



Baseline Spring Rate and Drag-Race Tuning Guide

Determining the correct spring rate and correctly adjusting your suspension is very important to achieving the best possible and most reliable performance from your components. In fact, the vast majority of problems people experience with coil-over shocks can be attributed to using the wrong spring rate or incorrect adjustment of the shocks many settings.

What is the Baseline Spring Rate?

“Baseline spring rate” is defined as the pound-per-inch rate (lb/in) at which the spring supports the corner weight of the vehicle with the coil-over shock at the correct installed height without the need to preload the spring. Once the baseline spring rate has been established, the vehicles performance goals and further testing will reveal the correct final spring rate for each installation. Differences such as how the spring is mounted (installation motion ratio), vehicle weight reduction, chassis stiffening, specific performance application, and driver preference and skill level all have a bearing upon the correct final spring rate.

Where to Begin? (Initial Spring Rate)

Based on our experience with vehicles and performance applications similar to your own, Chassisworks can recommended an “initial spring rate” to install on your vehicle, from which the correct baseline spring rate can be derived. In many cases our recommended initial spring rate will be the correct baseline spring rate. However, due to the sheer number of variables, it is impossible for our technical staff to predict the precise baseline spring rate for each and every installation scenario. To assist you in obtaining the correct spring rate, a second set of springs can be purchased at a discount.

Taking Measurements

Chassisworks has developed a simple method to determine the correct baseline spring rate. This method requires installation of our initially recommended spring, followed by a couple quick measurements and some simple calculations. Before getting started, the vehicle must be 100% complete. This includes interior, glass, fluids, weight ballasts, and sand bags or free weights to substitute as the weight of the driver. At this point, the springs should already be installed on the shocks with NO PRELOAD and ready to go onto the vehicle. *Lower spring seats should be just tight enough to remove free play from the spring.*

1. Record the initial spring rate as value “R” in the calculation table that follows. Most VariSprings will have the rate printed directly on them.
2. With the shock fully extended, measure the installed free-length of the spring. At the upper-spring-seat slot, hook the end of the tape measure against the spring and measure, with one sixteenth-of-an-inch accuracy, the distance to the ground bottom edge of the spring. Record this dimension as value “F” in the calculation table that follows.

NOTE: The measured length may differ slightly from the nominal spring length. In our example the 9” VariSpring actually measures 8-15/16” when correctly installed.



Hook the tape measure against the spring at the upper spring seat slot.



Measure the bottom end of the spring.



3. Install all shocks and springs onto the vehicle and lower it to the ground.
4. Verify that the springs are supporting the full weight of the vehicle. Any chassis or shock bump stops that are in contact must be temporarily removed. Make sure to replace bump stops when finished.
5. Measure the springs again at their newly collapsed installed height to within one sixteenth-of-an-inch accuracy from the same spring reference points used previously. Record this dimension as value "L" in the calculation table that follows.

Installed Height by Performance

When a shock is at installed length (ride height) a certain amount of travel is available in either direction. Depending upon performance application, shock travel will be reserved in different percentages for bump (shock compressing) and rebound (shock extending). Use the Reserved Shock Travel Percentage Guidelines and appropriate chart to determine the amount of bump travel required to collapse the shock to the correct installed length for your performance application. Record this dimension as value "T" in our calculations.

NOTE: In our example calculation, a handling performance application with a 4.25"-travel coil-over shock lists a "T" value of 2.13.

Perform the Calculations

Calculation Table

The leftmost column in the calculation table gives you a place to record your values. Use a pencil in case you make a mistake.

Record Values	Variable	Description
___'___	F	measured initial Free length of installed unloaded spring
___'___	L	measured Loaded spring compressed length
F - L	Answer 1	Subtract L from F
___ ___ lb/in	R	initial spring Rate in pounds per inch
Answer 1 x R	Answer 2	Multiply Answer 1 by R
___'___	T	spring Travel to achieve desired ride height (from chart)
Answer 2 ÷ T	BASELINE SPRING RATE	Divide Answer 2 by T

Example:

Measured free length (F) 8-15/16" or 8.94

Minus measured loaded length (L) 6-1/2" or 6.50

$$8.94F - 6.50L = 2.44$$

Multiply that answer by the current spring rate 500 lb/in

$$2.44 \times 500R = 1220$$

Divide that answer by the correct (T) value in chart

$$1220 \div 2.13T = 572.77B$$

Round the final answer up or down to a suitable spring rate.

$$\frac{(F - L) R}{T} = \text{Baseline Spring Rate}$$

Reserved Shock Travel Percentage Guidelines

Street Baseline: 60-percent Bump, 40-percent Rebound

Street vehicles require more available compression (bump) travel for improved ride quality and unexpected road hazards. At baseline ride height, the shock and spring should collapse 40-percent from their installed heights. This results in 40-percent of travel available for extension and 60-percent for compression travel.

