SUPER CHEVY

How to Maintain Valvetrain Stability – LS7 Exhaust Valves

Tech - A Weighty Decision

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In the pre-LS era, a typical small-block-powered street car would rev willingly to around 5,000 rpm. You could assemble a cam package for it—even using heavy components—and you probably wouldn't have any problems. With LS engines, however, the redline is in the mid-6,000-rpm range, and the mighty LS7 revs to 7,000 rpm, with some owners pushing things even higher. On top of that, valve lift is typically far greater than anything an old-school small-block would see, with upwards of 0.650-inch lift from a street-friendly hydraulic roller cam. With engine speeds so much higher than they used to be, valvetrain stability has become a more important issue. It's all too easy to slap together an unproven package that generates instability beyond the 6,000-rpm mark, beating up valvetrain components and adversely affecting performance.

"Some people think it's all good, as long as it's not floating the valves on the chassis dyno,"says Katech's Jason Harding. "Valve float kills the power, which is pretty much a [known] fact, but it's the valve bounce that accompanies an instable setup that does the most harm. It's kind of like that adage, 'It's not the fall the kills you, it's the sudden stop at the bottom.'"

When that valve slams shut and then bounces open, sometimes numerous times, it beats up the seats and can break valves or springs.

"Some believe having a double spring makes them safer, because if the main spring breaks, the inner spring will hold the valve from dropping into the cylinder,"says Harding. "Well, how about just making a combination that doesn't break springs? That's our philosophy with the beehive springs that are carefully tested and combined with our packages.”

The theory and practice of valvetrain stability are particularly relevant when it comes to the LS7, because one of the urban legends about it—that it has a tendency to drop or break the exhaust valves—has some merit. There are plenty of documented cases of the lightweight, two-piece, sodium-filled parts breaking. Typically, the valve's head separates from the stem, causing catastrophic damage.

This is an issue experienced mostly by racers and those with more-modified engines—particularly when employing a larger cam—but owners of stock, street-driven Z06s have also encountered it.

Katech engineers tell us their research has found extremely high valve-guide wear in LS7 and LS9 engines—so much so, that in some cases a valve can "wiggle"around in the guide. That, they say, is the culprit behind failures of both intake and exhaust valves, not the valves themselves. For the purposes of this article, we'll be focusing on valvetrain stability rather than valve-guide wear, which is another story entirely.

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Implications of a Valve Change

Of course, an enthusiast who's going to the trouble of upgrading or rebuilding an LS7 will want to know whether replacing the stock valves is prudent. At a glance, swapping the hollow-stem, two-piece sodium valves for conventional single-piece valves seems like a no-brainer, but there are critical implications on valvetrain stability to consider, regardless of the camshaft or valve springs used.

"Since Newton's Law of Motion tells us force equals mass times acceleration, if we change either the mass of the valvetrain components, or the acceleration rates of the camshaft, we change the forces applied to the valvetrain components."says Harding. "Changing the lightweight valvesprings with heavier, solid-stem one-piece valves is going to fundamentally affect the durability of the valvetrain and, ultimately, the engine's performance."

Think of it this way: The mass of the valve and all the reciprocating components of the valvetrain affect the forces in the system. The acceleration and force of the system are dictated by the camshaft lobe profile—or the rate at which the lobe moves the hydraulic lifter—so a careful balance of component mass, stiffness, natural frequency, cam-lobe acceleration, and forces experienced in the system is critical to high-rpm valvetrain stability.

That's why simply replacing the exhaust valves with those with a different mass has significant implications on performance: It upsets the balance that was built into the system in the first place.

We recently attended a test session at Katech's Detroit-area headquarters, in which company engineers tried to definitively determine the effect on LS7 valvetrain stability that comes with changing to heavier solid-stem, stainless-steel exhaust valves.

Note that while there is much more to valvetrain stability than simply the valves—the rocker arms, springs, pushrods, and camshaft all play critical roles—for this experiment, we're focused solely on how heavier valves affect stability.

