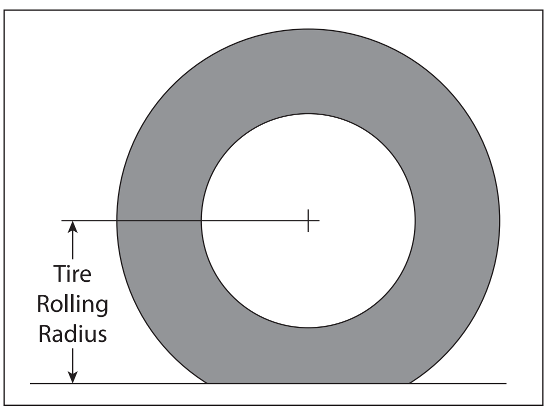
Coil-Over Conversions Explained

by Chris Alston

To dispel some popular myths and help you understand which coil-over conversion is best for your project, it is necessary to explain in great detail about shocks and springs. For the purpose of this discussion it is assumed that your vehicle will be street driven and either autocrossed or road raced. Although the technical explanation is correct for other uses such as just autocross or road racing, the specifics of spring rate and travel could be outside the parameters established here. This information is intended as a set of general guidelines to help you understand the basic principles and make informed decisions for yourself. Before we get started, review the definitions of the terminology I am about to use.

Tire Rolling Radius

The distance from the center of the spindle to the ground, for a fully inflated installed tire on a full weight completed car, is referred to as the tire rolling radius. This measurement will be slightly less than the nominal radius of the tire's overall diameter. As an example, a 25"-diameter tire may have a 12" tire rolling radius, because the car's weight compresses the tire 1/2".



Shock Installed Height

This is the installed length of the shock absorber when the car is fully complete and ready to drive. That length should be within +or- 10% of the shock's center of travel, so that 40% to 60% of the shock's available bump travel has been used. You need to have adequate travel in both directions or the vehicle's suspension will top- or bottom-out as you drive down the road.

Use fixed shock features, such as the upper spring seat, to measure the compression travel used at the installed height.

Vehicle Ground Clearance

This is the distance between the ground and the bottom of the front frame crossmember. Chassisworks has a very specific reason for using this distance as a way to describe how the vehicle sits in relation to the ground. A common methodology is to say “stock ride height” or “lowered from stock”. There is a tremendous problem with this. No one actually knows what the stock ride height of their vehicle is, especially after it has been disassembled. Adding to this problem is the fact that any change in tire size also affects the ride height. In order to provide our customers with a known measurable ground clearance, we use the front crossmember to ground clearance.

As an example, we can tell you that our front control arm system, with our coil-over conversion installed at the correct shock ride height, the vehicle ground clearance will be 5-1/2” (+or- 1/2”) with a 12” tire rolling radius. A 25”-diameter tire will have approximately a 12” rolling radius as the mathematical radius of 12-1/2” is compressed to 12” by the weight of the car. This method gives you an exact way to determine how high your car will sit off the ground. (Call to verify the dimension for your car.)

Measuring ground clearance in this way also provides you with a method for mocking-up your vehicle at its actual ride height. Place some boards for spacers under the crossmember to simulate its distance off the ground. This will allow you to see if you like the look and if you have enough ground clearance for any exhaust and frame modifications.

Chassisworks measures **vehicle ground clearance** from the bottom of the suspension crossmember directly to the ground.

Adjusting Ride Height - Fixed Mounts

In systems without adjustable or changeable shock mounts you are limited to a couple of options for achieving your desired vehicle stance. Dropped spindles can be installed to lower the crossmember-to-ground clearance exactly 2”, reducing clearance to 3-1/2”. From here installing 26”-diameter front tires on the car will raise the car 1/2”, for 4” of ground clearance. Here is where having a little extra available travel in the shock comes in handy. Raise the shock spring seat up 1/4” and the crossmember will come up about 7/16”. (The 1/4”-to-7/16” relationship is determined by the motion ratio of the lower control arm.) Now your crossmember is 4-7/16” off the ground. Different combinations of these adjustments will yield the desired results, but will take a bit more foresight when planning your project. My personal absolute minimum for a street car is 4” to 4-1/2” of clearance depending on the car.

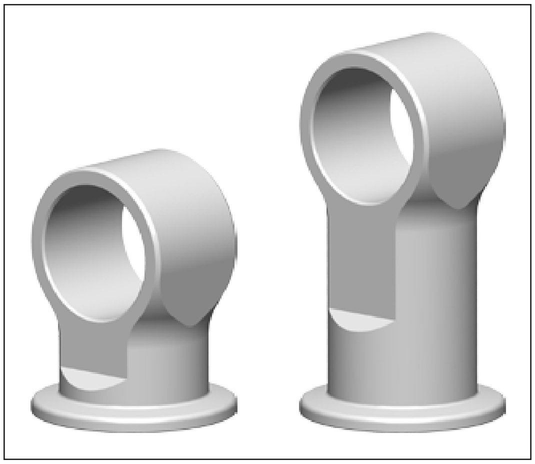
Adjustable Mounts

Some of the Chassisworks mounts have optional ride height changes built into them. The additional adjustment allows you to set the vehicle at the perfect stance while keeping the shock well within it’s designed operation range. “Band-aid” fixes, such as making large adjustments to the spring preload run the risk of topping- or bottoming-out the shock and should be avoided.

