

COMPRESSOR BYPASS BLOW-OUT

We test 17 blow-off valves

BY MIKE KENT
PHOTOGRAPHY BY JOSH JACQUOT



I first became aware of the problem nearly a decade ago. That day, like most, I tried to finish my drive to school with a glorious, ass-out slide into the parking lot. Deep down, I always hoped to impress the chicks. It never seemed to work.

Settling into my zero period math class, the voluptuous Virginia asked, "What's wrong with your car? It sounds like you ground your gears coming into the parking lot." As my pride evaporated, I tried desperately to explain that it was actually the sound of my shiny new HKS compressor bypass valve, which... The blank stare told me not to bother.

I realized two things that day. Virginia doesn't care about bypass valves, and many of those who do don't understand them.

Compressor bypass valves, commonly known as blow-off valves (BOV) or diverter valves (DV), are a solution to a real problem.

In turbocharged and centrifugally supercharged engines, the compressor often tries to flow more air than the engine (or closed throttle plate) will accept. Every time you shift a turbo car, for example, the turbo has to pump against a closed throttle plate. Pressure piles up in the pipe and pushes backward through the compressor. This causes all sorts of bad stuff to happen; compressor wheel blades resonate, thrust bearings fail.

Ball-bearing turbos can handle this surge, but conventional bearing turbos can be killed quickly. The real bummer with either kind of turbo is this backpressure slows the turbo, increasing lag the next time power is demanded.

Centrifugally supercharged cars have similar problems, but since the compressors always spin with the crank, even high-rpm cruise can make the compressor fight the throttle. Since superchargers won't slow, they waste large amounts of horsepower fighting the pressure buildup.

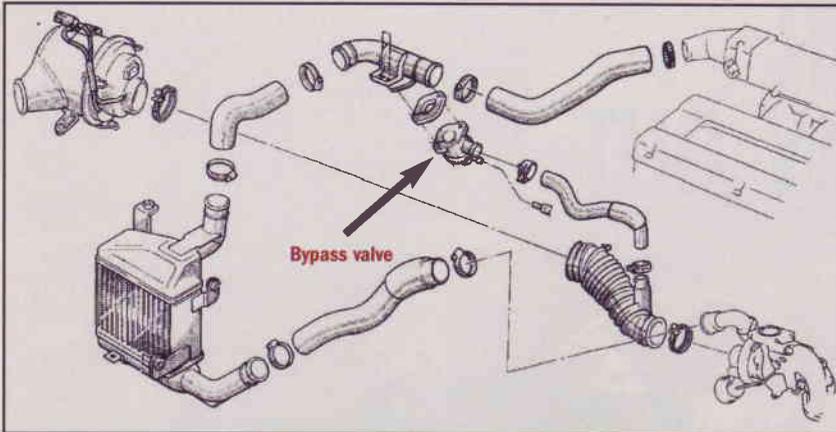
The opposite problem also occurs. At low rpm and high throttle angles, the engine



often demands more air than a laggy turbo is pumping, making the compressor little more than a restriction.

Compressor bypass valves can alleviate both problems. Blow-off valves vent the pressure to the atmosphere, while diverter valves recirculate the air back in front of the compressor. So-called "hybrid" valves are just a mix of the two, recirculating air at light load, and venting some at high load. Selecting the correct valve type is key.

If your engine management is speed-density based, both styles of valve will work. Mass airflow (MAF) vehicles require a DV setup to ensure correct fueling, otherwise



Typical layout of intercooler and plumbing in a FWD turbo application. Notice the compressor bypass valve location, and direct plumbing back to the turbo inlet.

Photo courtesy of Mitsubishi Motors of America

the air blown out the blow-off valve will be measured by the MAF, and fuel will be delivered, but that air will never reach the cylinders. This can profoundly affect driveability. Diverter valves can be used as blow-off valves by simply not recirculating the discharge, but be sure to put a filter on the end if the valve opens under vacuum.

Bypass valves should be placed as close to the throttle body as possible. Since pressure surges begin here, it's the best place to stop them. The exception to the rule is that any additional fuel injectors or nitrous oxide nozzles should be placed after the valves. The routing of air back from a DV to the compressor inlet is important, too. Try to keep the path smooth and straight, but most of all, be sure to direct the air back into the compressor. Sending air backwards out the MAF will give it a false signal and degrade driveability just as much as venting the air. A bonus for recirculating the air is an increase in pumping efficiency, as the compressor doesn't need to draw additional air through the filter. This keeps compressor speed up, further reducing lag.

