valve control.

Most enthusiasts purchase aftermarket cylinder heads already assembled mainly for convenience. Unfortunately, the valve springs on these heads may be somewhat generic and not up to controlling the valve train in your performance engine, especially when it comes to the latest generation of roller cams on the market. You may want to consider purchasing the heads bare, investing in higher-quality components and assembling the heads yourself.

One of the biggest valve float culprits is a heavy intake valve. It's not unusual for a big-block to run a 2.19- to 2.30-inch intake valve. It's possible to save a little weight with an 11/32-inch (0.343) stem instead of a 3/8-inch (0.375) diameter, but a stainless steel Rat valve is still between 130 and 160 grams, while a 2.08-inch stainless small-block valve weighs much less at around 115 grams.

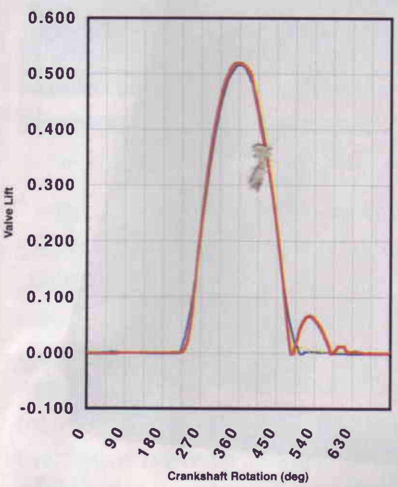


We used a GM Performance Parts 454 H.O. Rat motor as our test mule mainly because big-blocks are notorious for suffering from valve float due to their large, heavy valves, high 1.7:1 rocker ratios, and long pushrods. Just by changing to the conical spring the engine picked up both low-speed torque and top-end power.

Parts List

All part numbers listed here are COMP Cams® pieces. The PN 26918 Beehive™ spring is also a great drop-in for use with the small-block Chevy iron Vortec heads.

Component	PN
Beehive™ spring, big-block	26120
Beehive™ spring, LS1, LS6	26918
Beehive™ spring, LS1, LS6	26915
Beehive™ springs, 4.6L Ford two-valve	26113
Retainer, steel for PN 26120	795
Retainer, titanium for PN 26120	794
Retainer, steel for PN 26918	774 or 783
Retainer, titanium for PN 26918	772



This is a trace generated by COMP Cams®' Spintron valve spring test machine, which accurately measures forces on a spring. Loss of valve control (called valve float) generally occurs as the valve bounces off the seat on the closing side as shown in the two traces. Valve bounce on the intake side causes loss of power, because the cylinder is not sealed when the valve is off the seat.

Test Results

RPM	Test 1		Test 2		Difference	
	HP	TQ	HP	TQ	HP	TQ
2,200	416	174	433	182	17	8
2,400	421	192	447	204	26	12
2,600	449	222	462	229	13	7
2,800	466	248	474	252	8	4
3,000	468	267	479	273	11	6
3,200	480	293	497	303	17	10
3,400	501	325	515	334	14	9
3,600	516	354	526	360	10	6
3,800	520	376	529	383	9	7
4,000	523	398	527	402	4	4
4,200	516	413	518	414	2	1
4,400	504	422	505	423	1	1
4,600	490	429	494	432	4	3
4,800	478	437	485	443	8	6
5,000	468	445	475	452	7	7
5,200	454	449	463	458	9	9
5,400	433	445	442	455	9	10
5,600	412	439	430	459	18	20
5,800	–	–	413	456	–	–
AVG	473.0	351.5	479.7	363.8	10.4	7.2

spring-pressure chart, the Beehive™ spring offers 30 pounds more load on the seat (part of this load is due to the shorter installed height), with open pressures within roughly 5 to 10 pounds. We installed these springs directly on the big-block heads with no prep work and with no other changes so we could do a direct comparative test.

Once the engine was back up to temperature, the first test with the new beehive COMP springs was a bit of a shock. We expected to see a slight increase in power above 5,000 rpm, but what we saw instead was a power increase virtually across the entire rpm band from 2,200 rpm to 5,700 rpm. There was only one point at 4,300 rpm where the power numbers were the same. Amazingly, we picked up 26 lb-ft at 2,400 rpm and then 20hp at 5,600 rpm. The large gains also both occurred at the opposite ends of the rpm scale, with minimal changes in the middle.

We discussed this test with COMP Cams®' spring design engineer Thomas Griffin, and he attributed the increase at low speeds to the additional load pumping the lifter down slightly, which could shorten the cam's duration and boost torque. To test that theory, we installed a set of COMP Cams® mechanical-roller lifters and different pushrods to eliminate the hydraulic lifter as a variable. This is not a recommended procedure, but with a very tight 0.004-inch lash for a quick test, COMP felt we could get away with it. This test revealed 11 lb-ft less torque at 2,400 rpm than with the Beehive™ springs and hydraulic lifters. This was at the 432 lb-ft that was the same exact rpm where we had gained as much as 26 lb-ft. This tells us that Griffin's theory was worth at least 11 lb-ft of the total 26 lb-ft change. However, this still leaves at least 15 lb-ft not accounted for.

Conclusion

This one test should by no means create the illusion that this new beehive spring is the ultimate solution to everyone's valve spring problems. Load is certainly still important to control valves at virtually any rpm, but it's also clear from COMP's dynamic testing and our own quick dyno flog that adding in the concept of valve spring frequency and what the entire valve train needs to ultimately control the valve is also very important. We've also learned that the lifter side of the valve train will benefit greatly from additional stiffness, especially for pushrods (even at the expense of additional weight), while the valve side of the rocker arm will work better by reducing weight. This makes life much easier on the valve spring.

You can expect to see more of this kind of information in the future as valve train testing and experimentation continues, but don't be surprised if you begin to see valve spring pressures become more conservative, especially with the use of these new beehive type of spring designs. Are you prepared to become a cone head? **P&P**

Source

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