Adjustable Mounts (continued)

Adjusting the height of the upper shock mount is generally handled by changing the mounting components. In the case of a standard coil-over mounting eye, a simple extended top mount can be used. In applications that require a direct-fit shock tower adapter, different welded-assembly mounts can be selected at the time of purchase to alter the ride height. Both styles accomplish the same goal of relocating the shock to adjust the ride height, without affecting the shock's length at ride height or balance of available travel.

Lower shock mounts, specifically at the rear suspension, can be more easily accessed and manipulated. So, in many applications Chassisworks has chosen to design mounting systems that are truly adjustable. The billet-aluminum clevis system is used in a number of Chassisworks' direct-fit products and relies on a multi-position bracket to move the clevis to one of four or more positions. Multi-position brackets are engineered to mount directly to various types of factory axle brackets, or take the form of welded brackets with integrated OEM or Chassisworks suspension-link mounts.

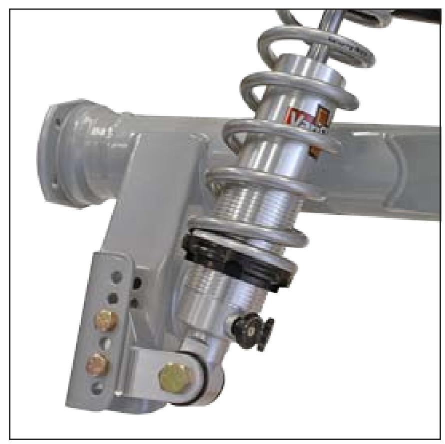


The 1"-extended upper poly-eye shock mount (right) provides a simple means for raising the ride height of VariShock coil-overs.

This style of shock mount adapter, used on early Mustangs and Chevy IIs, bolts directly to the factory shock towers and allows the shock's pivot-ball stud to be mounted at different positions to vary the ride-height adjustment range.

Bolt-on shock mount adapter for GM A-body factory lower axle bracket

Bolt-on shock mount adapter for GM leaf-spring pad



Chassisworks weld-on axle bracket clevis for billet shock mount

What is Ride Quality Made Of?

Ride quality is determined primarily by a combination of the spring rate, shock valving, and anti-roll-bar rate. The problem starts with the spring rate selection. The spring does two primary things. It supports the static weight of the car and it contributes to the prevention of body roll by opposing dynamic forces. Initially we will only be concerned with the static weight requirement of the springs.

Static Weight

An oversimplification of how the vehicle weight is supported is simply–the spring must have sufficient force to hold the vehicle at ride height. However in truth, there are multitudes of different spring rates that could support the weight of the vehicle, but some would have disastrous results.

If you put a scale between the spring and either its top or bottom mounts you would know exactly how

Static Weight (continued)

much static force is acting on the spring. There are all sorts of calculations to determine the theoretical spring rate, but what you need to understand is, depending upon the spring's chassis mount and the motion ratio of the linkages involved, there is a very specific force required to hold the vehicle at the correct ride height.

For the purpose of this discussion we will use a front upper and lower A-arm system as an example, the principles apply to all styles of suspension. If the spring needs to exert 1000 pounds of force between the upper and lower spring mounts to hold up the vehicle, there are any number of ways to achieve that. Using a spring with 1000-pound rate, the spring's free length would be 1" longer than ride height. When collapsed to ride height, it would exert 1000 pounds. You could also use a 200-pound spring that was 5" longer than ride height. When it was collapsed 5", it would also exert 1000 pounds. Any number of spring rates can **hold** the vehicle weight. However, you want to *drive* the car...

The stiffer (higher-rate) spring can hold more vehicle weight in a shorter bump distance, but the shorter the shock travel the harsher the vehicle ride. The reason is obvious. As a vehicle travels and rolls over irregularity in the road, that irregularity is dampened out by the spring collapsing or extending. Ride quality (as it relates to springs) is all about the vehicle's suspension not transferring all the irregularities of the road into the driver's compartment. The stiffer the spring rate, the harsher the ride–this is an absolute truth.

VariShock has the advantage of a huge array of coil-over styles. This allows us to easily produce unique product solutions for very specific vehicle requirements. The modified '65-73 Mustang suspension (above) uses an extended base, 4.25" travel coil-over that correctly fits the suspension, and keeps the spring rates within a reasonable level. Simply adding a longer shock to take up the space is the incorrect solution for this application, as the additional shock travel would allow the balljoint to over travel and possibly break the studs.

Choosing a Spring Rate

This brings us to the most important part of the process, choosing a spring rate. The selection of spring rates suitable to support the vehicle weight at ride height is directly dependent on the coil-over shock's available travel.