Vehicles with long, complex inlet and intercooler plumbing will benefit from DVs that open under vacuum conditions. For many years, OEMs have designed these valves to open under light load, allowing the engine to draw air directly through them from the MAF/filter, bypassing an idling turbo and the restricting intercooler plumbing. Much like two resistors in

parallel, the net loss is lower than either individual avenue. Throttle response at these low loads improves, as does turbo spool and economy.

How important is it that MAF cars have recirculating diverter valves rather than open-air blow-off valves? To make a BOV work successfully involves a long string of compromises. To keep the BOV from leaking at idle, which would introduce unmeasured air, the spring has to be excessively tight. This slows the valve's response, and allows brief periods of surge. In addition, any time the valve opens, air is lost and the vehicle runs too rich. This usually shows as a hesitation or flat spot in throttle response. Recirculating the discharged air doesn't necessarily eliminate all the cool blow-off valve sounds, either. Any open-element air filter will let you hear it just as well as if it vented to the open air.

It should be stated that compressor bypass valves are not designed to limit boost under normal conditions. Pop-off valves, like those used in CART, Le Mans, and professional motorsports, are a separate animal entirely. These valves are designed to limit boost and power, as mandated by regulations, and are of no real use for street cars.

Interestingly, we have seen some rally cars, specifically Subaru's Pro Drive-prepped Open-class U.S. rally cars, running very small valves in an effort to keep some pressure in the pipe during shifts. This

compromise allows some surge, but according to its data gathering, maintaining about 4 psi in the pipe during a shift makes them faster. This should only be considered with a ball-bearing turbo, of course.

TESTING

Always the inquisitive bunch, we gathered every compressor bypass valve in arm's reach for a little real-world testing. Our goal was to get a feeling for how different valves would perform under similar conditions, on a relatively common vehicle. Jason Gardner of Diamond Star Specialties (DSS) in San Luis Obispo, Calif., the sucker that he is, offered up his 1993 Mitsubishi Eclipse GSX for testing.

Modifications to the Eclipse were minor; an AFC-MASC with cone filter replaced the stock air box and MAF assembly, 2.5-inch DSS upper intercooler pipe, ported 2G (or second generation) exhaust manifold, 16G turbo, ported O₂ housing, and Walbro fuel pump. The wastegate was plumbed directly to manifold pressure to eliminate any variation induced by an aftermarket boost controller. Our tests were run at a relatively mild 9 psi of boost. Some of the valves will respond differently at higher pressures.

All the bypass valves were mounted to a common adaptor plate on the same section of intercooler pipe, and used the same dedicated manifold pressure hose. Adjustable valves were set to the lightest setting. All the diverter valves were plumbed to recirculate, with the exception of the Subaru and Vortech. These two have somewhat goofy discharge passages that just weren't going to work with our setup.

For a baseline, and to see what compressor surge is really all about, the stock bypass valve discharge was plugged, rendering it useless. Using an Edelbrock Quickdata datalogger, we logged throttle position (TPS) and pressure in the compressor discharge pipe during a one-to-two gear change.

From the graph, it's clear to see the compressor discharge pressure rise as the throttle is closed. This is to be expected and really isn't all that bad since the compressor

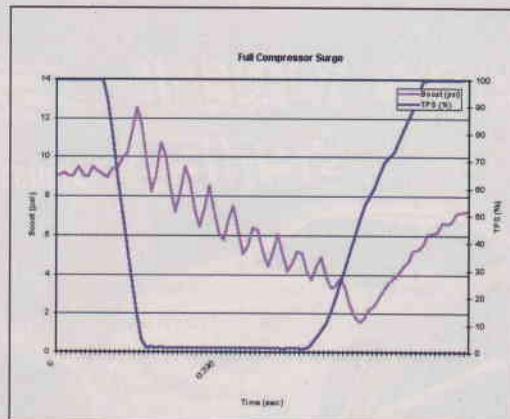
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is designed to compress air. As the flow through the compressor stalls (remember the throttle is closed), and discharge pressure increases, the compressor enters surge. Much like a spinning tire or cavitating prop, the compressor spins but no air moves, then it does, then it doesn't, over and over. The event is audible, and has a warbling sound. Not "Wooo, wooo," rather "Wuh, wuh, wuh, wuh." It's the sound of bad news.