"You can test combinations endlessly,"says Harding. "Typically, taking weight out of the system can improve stability. You can try a lighter lifter—if one exists—a lighter pushrod, different spring, lighter retainer, lighter valve, and so on. You want the lightest-possible spring that can control the valve. Some try to 'over-spring' the system, thinking a stronger spring will close the valve better, but sometimes slamming it shut hard can cause it to bounce. That's why the lighter beehive springs are usually better."

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01 The LS7 cylinder head is a modern marvel of airflow, but the issue of dropped exhaust valves has prompted many enthusiasts and builders to consider replacing them with single-piece stainless units.

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02 The problem with changing the stock two-piece, sodium-filled exhaust valves is weight: A stainless, single-piece valve is heavier, which can adversely affect valvetrain stability.

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03 The rest of the valvetrain parts can also affect stability, from the springs to the pushrods and even the camshaft. Each incremental change can have a comparatively large impact on high-rpm performance.

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04 Katech’s valvetrain test involved comparing the stability of replacement valves vs. the stock LS7 exhaust valves, as well as the stability of popular camshaft and spring upgrades.

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05 When it came to spring testing, the standard beehive-type was evaluated against conventional dual-coil springs. Many builders use duals as a failsafe against dropped valves, but Katech's tests would show it's not necessarily the best solution.

Setup and Test Components

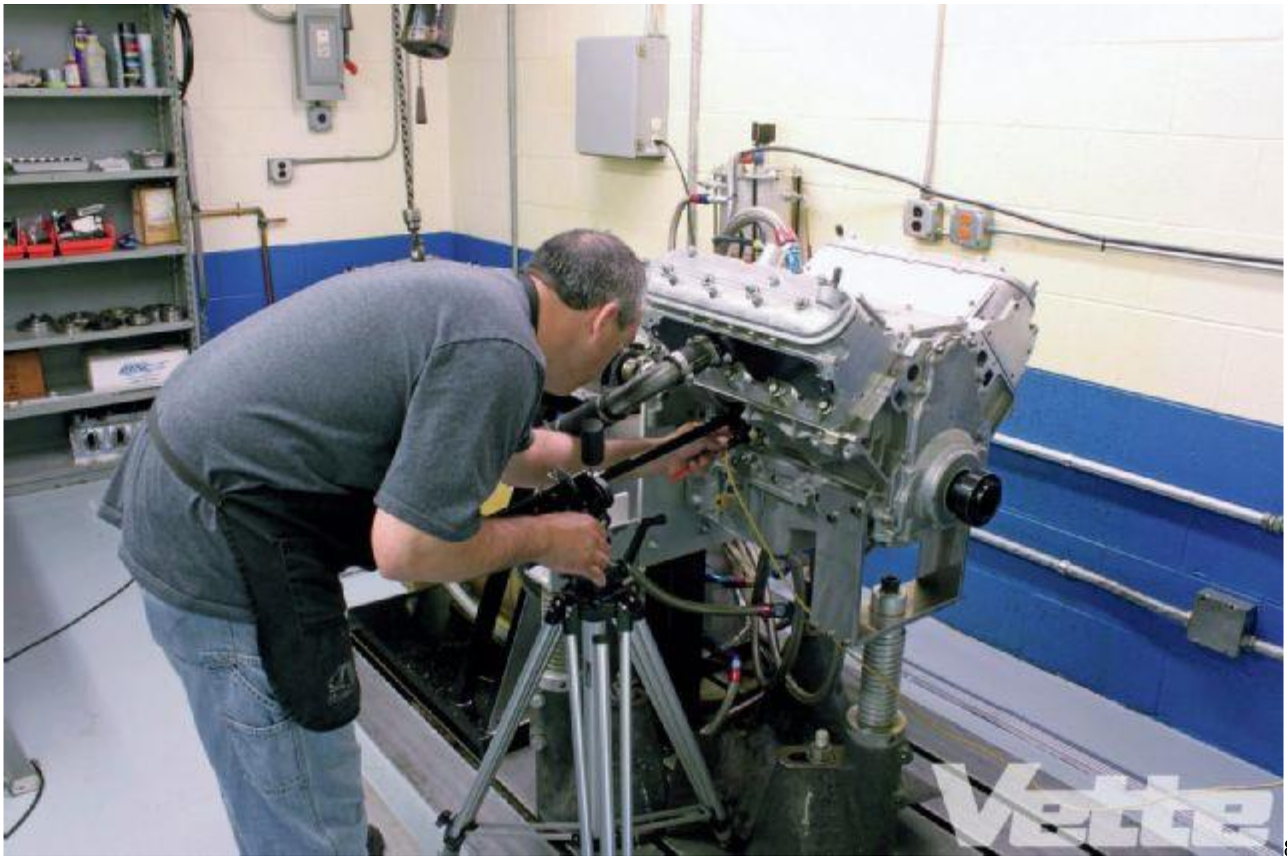
Katech has a Spintron valvetrain test cell that's set up specifically for such stability evaluations. It features a DC electric motor that drives a "spin buck,"which is essentially a test engine with a window cut into a cylinder. There is a dummy crankshaft (no rod journals or bob-weights) and camshaft in the engine, but no pistons or rods. And, of course, there's a complete valvetrain for just one cylinder.