In a street-driven performance vehicle it is usually best to have about 60% of the shocks available travel reserved for bump travel. This means that 40% of the travel is used up collapsing the spring to ride height. The reasons for using only 40% of the available travel on a street-driven vehicle are twofold. First, street cars have widely varying spring support requirements as the number of occupants and the amount of baggage can affect the overall weight of the vehicle significantly, especially in lighter vehicles. The second issue is that you have to drive over bumpy roads. I can hear you plotting right now, "Well my car is really a track car and nobody rides with me." Then you could go to 50% to 55% reserved bump travel, but when the suspension bottoms out, *I told you so*.

Let's do some quick math using our prior example. If you need to support 1,000 pounds and you have a 5"-travel shock, 5" of travel times 40%, equals 2.00" of bump travel. The required spring force can be accommodated by 1,000 pounds divided by 2" of travel, which equals a 500 pound-per-inch spring rate.

***5" shock travel** x 40% = 2" compression*

1,000 load ÷ 2" ***= 500 lb/in spring***

Here is where vehicle space limitations start to become a problem. You could never put a properly designed 5"-travel coil-over conversion in any OEM-style A-arm front suspension without drastically modifying the chassis, there just isn't room.

Let's see what happens if we use a shorter shock absorber, say a 2.8"-travel coil-over. 2.8" of travel times 40%, equals 1.2" of bump travel. The same 1,000 pounds divided by 1.2" of travel, equals a jarringly stiff 833 pound-per-inch spring rate that is now required to hold the vehicle up at that specific height.

***2.8" shock travel** x 40% = 1.2" compression*

1,000 load ÷ 1.2" ***= 833 lb/in spring***

With these examples it is brutally obvious how the available shock travel drastically affects the spring rate.

Choosing a Spring Rate (continued)

So here is the giant bad news. If you want your front A-arm coil-over conversion to have any chance of having decent ride quality, you need to have a 4”-travel shock absorber at a minimum. With common OEM motion ratios this results in about 5-1/2” to 6-1/2” of travel at the wheel. Unfortunately, a 4”-travel shock requires some serious engineering to get it to fit into most OEM-style A-arm systems.

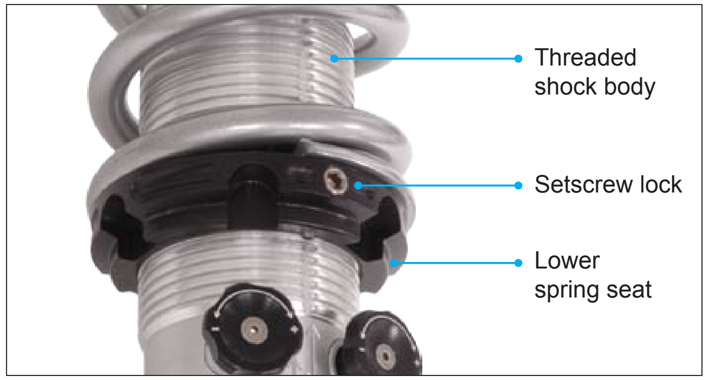
The rear of the vehicle needs a total minimum up- and down- travel of 5” to provide acceptable ride quality. Solid axle rear suspensions have approximately 1:1 motion ratio in that direction. Shock absorber travel and wheel travel will be nearly identical when the suspension travels up and down. Consequently, a minimum shock travel of 5” is required. Shock travel can only be this short if you use an adjustable ride-height mount so that no coil-over travel is used adjusting the car’s ride height. Fortunately, there is usually a lot more room available in the rear suspension area to accommodate shocks with adjustable mounts.

Spring Rates for Tuning

As this has been a simplification of the principals involved, it is important to point out that in a correctly optimized vehicle, the spring rate could easily be higher or lower than what is required to merely hold up the car at the correct shock length. If the spring rate is lower, ride height can be restored by screwing the spring seat up and preloading the spring, which will actually make it support more load and restore the ride height. Too low of a spring rate and the car could become too soft and allow excessive chassis movement. Not ideal for a street car or a project with the focus on handling, but drag racers regularly use low spring rates to more easily transfer weight to the rear for improved traction at launch.

Adjusting the Spring Height

As the combination of vehicle weight and available spring rates will never position your vehicle exactly at the desired shock ride height and vehicle ground clearance, you will need some method of adjusting the two. That is the purpose of the threaded sleeve on the shock reservoir body. There is an extremely important warning that comes with adjusting the lower spring seat. As you raise the lower spring seat to increase the vehicle’s ride height, you are moving the shock away from the targeted 60/40-percent travel balance and using up a portion of the shock’s available extension travel. Running the shock with less than 40% available extension travel risks topping out and possibly damaging the shock. So, if you can start with a shock



When adjusting the lower spring seat to fine tune the vehicle’s ride height, the shock must remain within +or- 10% of the shock’s center of travel. Never adjust the spring seat without removing the vehicle weight from the springs by jacking up the car.

that is longer, you will at least have more room to fine tune the vehicle’s ride height without shock travel becoming too shallow in either direction.