More ideal than this dramatic

fluctuation would be a smooth reduction in pressure as air is vented from the compressor. Lots of time could be spent analyzing and speculating the slope of the boost curve, peak pressure rise, total pressure loss, and my inconsistent shifting. Having driven all the valves, however, those with the least surge and most gradual pressure loss drove the smoothest. Maintaining compressor speed and discharge pressure, a seemingly contradictory endeavor, is apparently the key to seamless throttle response.



Source: Edelbrock Quickdata

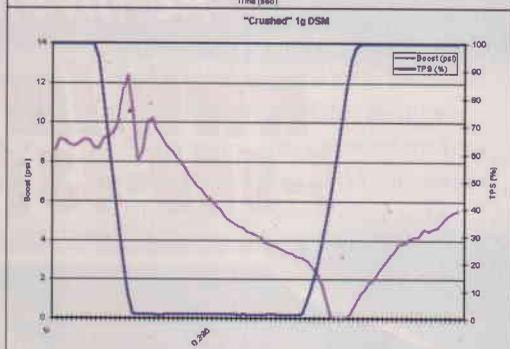
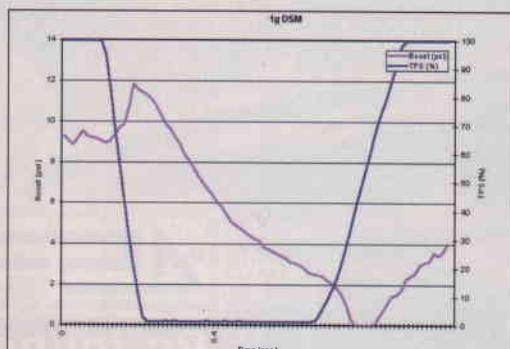
Stock Valves:

MITSUBISHI DV FROM 1G DSM

It's not all that surprising that Mitsubishi did a good job specifying the DV for the first-generation DSM. It's been doing turbo cars for some time, and has some deep pockets. A popet valve design is used, which is very similar to an external wastegate. These valves open under vacuum and are capable of holding significant boost.



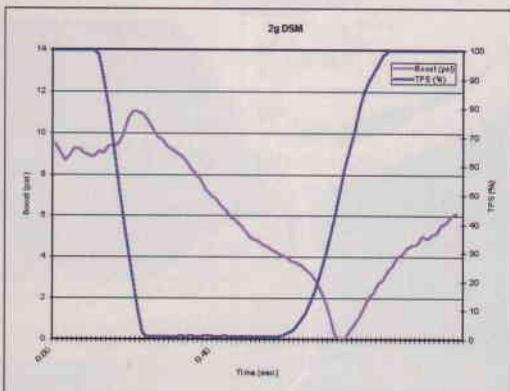
A common modification is to "crush" the top of the cap assembly down a few millimeters to raise the internal spring rate. This allows higher boost to be run prior to leakage. If you're anxious about crushing your own valve, Diamond Star Specialties offers these valves both stock and pre-crushed.



Source: Edelbrock Quickdata

MITSUBISHI DV FROM 2G DSM

The 2G DSM bypass valve is an excellent performer at low boost. Like its older brother, it's a popet valve design, though it's manufactured in plastic rather than aluminum. The rub is that it leaks badly beyond 15 psi of boost, degrading into a pop-off valve. If you're never going to run more than 15 psi, chances are you can pick up a used one for a song. Most people, however, want more boost, and should just stay away.

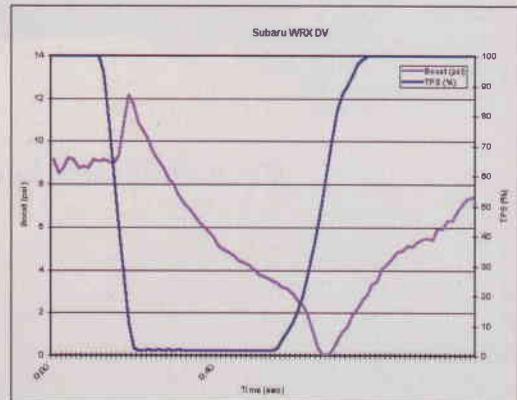


Source: Edelbrock Quickdata



SUBARU WRX DV

The OEMs know a good thing when they see it. Despite the different inlet flange and discharge fitting, the WRX DV appears to be the same one used by Mitsubishi on its 1G DSM. We're not aware of anybody crushing their top caps yet, but there sure are a lot of DSM owners purchasing WRXs...