The setup aims a laser at the bottom of a valve, which enables engineers to watch in real time at the control panel how it deflects under load, lofts (floats), and bounces, helping them determine the relative stability of the valvetrain. Katech's equipment measures valve lift in 0.0005-inch increments at 1 crank degree resolution up to 12,000 rpm. With such precise measurement, you can see things you might not expect. The closing event is not the only place you can see a valve or lifter bounce. Sometimes lifters can actually bounce up the camshaft lobe during valve opening.

For the record, the test used a stock LS7 camshaft and valvetrain as the baseline and featured tests with Katech's higher-lift Torquer camshaft and PSI beehive springs, as well as dual springs. When it came to the exhaust valves, the stock ones were compared with heavier single-piece, stainless valves from Racing Engine Valves (REV) and Katech's own lightweight titanium valves with molybdenum-coated stems.

The stock LS7 exhaust valve weighs 74 grams, while the REV exhaust valve weighs 98 grams—a significant 33-percent increase. The titanium valve used in the test came in at a featherweight 66 grams.

It should be noted that while lighter than the stock exhaust valves, titanium valves should not be swapped directly without additional cylinder-head preparation aimed at preventing stem and/or head wear. Some race shops insist on having them micro- polished and coated with a chromium-nitride or similar material. Katech recommends molybdenum-coated stems on titanium valves, and only when used with bronzed valve guides in the heads.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06 Katech's test cell is fitted with a specially equipped LS7 "spin buck," which is used with a laser to gauge valve bounce across the rpm band. Less bounce means greater stability.