Remember that in actual use your shock needs to be within +or- 10% of center of travel to have adequate travel in both directions. *Attempting to set a coil-over ride height outside these parameters rarely results in success.*

The extra bit of adjustment room is why we prefer to use at least a 4” travel shock for a front A-arm coil-over conversion, even if in some cases you could get by with a 3.5” travel shock. If you go the shorter, 3.5” travel route, just remember that everything must be absolutely perfect. This includes the spring rate, upper shock chassis mount, lower shock control arm mount, and the tire size. All must be perfectly placed to attain the desired vehicle ground clearance and correct shock ride height. But remember, as the shock gets shorter the spring rate must get higher, which will make the ride harsher.

Spring Tuning Guide

Chassisworks and VariShock provide an excellent worksheet in our Spring Tuning Guide to assist in determining your baseline spring rate. It can be downloaded from the tech section of our website.

http://www.cachassisworks.com/Attachments/worksheets/BaselineSpringWorksheet.pdf

The Bump Stops Here

Any decent coil-over conversion will have a cellular foam bump stop surrounding the piston rod. Bump stops can also be mounted to the chassis instead of the shock shaft, but their placement must limit the suspension travel prior to the shock bottoming out. However, bump stops on the shock shaft are always correctly located in relation to the shock travel.

The VariShock bump stop shown here is made from a very high-tech cellular foam, and surpasses the durability and compression limitations of rubber or urethane. This material can be collapsed almost its full length without splitting or permanently deforming. Its shape provides a progressive spring rate increase as it collapses. This progressive increase in the spring rate obviously only applies as the shock absorber nears its fully collapsed state.

The bump stop does two things. It protects the shock from damage by preventing metal-to-metal contact. And, its progressive-spring-rate effect at the end of shock travel prevents the suspension from being upset by an abrupt stop. Nothing will un-stick a car from the road faster than a hard bottoming of the suspension.

Air Springs vs. Coil-Overs

There is a very important difference between air springs and coil springs when designing a proper suspension conversion system. When it comes to the shock's installed ride height, air springs have an advantage. Since the actual spring rate of an air spring is much lower than a coil spring when supporting the same amount of weight, you can violate my travel rule a little and actually be successful. An air spring supports weight by a combination of the bag's diameter and air pressure. This effectively presents to the vehicle a much lower spring rate, which means the car will ride really soft. The softer ride is an obvious improvement over a short-travel coil-over, which will ride really harsh because it requires such a high-rate spring. In addition you get the ability to place the car at its exact preferred shock ride height by just changing the air pressure. However, you do not get to overcome all the problems of a short coil-over. You still need the extra travel to prevent harsh bottoming and to provide some vehicle ground clearance adjustment. The fact that in the past you got away with a short-travel air spring is not going to fly with coil-overs.

3.5”-travel Air-Spring Shock

4.25”-travel Coil-Over Shock

A coil-over system has more difficult shock length constraints than an air system, so Chassisworks designed all of its control-arm systems to work with a coil-over first. That way the air springs also work perfectly and you have the added benefit of extra travel in a coil-over system, which you will desperately need.

With the same travel length shock an air-spring shock combination is longer than a coil-over, because you have the additional length of the upper bag seal, which typically adds about 5/8”. To compensate for the additional length of the air spring, our systems use a shorter travel length shock that fits using the same mounts from the original coil-over design. If you use the next shorter length air-spring shock, stepping down to a 3.5”-travel one instead of a 4.25”, the 3.5” air-spring will have approximately the same installed length as the 4.25” coil-over because of the extra 5/8” added for the upper bag seal. In an air system, the reduced travel is not a problem since it does not require harsh-riding stiff springs as we explained earlier. That does not mean that you can use extremely short travel air springs, like 2.8” of travel, as again you will run into problems of not enough travel to properly operate your suspension. We try to stay with a minimum of 3.5” shock travel in an air-spring front A-arm suspension for all the same reasons we use at least a 4”-travel coil-over.

Anti-Roll Bars

As your car turns the suspension is also subject to dynamic loads, which of course also affect the spring rate choice. To prevent excessive chassis roll,

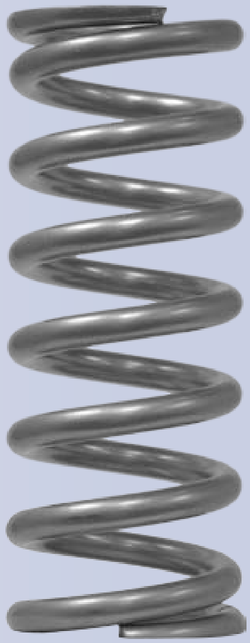
Adequate Spring Travel

All springs have a certain amount of travel available in them (the difference in length from extended to fully collapsed). When a spring compresses it twists the steel wire it is made from. As the twist exceeds the yield stress of the material, the spring takes a set, gets shorter, and has less travel. Additionally, it is difficult to design a spring that does not overstress the wire, yet still has as much travel as the coil-over on which it is to be installed. All the time and energy spent setting the correct travel length coil-over in place instantly becomes pointless if the spring won't let you use that travel. The design of the spring should not allow these things to happen. Unfortunately, there are a great number of these poorly manufactured springs that in fact have less travel than the shocks they are installed on.

There are several ways to manufacture a spring that minimizes this. The most effective way is to use an extremely high-tensile-strength wire that allows more stress without taking a set. The best materials are vastly superior to commonly used Chrome-Silicone wire, which itself is a good choice. All VariSprings are domestically wound from the superior high-tensile wire to provide a significant increase in spring travel, without using a high-priced European produced spring.