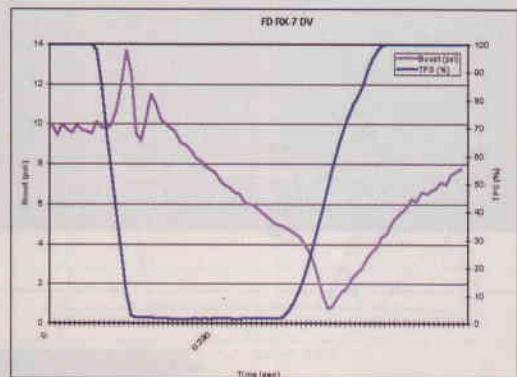


Source: Edelbrock Quickdata



MAZDA DV FROM FD (3RD GEN.) RX-7

It's like the little valve that almost could. Nearly the entire valve could fit in the GReddy Type R discharge passage. The valve has a Nippon Denso part number, which we think is very similar to the unit used on the twin-turbo Supra. Since RX-7 and Supra owners tend to make a good bit more power than our test car, at significantly higher boost levels, it's probably a good idea to upgrade. In addition to all the aftermarket offerings,



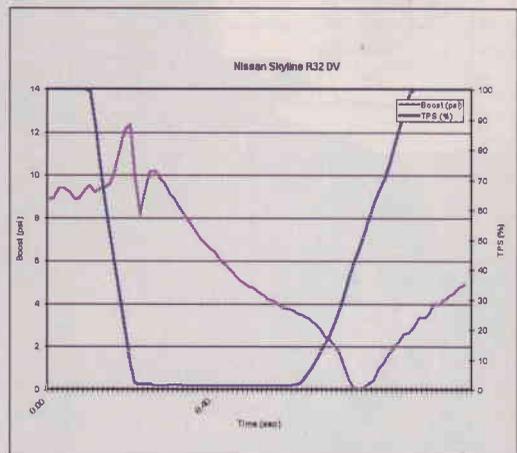
Source: Edelbrock Quickdata

running two of these stock units in parallel would be a valid option.



NISSAN R32 SKYLINE GT-R DV

We had it, so we tested it. Nissan used two of these in parallel on its twin-turbo terror. Two generations later, on the R34, Nissan began using—surprise, surprise—a valve much like the 1G DSM.



Source: Edelbrock Quickdata

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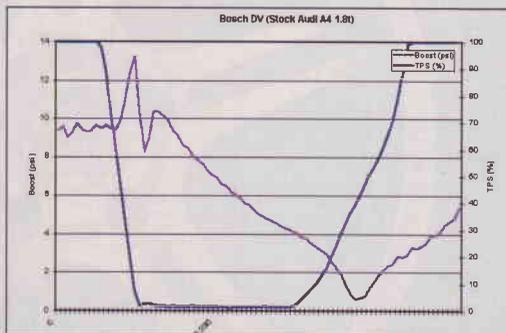


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BOSCH DV FROM AUDI A4 1.8T

Variations on this basic Bosch valve are used in all manner of Audi, Porsche and VW. The design uses a simple diaphragm to control pressure. While the design is light and fast-acting, the diaphragms are known to tear, causing boost leaks and performance loss. These valves do open under vacuum and are quite inexpensive. The A4 1.8T model was tested here, though it seems the unit from the TT is more desirable. Available through Audi/VW dealers, the TT part number is 06A-145-710-N.



Source: Edelbrock Quickdata

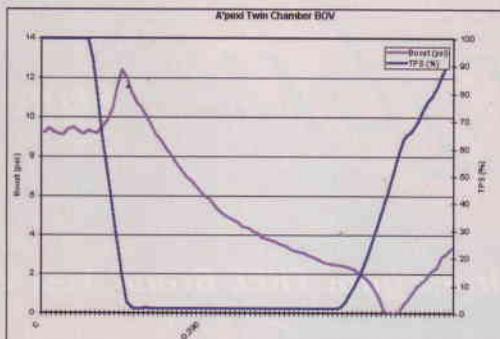
Aftermarket Valves:

A'PEXI TWIN CHAMBER BLOW-OFF VALVE

A'PEXi delivers a great unit, albeit it's a somewhat large package. The poppet-style BOV offers adjustable preload and discharge flow. Restricting the discharge flow could achieve the rally-style semi-surge we mentioned earlier. It also changes the audible tone, which is probably why it's there. It's the only valve in the test to come set up to use a push-pull-style actuation where both manifold vacuum and boost pressure are used for actuation. (Both the GReddy valves can be configured this way, but weren't for the test.) Application-specific install kits and instructions are available for many Japanese vehicles. Blank steel flanges are



available for custom installs. List price, \$219. A'PEXi Integration, Inc. (714) 685-5700, www.apexi-usa.com.



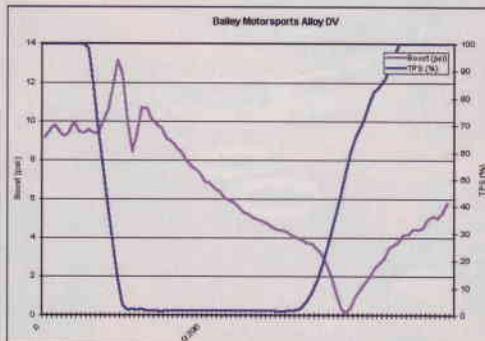
Source: Edelbrock Quickdata

BAILEY MOTORSPORTS ALLOY DV

Bailey Motorsports developed this direct replacement for the Bosch-style valves common to European vehicles. A high-temperature composite piston is used to control airflow. This alternate design is claimed to help it respond faster and hold more boost than the OEM part. Both straight and angled manifold pressure fittings are available. The compact size and lifetime warranty are real pluses, as are the detailed instructions for VW and Audi owners. Available in polished silver or anodized black.



List price, \$159.95. AWE Tuning, (888) 565-2257, www.awe-tuning.com.



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"For God so loved the world, that He gave His only begotten Son, that whoever believes in Him should not perish, but have eternal life."
John 3:16

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'91 Honda Civic 4/1.5	50	78	+28
'94 Suburban 350	120	140	+20
'84 Ford 5.0 TBI	140	153	+13
'84 Volvo 2.1 EFI	120	130	+10

(Dept. of Auto Tech - Southback College, CA - Actual Results May Vary)

MILEAGE RESULTS

VEHICLE TYPE	BASE MPG	AFTER	+/-
'02 Chevy Impala 6cyl 3.8	21.90	28.20	+28.8
'03 Dodge Caravan 63.0	19.94	22.90	+13.7
'02 Ford F-250 6.5L 4	12.60	16.00	+27.0
'00 Honda Civic 4/1.5	29.30	35.80	+21.5
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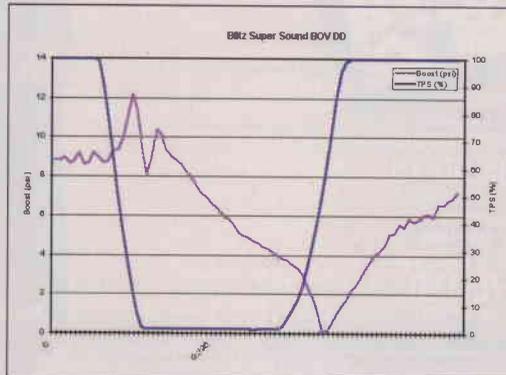
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BLITZ SUPER SOUND BLOW-OFF VALVE DD

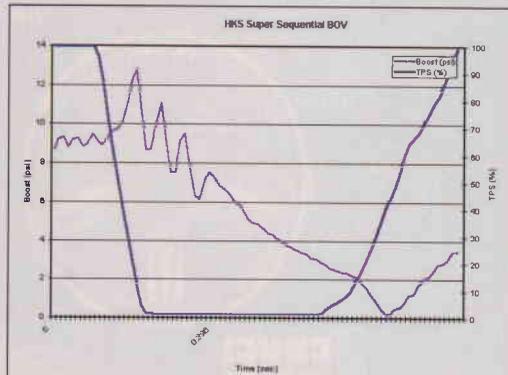
Blitz offers its trick, piston-style Super Sound BOV DD. Two discharge flanges are included, one with a couple of whistle-like features machined into the body, the other with a mini-integrated air filter. Since the spring tension on the model we tested was light enough to leak at idle, the filtered flange could work well for some. Of course, the preload adjustment can keep the valve sealed, too. Why it doesn't offer a fitting to allow recirculation is a mystery to us, though there's no reason you can't make your own. Applications-specific install kits and instructions are available for most Japanese vehicles. Blank aluminum and steel flanges are available for custom installs, as is a heavy spring for those running big boost. List price, \$235. Blitz North America, (714) 777-5508, www.blitz-na.com.