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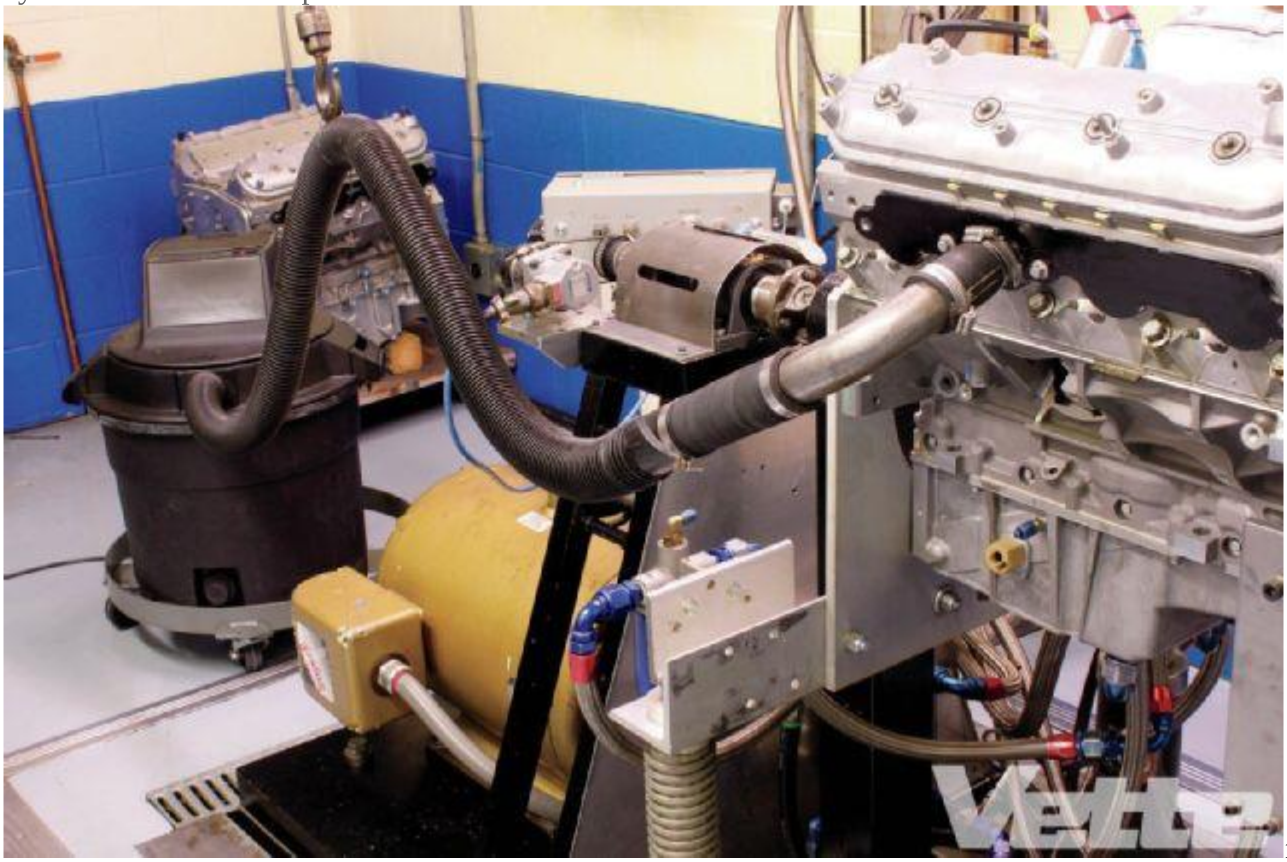
07 The sacrificial LS7 engine was relieved of a cylinder wall in order to insert the laser gauge. It goes in the cylinder and is aimed up at the valve faces.