As a spring gets to higher rates and shorter travels this problem gets quite severe. Nothing is worse than an already short coil-over shock with a spring that has even less travel. This scenario is a tuning nightmare. The problem gets even worse as the spring rate increases. Which is another significant reason why short travel shocks should be avoided. Make sure you verify that the spring has adequate travel for your installation.

The competitor spring (left) is manufactured from Chrome Silicone wire and must use a thicker wire diameter and a seventh coil to achieve the same spring rate as the VariSpring, shown to the right. This 650 lb/in spring is 9" long and has 3.8" spring travel, .45" less than the 4.25" travel coil-over shock on which it goes.



The same 9" long, 650 lb/in VariSpring (right) uses a special high-tensile-strength wire with improved yield characteristics. This material allows the same spring rate to be achieve with a more coarse coil pitch (only six coils), a slightly thinner wire diameter, and less material, resulting in a lighter weight spring. The VariSpring provides the same spring rate, but with 15% more travel, so the spring now has more travel than the coil-over on which it is installed.

Air Springs vs. Coil-Overs – Anti-Roll Bars (con't)

which decreases cornering ability, the suspension roll stiffness must be increased. The two most popular ways of increasing roll stiffness are changing to higher-rate springs or installing a larger diameter anti-roll bar. A popular combination is to use a lower spring rate for good ride quality combined with a heavy bar rate (increased diameter) for controlling weight transfer during turns.

Chassisworks offers anti-roll bars in multiple diameters for optimal component matching with air-spring or coil-over suspensions.

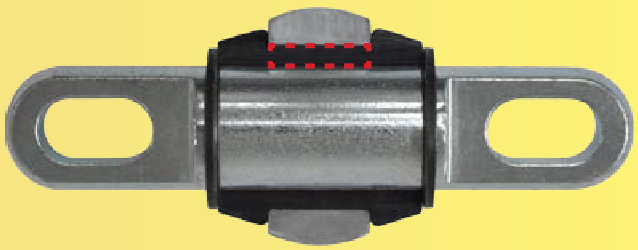
It is important to point out that an air spring has a lower spring rate and needs more help counteracting the dynamic loads when turning. For this reason many air-spring vehicles can successfully use a very large-diameter anti-roll bar, which would be considered too stiff for a coil-over equipped car. These differences between the two styles of spring systems is why Chassisworks has a significant array of anti-roll-bar components available.

Anti-Roll-Bar Diameter Comparison

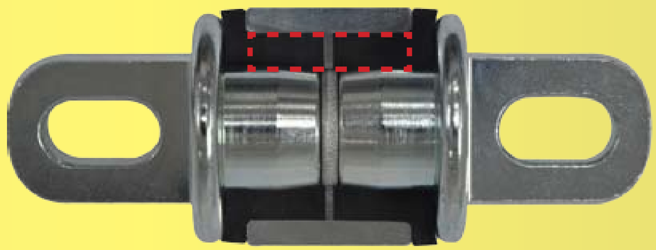
Optimal anti-roll-bar diameters will differ depending upon whether the vehicle is equipped with coil-springs or air-springs.

Urethane Bushing Comparison

Original Competitor Design



VariShock Improved Design



Improper Design for Coil-Over Use

This bushing housing is modeled after the OEM crossbar mount used for standard shock absorbers. While perfectly acceptable for handling the forces from the shock alone, the limited amount of urethane material directly in the load path makes this design unsuitable for carrying the weight of the vehicle as a coil-over would. The red box highlights the loaded area of the bushing.

Suitable Design for Coil-Over Use

By comparing the sizes of the red highlighted boxes it's easy to see the difference in volume of urethane material that carries the weight of the vehicle. The VariShock bushing assembly uses 3-1/2 times the material of the OEM-style crossbar. This provides a higher load capacity, as well as additional material for expansion to the unloaded side of the assembly during operation.

Mounting Methods

The method used to attach your shocks is the third most misunderstood, behind travel and spring rate. It is important to note that the vast majority of coil-over conversions were designed to be used with an OEM-style lower-control-arm mount. The first mounting design produced is by far the worst; a standard OEM-style crossbar, mounted in a shock base that was originally designed only to carry the shock load not the vehicle weight. A correct urethane bushing eye, for use with a coil-over, requires a much larger volume of urethane, and cannot be accommodated by the OEM-style design. To comprehend what a bad design this is requires an understanding of the proper installation and use of urethane bushings.

Urethane bushings, just like rubber, require significant preload in their assembly if they are going to see even moderate loads. In a coil-over, if you can push the sleeve into the urethane bushing by hand, it is absolutely improperly designed. Proper design requires that the sleeve or pin is pressed into a bushing bore that is significantly smaller than the sleeve. This puts a load in the urethane that presses outward, against the bushing housing. When the urethane is loaded by the vehicle weight, it compresses the urethane along one side of the sleeve and allows room for the urethane to expand along the opposite side. In a properly designed assembly, the preload in the bushing allows

Lower Shock Mount Base Options

Standard Length   1/2" Shorter Eye

Poly-Crossbar   Pivot-Crossbar   COM-8 Bearing   Pivot-Ball

Many of the lower-mount styles are available in standard and 1/2"-short lengths to accommodate different space requirements and vehicle stance preferences.