Source: Edelbrock Quickdata

HKS SSQV BOV (SUPER SEQUENTIAL BLOW-OFF VALVE)

If all we cared about were looks, HKS would steal the show with its Super-Sequential BOV (SSQV). It's a darn handsome piece of polished billet aluminum. Alas, function is the crux of this study, and on our test car, the adjustable valve was a bit slow to respond. When the valve did open, it emitted a sound reminiscent of a seal being beaten to death. Fun, kind of exciting, and bound to get you the looks. Of all the valves tested, this one is the catcall. Other inserts are available to raise or lower the tone, as is a fitting to provide for recirculation. The HKS SSQV is available as a universal unit with aluminum or steel flanges for custom applications and also as vehicle-specific kits for bolt-on applications. List price, \$250. HKS USA (310) 763-9600, www.hksusa.com.



Source: Edelbrock Quickdata

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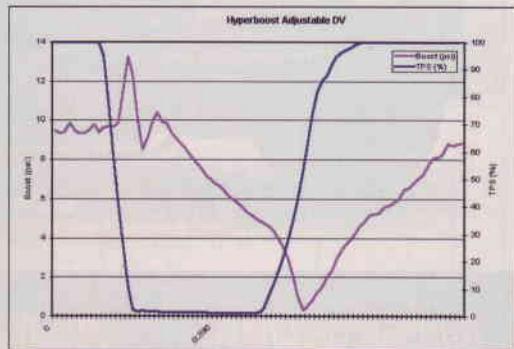
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STRATOSPHERE HYPERBOOST DV

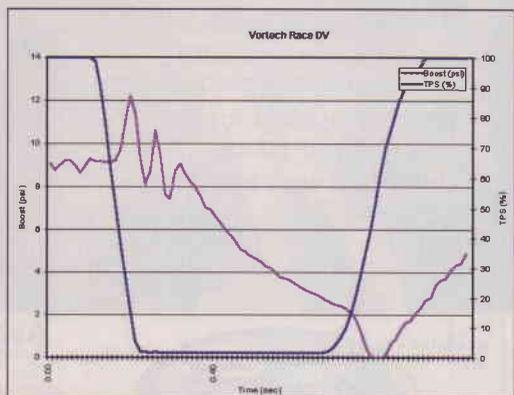
The Hyperboost is designed as a drop-in replacement for Bosch-style valves. It's really unique in that the valve can be disassembled and serviced without tools. Simply unscrew the cap, lift out the large Teflon-coated aluminum piston, clean and grease the O-ring, and slide it back together. While the valve is apart, it's curious to note the fundamental similarities between the Stratmosphere and Forge units. Preload adjustment is an option that can be upgraded down the road. Finish options are nickel-plated silver or anodized black. Lifetime warranty. List price, \$139, \$179 for the adjustable model. Stratmosphere, Inc. (888) 533-1777, www.stratmosphere.com.



Source: Edelbrock Quickdata

VORTECH RACE BYPASS VALVE

Vortech sent us its "small" bypass valve for testing. It's the second largest we received. Coming from a company with a history primarily involving supercharged V8s, it makes sense. The popet valve design is very similar to GReddy's. Spring tension is adjustable from the lid. Like GReddy, too, putting pressure to the bottom of the diaphragm can be a chore. Vortech installs a porous metal filter to keep debris out, though replacing it with a nipple shouldn't be too tough. We'd figure performance would benefit significantly. The oval discharge is a big one and can be tough to mate to commonly available materials. Mounting is pretty simple, amazingly. It uses a GReddy compatible flange. Numerous finish choices are available, as are aluminum and steel-mounting flanges. List price, \$216.55. Vortech Engineering, (805) 247-0226, www.vortechsuperchargers.com.