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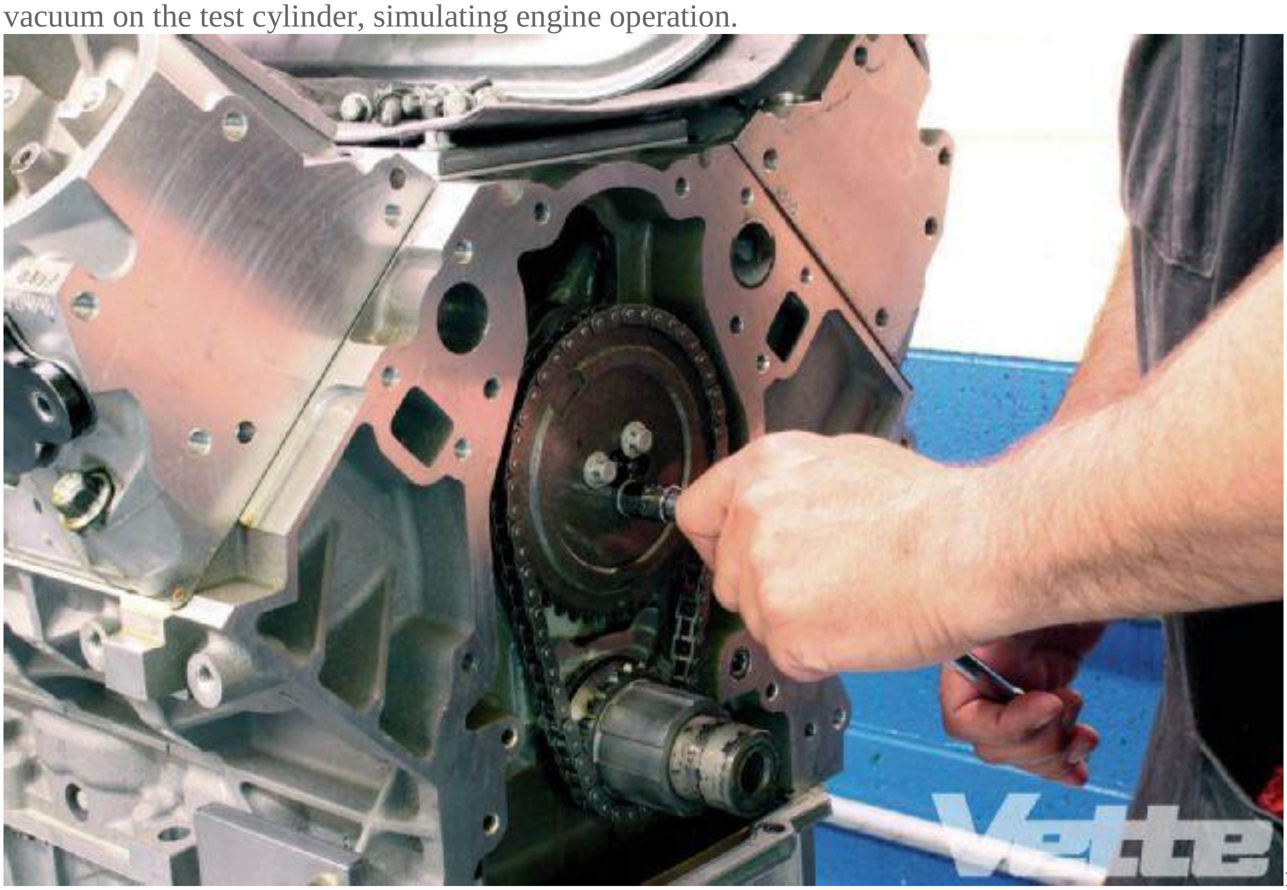
08 Complementing the high-tech laser gauge tool is the decidedly low-tech shop vac, which is used to draw a vacuum on the test cylinder, simulating engine operation.



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09 The spin buck is equipped with a crankshaft and camshaft. They're spun together via the standard timing chain, but there are no rods or pistons in the engine.


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10 The combustion chamber and valve faces are painted white on the test head for more-accurate readings with the laser, which measures the movement of each valve as it opens and closes.