Having a versatile line of coil-over conversion products requires being able to easily adapt to the variety of needs for various vehicle and performance applications. From left: short polyurethane crossbar and pivot-ball crossbar for OEM A-arms, followed by short COM-8 bearing and standard length pivot-ball for coil-over lower arms.

Mounting Methods (continued)

the urethane to expand on the side opposite the load, and prevents a gap from forming. Poorly designed assemblies, with no preload, allow a gap to form on the unloaded side. With free-play now introduced into the assembly, the sleeve will act like a hammer and beat the urethane out of round, making the suspension noisy. And worse, the gap has to be closed up before the shock can even work in that direction.

Designing a urethane bushing assembly that enables the bushings to stand up to the heavy work load of a coil-over requires a significantly different approach. The most notable difference is the much larger volume of urethane used throughout the VariShock bushing, and more specifically the 350% increase in the area between the housing and cross-shaft that carries weight. Each threaded crossbar halve features a tapered end for easier insertion into the smaller bushing bore, and when tightened, further compresses the bushings to the correct level of preload.

Pivot-Ball Upper Stud Mount

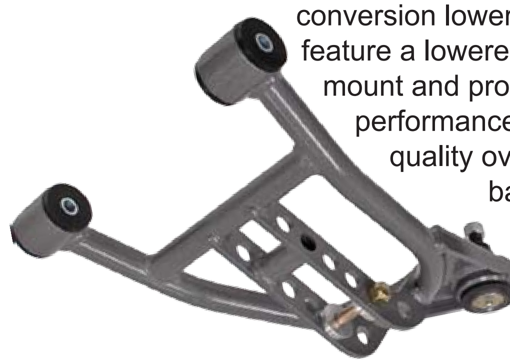
Working from a factory upper-shock mounting location usually dictates the use of a bushing stem mount. For a modern performance coil-over conversion, we needed to find a better solution. The VariShock adjustment knobs being located at the base of the shock allowed our engineers to develop a greasable pivot-ball upper stud mount that provides the accuracy of a spherical bearing. Other manufacturers, limited by piston rod adjusted valves, must use either a standard urethane bushing stem, or a plastic spherical washer system. Both options have their limitations. Bushings risk inconsistent preload and side load the top gland as the shock misaligns. The plastic washer option does pivot more freely, but has limited misalignment due to the stem having to pivot through the chassis mounting hole. VariShock's pivot-ball mount surpasses these limitations, providing up to 60-degrees of free movement with zero side-load forces.

OEM-style bushing stem mounts increase side load force as shock misalignment increases.

VariShock pioneered pivot-ball upper stud provides simple direct-fit mount with the accuracy of a spherical bearing and 60-degrees of free misalignment.

Redesigned Lower Control Arm

As all prior coil-over conversions were originally designed to work with stock lower A-arms, a coil-over mount located at the stock position could never give enough room for a proper-travel-length coil-over and still allow it to lower the car. Taking a completely new approach by designing an aftermarket lower arm with lowered shock mount allows room for a longer travel shock that can take advantage of a better riding, softer spring rate. All Chassisworks coil-over-conversion lower control arms feature a lowered shock mount and provide improved performance and ride quality over conversions based on the shock geometry of the OEM control arm.



Drawbacks of Conical Springs

Many shocks with the original crossbar design also feature a conical spring, adding to the poor design of the package. In the types of OEM coil-over conversions that we are talking about, a conical spring has a 2-1/2"-diameter bottom end to fit the coil-over shock and a 5"-diameter top coil that fits the spring pocket in the frame. At first thought it would seem like a good design, but this system has several significant deficiencies and just two advantages.

On the plus side, the conical-spring coil-over has the shortest combined length of any coil-over. Since there is no upper shock mount, a longer travel shock can be used in a short chassis space. Secondly, the omission of the upper spring seat hardware combined with the low-cost OEM-style crossbar lower mount makes this the cheapest design to manufacture. Everyone can appreciate a cheap price, but as in most cases you definately get what you pay for.

The underlying truth of conical springs used in A-arm suspensions is that they present major problems that affect the reliability of the shock and mounting hardware. As the upper spring mount is attached to the chassis and the lower spring mount is attached to the lower control arm, the spring seats do not stay parallel to each other when the suspension travels. This puts a significant bind in the spring and severely side loads the top gland in the shock, causing premature wear and eventual oil leaks. The top-stem bushing mounts used on these styles of conversions were never designed to accept a side load. Through regular use, the small bushing nipples that shield the

Drawbacks of Conical Springs (continued)

stem get sheared off and the stem threads then file the frame mounting hole out of round. Additionally, conical springs are a proprietary design and not made in a wide range of lengths and spring rates, so it's hard to get exactly what you need to properly spring your car.

The only thing more amazing to me than someone thought this was a good idea, was the fact that so many people copied it.