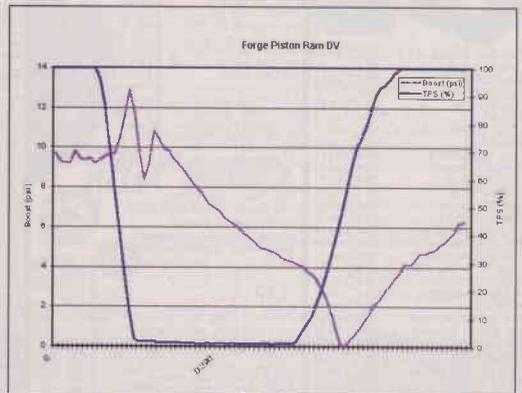
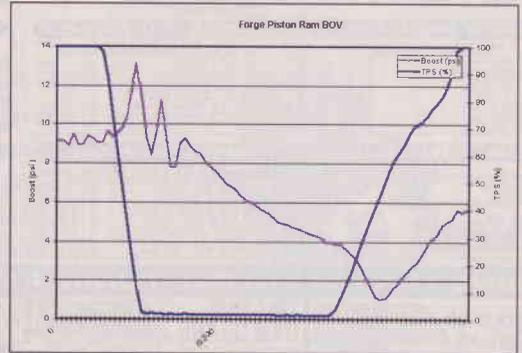
Source: Edelbrock Quickdata

FORGE MOTORSPORT FAST ROAD DV & PISTON RAM BOV

The term "forge" usually implies strength, and, boy, is that the case here. These valves are beefy. Forge Motorsport makes quite a few different bypass valves for a number of applications. The two here are suitable as drop-in replacements for the 2G DSM. The Fast Road DV uses a large self-aligning floating piston for positive closure. Even more interesting is the dual-piston arrangement on the Piston Ram BOV. Manifold pressure acts on the outer piston, either opening or closing it depending on condition. A small inner piston is independently sprung and opposed only by boost pressure in the intercooler piping. This design guarantees no idle leakage while still allowing the use of a reasonably soft primary spring. All Forge

products are user serviceable and covered by its lifetime warranty.

List price, \$135. Forge Motorsport (321) 689-0982, www.forgemotorsport.com.



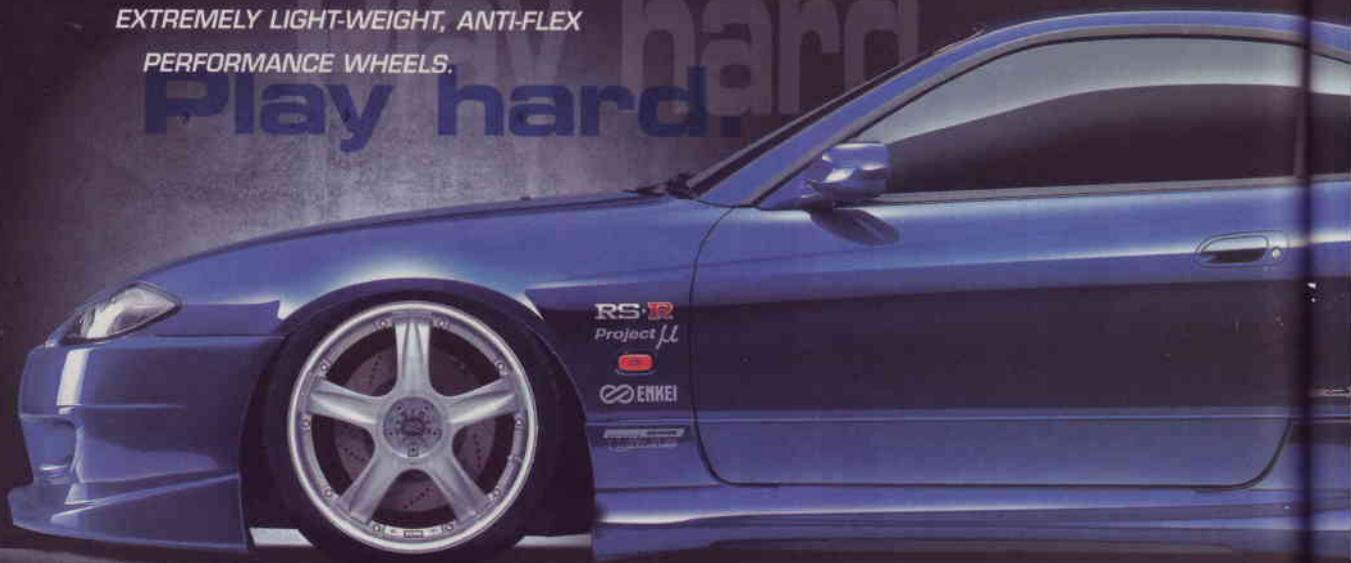
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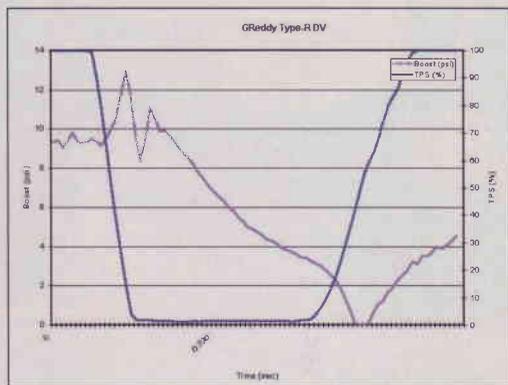
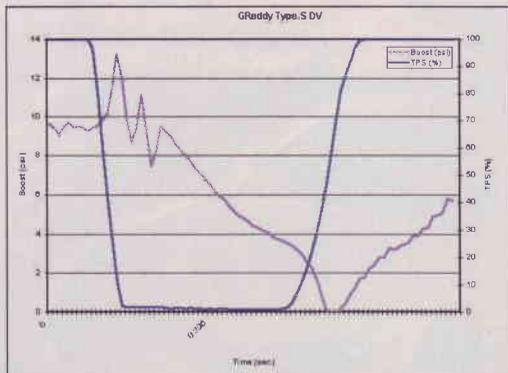
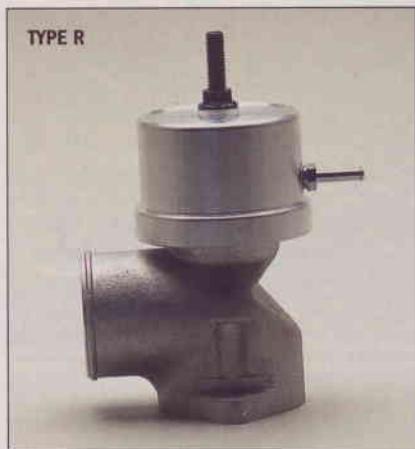
Play hard.