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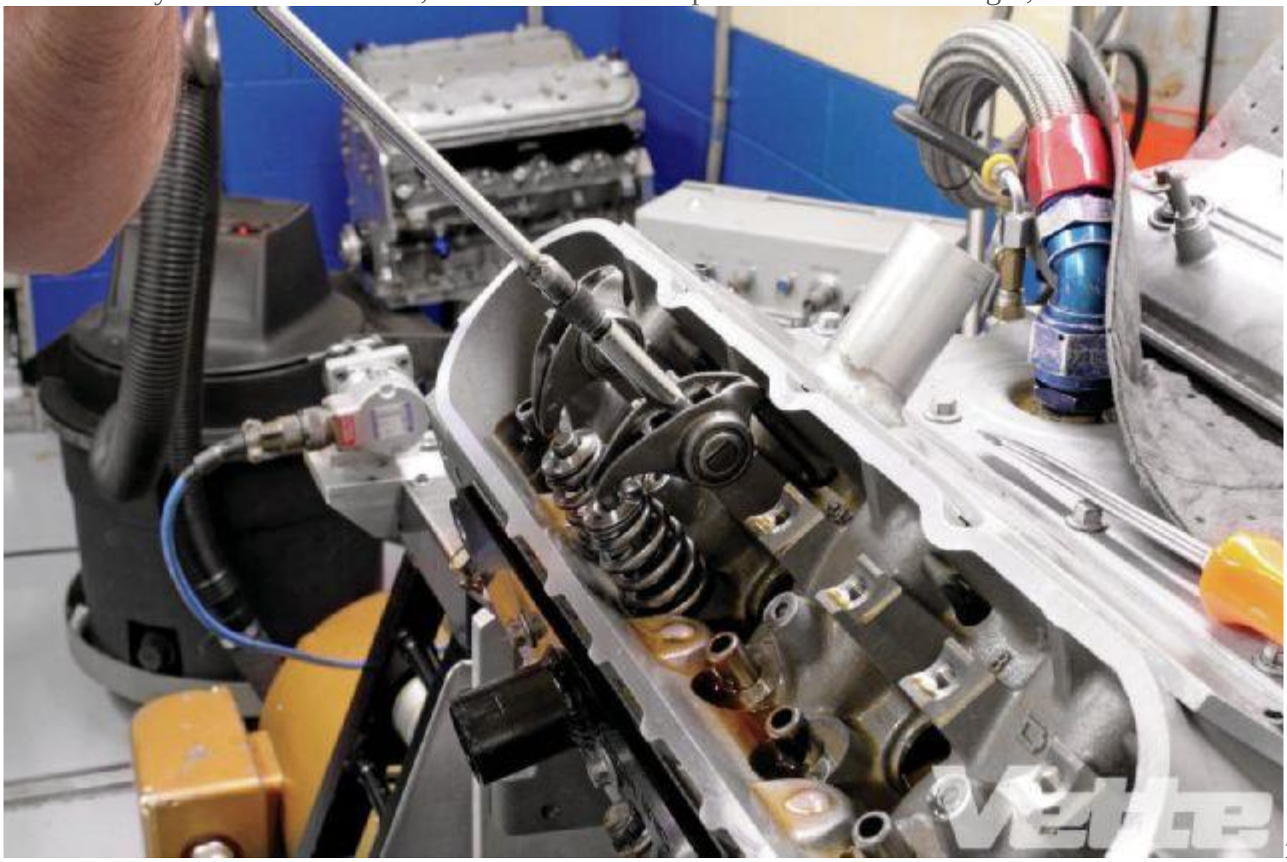
11 The test measured the performance of the stock LS7 valve (74 grams), a REV stainless valve (98 grams) and a titanium valve (66 grams). The heavier stainless valve doesn't have the separation issue that has occurred with some factory sodium-filled units, but with about a 33 percent increase in weight, it is less stable at high rpm.



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12 Katech's test also measured the stability of the valves with the stock beehive springs, higher-rate PSI beehive springs, and dual-coil springs. The beehive design proved to be the most stable at high rpm.


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13 The bounce of each valve on the valve seat was measured and compared with the baseline test.


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14 Bottom line: When it comes to high-rpm valvetrain stability, the stock LS7 exhaust valve performs best with beehive springs. Builders worried about dropping the stock valve at high rpm can have the head fitted with

bronze valve guides, which should do the trick. The titanium valve performed well, too, but it's a costly alternative that also requires bronze guides.

Results and Recommendations

To no one's surprise at Katech, changing to solid-stem stainless valves proved to have a negative effect on the LS7's valvetrain stability. Interestingly, while the test was focused primarily on the exhaust valve, the effect on the intake valve was also noteworthy.

"Consideration for when a valve is out of control is subject to debate; however, 0.015-inch of bounce is the basis we use for our recommendations,"says Harding. "Keep in mind that we only tested for limiting speeds and did not perform durability testing. If this was a professional racing program, we would go back to the tests we want and run 24-100 hours of durability on the configuration to see what breaks, if anything."