Springs the Right Way

Sometimes the tried and true method of doing something is actually the best. And in the case of how to mount a coil-spring to a shock, the standard method works best. A simple parallel wound, 2-1/2" coil spring mounted directly to the shock's upper and lower spring seats avoids all of the issues introduced by the use of a conical spring. Provided the spring has ground ends, there is minimal side load introduced by the spring, regardless of spring rate. With the VariShock design, the only side loads present that have any affect on the shock gland are from the urethane bushings at the bottom end of the shock. This force is minimal compared to the force from a bound up 600-lb/in conical spring. Even better, VariShock coil-overs equipped with lower pivot-ball or bearing mounts will have no side loading at all.

New Math – 16 Is Greater Than 24

The Chassisworks manufatured VariShock has several significant design improvements over the competition. Besides the fact that our shocks have more travel, our 16-click adjuster actually has a wider range of adjustability in the valving than the competitor's 24-click adjuster. I know what you're thinking, "more clicks means more adjustment."

A Selection of VariShocks

VariShock offers a number of different valving styles throughout the product line to suit a variety of performance applications. The range includes non-adjustable hybrid-design twin-tubes to 4-Way Remote Reservoir mono-tube shocks.

Non-Adjustable

Single-Adjustable

Double-Adjustable

4-Way-Adjustable

4-Way Remote Reservoir

New Math - 16 Is Greater Than 24 (continued)

Well what you see isn't always what you get. The marketing-hyped 24-click adjuster originally started life as a 12-click adjustment mechanism, which was later modified to have 24-clicks across the same adjustment range. So, you're not actually getting twice the adjustment, or even a 50-percent increase over VariShock's 16-click adjuster. You're buying into a narrower valve adjustment range that will have you making 3- and 4-click adjustments just to notice a difference. To keep suspension tuning a productive experience, VariShock's #2 position feels different from #3, which feels different from #4, and so on.

Isn't marketing grand. At most companies it's all about the hype–at Chassisworks it's all about the product.

Shock Technology

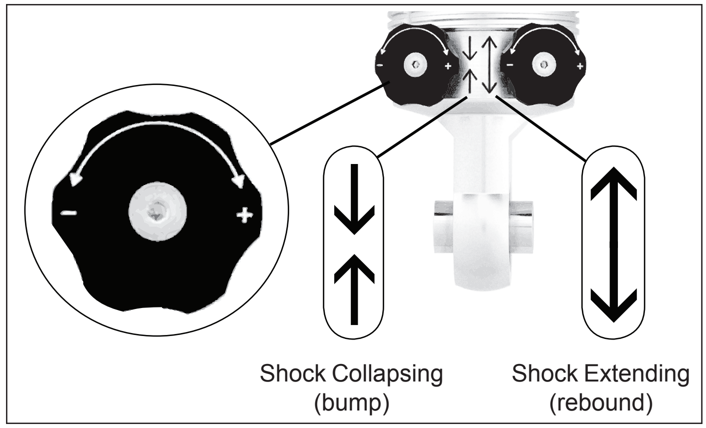
There is a tremendous amount of chatter about new and old shock technology. Lots of people are under the impression that the monotube shock is some *new* magic technology. The truth is, the original monotube shock patent was issued back in 1956, hardly new technology; although the original twin-tube design is even older. The statement, "Our monotube shock is new technology.", is just a marketing claim and you know how I feel about those.

Basically, there are two styles of shock absorbers, twin-tube and monotube, each has their own set of pros and cons. Both styles are continually being advanced and neither one is better than the other in every application. In many applications they can produce similar performance. There is a whole slew of hybrid designs of both shock styles. The VariShock we use for OEM-style coil-over conversions is a hybrid-design twin-tube. However, we also utilize our monotube and hybrid-monotube shock designs for other applications. Trying to classify all shocks as twin-tube or monotube is as dumb of an idea as saying every vehicle is a car or a truck.

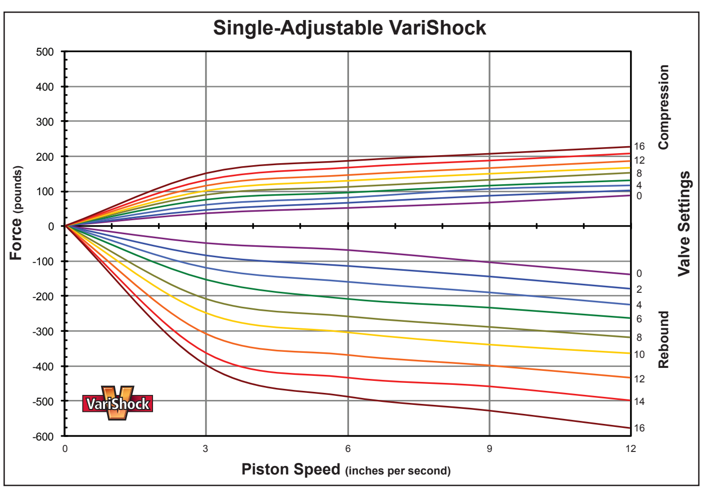
Shock Valving

In the world of shock valving there are non-adjustable shocks and adjustable shocks, adjustable being available in many configurations; single, dual, 3-way, 4-way, etc. They all have their purpose and it is important to understand how they all function and what they can provide in chassis tuning.