GREDDY TYPE S AND TYPE R DVs

GReddy always seems to come through with a pretty well-engineered product. Both valves use a poppet design much like A'PEXi's. The Type S and Type R allow for recirculation, however, and despite the huge diameter of the Type R's discharge, handy threaded reducers are available to adapt to nearly any hose size. Spring tension is adjustable on both, in addition to a stiffer spring option for the Type R. A captive O-ring in the valve face ensures positive closure. Like that from A'PEXi, these are both push-pull valves, though neither one was set up to run that way. It seems both valves could have benefited from the boost assist, though the resulting part-throttle boost leakage may not be worth it. GReddy offers install kits for most

Japanese turbocharged vehicles, as well as flanges for custom installs. List price: Type S, \$227. Type R, \$254.55. GReddy Performance Products (949) 588-8300, www.greddy.com.



Source: Edelbrock Quickdata

ENKEI DM5

For Serious Players. The DM5 reflects the latest of Enkei's performance design concepts. DM5's innovative style and lightweight technology lend an exciting sporty look to most tuner vehicles. Enkei's latest CNC deep lip, diamond cut, dimple spoke design was developed to lessen the weight of the wheel.

The DM5 was designed using the latest FEM computerized analysis that is also used in the development of race wheels.

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ENKEI CP1

Accelerating Performance. Developed by Enkei's innovative European design team, the CP1 is part of the new performance trend that embraces clean Euro designs. The CP1 has a deep center drop that emphasizes the spoke length and sculptured lines. The wheel's glistening machined finish uses the latest CNC technology and high quality casting system.

The CP1 is available for large luxury sedans.

Silver Machined Finish Available in 17" and 18"



ENKEI MM2

A Blend of Style and Performance. This new generation 3D mesh wheel was developed by Enkei's global design team. The innovative, sophisticated style is a must for today's high performance sports cars. The MM2 has a new Euro Dark Silver finish with a deep diamond-cut lip. Lightweight and manufactured with an anti-flex design, the MM2 is race engineered for the street.

Silver and Anthracite Finishes Available in 16", 17" and 18"