Here's how seven combinations performed, along with Katech's test notes:

TEST 1: Stock cam and springs, with stock exhaust valve

Intake valve: 0.006-in. max bounce at 7,000 rpm; tested to 7,500 rpm

Exhaust valve: 0.008-in. max bounce at 7,100 rpm; tested up to 7,500 rpm

TEST 2: Stock cam and springs, with REV solid exhaust valve

Intake valve: 0.006-in. max bounce at 7,000 rpm; tested to 7,500 rpm

Exhaust valve: 0.015-in. max bounce at 7,100 rpm; tested up to 7,500 rpm

Katech notes: Nearly twice the bounce by simply changing the valve. This combination is fine for a street car, if the rev limiter is set at 7,000 rpm. In road-racing conditions, we prefer to see a 500-800-rpm safety margin, which would mean a 6,300-6,600-rpm rev limit.

TEST 3: Stock cam and dual-coil springs, with REV solid exhaust valve

Intake valve: 0.014-in. max bounce at 7,300 rpm; tested to 7,500 rpm

Exhaust valve: 0.016-in. max bounce at 7,200 rpm; tested up to 7,500 rpm

Katech notes: Twice the bounce overall of the stock configuration, but within the realm of acceptability. This combination is fine for a street car with the rev limiter set at 7,000 rpm. In road-racing conditions, it would be a 6,400-6,700-rpm rev limit.

TEST 4: Katech Torquer cam and PSI beehive springs, with stock exhaust valve

Intake valve: Not tested

Exhaust valve: 0.015-in. max bounce at 7,700 rpm; tested up to 7,700 rpm

Katech notes: This is a strong combination—proven and stable. Fuel cut-off should be 7,100 rpm with it.

TEST 5: Katech Torquer cam and PSI beehive springs, with REV solid exhaust valve

Intake valve: Not tested

Exhaust valve: 0.016-in. max bounce at 7,100 rpm; tested up to 7,500 rpm

Katech notes: This combination is not recommended, because valve bounce exceed the 0.15-inch threshold, although the PSI spring did control the REV valve better than did the dual spring.

TEST 6: Katech Torquer cam and dual-coil springs, with REV solid exhaust valve

Intake valve: 0.018-in. max bounce at 7,100 rpm; tested to 7,100 rpm

Exhaust valve: 0.029-in. max bounce at 7,100 rpm; tested up to 7,100 rpm

Katech notes: Talk about instability! The severe bounce displayed at comparatively low rpm made it unwise to continue testing up to 7,500 rpm. We flat-out don't recommend this setup.

TEST 7: Katech Torquer cam and PSI beehive springs, with titanium exhaust valve

Intake valve: Not tested

Exhaust valve: 0.014-in. max bounce at 7,900 rpm; tested up to 7,900 rpm

Katech notes: Minimal bounce at 7,900 rpm! This is an excellent combination all the way to 7,800 rpm—as long as the prep work has been done to the valve stems and bronze guides are used in the head.

In summation, the factory configuration unsurprisingly delivered the most stable performance, with the heavier, solid stainless valve matched with a dual-coil spring delivering the greatest instability. There's excellent high-rpm performance with the titanium valve, but it's a decidedly pricy endeavor.

"Since we are able to get a stable valvetrain with the OEM valve and have demonstrated it to be durable when using our completely tested systems, we don't find it necessary to change the exhaust valve,"says Harding.

And what about the fear of dropping one of those OEM valves? Harding suggests that while it's certainly a concern, it shouldn't be an overriding factor when considering the valvetrain – even if it involves a "bigger"camshaft.

"We believe using the titanium exhaust valve delivers the best performance when used with bronze guides,"he says. "If cost is a factor, OEM valves are proven to be durable when combined with a valvetrain system that has been validated.”

And those bronze valve guides help, too.

Sources

Katech Inc.
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