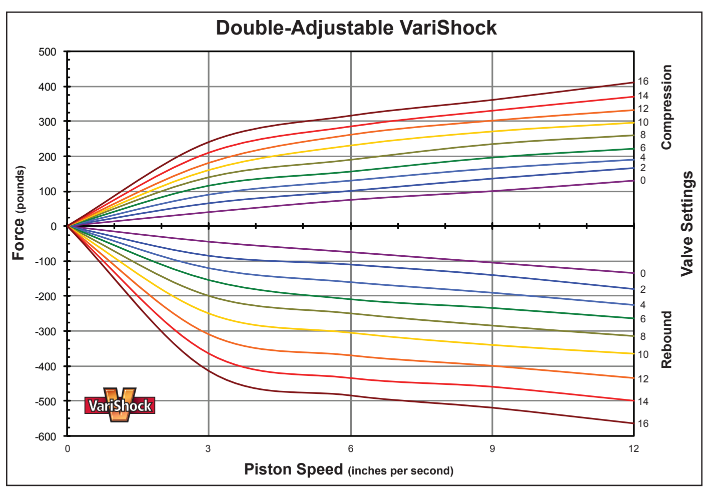
Let's start with non-adjustable shocks. As the name implies the valving is fixed and can only be modified by disassembling the shock and changing the internal components. A shocks job is to dampen the



VariShock bases and adjustment knobs are clearly etched with instructional features that describe the fuction of each knob. Facing or opposing arrows indicate which knob controls each direction of shock travel. Plus and minus signs at the ends of rotational arrows, located on the knob face, illustrate the correct direction to turn the knob to either increase or decrease stiffness.



VariShock's single-adjustable (QuickSet1) valve mechanism enables adjustment of the shock's overall stiffness. Some shock manufacturers limit their single-adjustment valve to affect rebound stiffness only. Desired changes in compression stiffness would then require the shock to be revalved by the manufacturer.



Double-adjustable (QuickSet2) valving expands the adjustment range of shock compression and enables compression and rebound to be adjusted completely independent from one another. VariShock's 4-way adjustable shocks essentially split the left and right sides of this chart, allowing separate adjustments for the slower (left side) and faster (right side) piston speeds.

One of the multiple fully-automated machining centers that Chassisworks utilizes to manufacture the precision components required for VariShock and various private label shock absorber brands.

Aluminum alloy material blanks are robotically fed to the machining center. Just seconds before this photo was taken, the double-adjustable shock base was detailed with its internal valve passages, and is now being milled to accommodate a COM-8 spherical bearing eye.

Shock Valving (continued)

suspension travel, so it will not oscillate as the spring compresses and extends, a simple yet extremely complex job. What determines the chassis' handling characteristics is a combination of the spring rate, anti-roll-bar rate, motion ratios, vehicle weight, tire size, etc. Obviously as the list of variables grows it is simply impossible for an aftermarket manufacturer to make a non-adjustable shock that is exactly correct for the vehicle, there are just too many unknowns. For this reason Chassisworks only makes a very limited variety of non-adjustable shocks. They simply are only correct for an application where every detail is known. A manufacturer's best guess at the required shock valving is still just a guess.

As the conversion of cars to coil-over has an almost unlimited number of combinations it seems only reasonable that without at least single-adjustable shocks you have absolutely no hope of realizing the full potential of a coil-over conversion. A single-adjustable coil-over can only vary the ratio of bump and rebound together, or just one and not the other, depending on the valve design. Although better than a non-adjustable shock, they are no match for a double-adjustable valve set which allows you to independently adjust bump and rebound to fine tune the suspension. The more recent top of the line is a 4-way adjustable shock which allows you to independently adjust the high- and low-speed characteristics of the bump and rebound. Chassisworks manufacturers shocks with each of these styles of valving.

In The Game Since 1975

I have been a manufacturer in this industry since 1975 and have had to compete against a lot of inexpensive, poorly designed components. There are only two ways to sell against these types of parts; option one - try to make it cheaper by manufacturing offshore, or option two - make a better part and explain why, so customers understand that our product is better, worth more, and truly a better value. Obviously we chose option two.

The Home of Higher Technology

It's easy to overlook the importance of acquiring your products from a real manufacturer, but in performance applications and when you want to get the most for your money, nothing should be more important. Chassisworks recognizes this and dedicates our extremely talented army of employees and consultants each and every day to developing innovative solutions and manufacturing high-quality products in our state-of-the-art factory.

Putting What You Know to Use

If you want to be successful when converting your car to coil-overs, it is imperative that you understand two basic principles.

1. The most important things about a coil-over conversion are travel, travel, and travel. Never pick a coil-over based solely on how it fits. For the best results, you must fit the required amount of shock travel into your application.
2. Look for a manufacturer who truly understands the complexities of coil-over conversions. If they have not provided detailed information about them to assist you with their product, do they deserve your business?

In closing, verify that your supplier is not just spewing marketing babble and you will be fine.

Chris Alston