Handling Baseline: 50-percent Bump, 50-percent Rebound

Handling performance applications are usually limited to smooth prepared road-course- or autocross tracks, therefore less compression travel is required. Suspension geometry or track conditions may require the travel percentages to be shifted to prevent topping- or bottoming-out the shock.

Drag Race Baseline: 40-percent Bump, 60-percent Rebound

Drag race vehicles generally require more extension (rebound) travel to help weight transfer, and because the drag strip is very flat, less compression travel is needed. The amount of extension travel available in the shock will drastically affect how the car works. At baseline ride height, the shock and spring should collapse 60- percent from their installed heights. This results in 60-percent of travel available for extension and 40-percent of compression travel.

Optionally, it is acceptable to adjust the shock's installed height to any length between the minimum and maximum spring-length value shown in the chart. This range allows you to adjust the vehicle ride height a small amount.

VariShock Coil-Over Shocks

Coil-Over Shock Travel	Street	Handling	Drag	Spring Free Length	Street	Handling	Drag
	60/40	50/50	40/60		Max.	Center	Min.
	<i>(T) Spring Travel Used At Ride Height</i>				<i>Installed Spring Length At Ride Height</i>		
2.80	1.12	1.40	1.68	7	5.88	5.60	5.32
3.50	1.40	1.75	2.10	7	5.60	5.25	4.90
4.25	1.70	2.13	2.55	9	7.30	6.88	6.45
5.15	2.06	2.58	3.09	12	9.94	9.43	8.91
6.15	2.46	3.08	3.69	12	9.54	8.93	8.31
7.15	2.86	3.58	4.29	14	11.14	10.43	9.71
Use above values for "T" in calculation table.				Compressed spring length will be close to above values when using the correct baseline spring rate.			

VariStrut OEM Bolt-In Struts

Strut Travel	Street	Handling	Drag	Spring Free Length	Street	Handling	Drag
	60/40	50/50	40/60		Max.	Center	Min.
	<i>(T) Spring Travel Used At Ride Height</i>				<i>Installed Spring Length At Ride Height</i>		
6.50	2.60	3.25	3.90	12	9.40	8.75	8.10
7.00	2.80	3.50	4.20	12	9.20	8.50	7.80
Use above values for "T" in calculation table.				Compressed spring length will be close to above values when using the correct baseline spring rate.			

VariStrut Integral Spindle Suspension Systems

Integral-spindle struts are designed for drag-race use only and are set-up to provide the maximum amount of extension travel.

Strut Travel	<i>(T) Spring Travel Used At Ride Height</i>		Spring Free Length	<i>Installed Spring Length At Ride Height</i>	
	Max.	Min.		Max.	Min.
4.00	2.5	2.75	9	6.50	6.25
6.00	3.5	4.5	12	8.50	7.50
Use above values for "T" in calculation table.			Compressed spring length will be close to above values when using the correct baseline spring rate.		

VariSpring Adjustment and Tuning Guide

Once the baseline spring rate has been determined, you are better prepared to make decisions with regards to changing spring rates for the purpose of tuning the suspension. Suspension tuning involves multiple variables such as: spring rates, anti-roll-bar rates, vehicle weight distribution, tire sizes, tire pressures, suspension geometry, and track conditions. The information contained in this tuning guide covers basic tuning procedures and has been greatly simplified to get you started in the right direction. We strongly recommend researching suspension tuning and vehicle dynamics, or consulting an experienced professional for further understanding of the pros and cons of making each adjustment.

Tuning Categories

VariSpring's broad range of spring rates and lengths are suitable to the three categories of suspension tuning: Ride Quality, Handling Performance, and Drag Racing. All three tuning categories have the common goal of controlled weight transfer, but have greatly differing vehicle-dynamic requirements. Each will be discussed in the following text.

Before proceeding verify that all suspension components, such as control arms, balljoints, and bushings are in acceptable condition and that tire pressures are correctly set.

Correcting Shock Installed Length

Threaded spring seats allow installation of spring rates that differ from the baseline spring rate for the purpose of performance tuning. With the spring free from the weight of the vehicle and the shock at full extension, spring seats can be threaded up or down to keep the shock at the correct collapsed install height. Raising the spring seat to compress the coil spring to any length shorter than it's free height, with the shock fully extended, is referred to as preloading the spring. During the tuning process if you elect to use a coil spring that is lighter than the calculated baseline spring rate, it may be necessary to add preload to achieve the correct balance of travel and ride height. If preload has been added make sure there is adequate spring travel remaining to prevent coil bind before the shock is fully collapsed.

Raising or Lowering Ride Height

The spring seats are not intended to alter the vehicle's ground clearance beyond the allowed range of ride-height shock lengths. Altering ride height in this manner, risks damaging the shocks due to the lack of reserved travel in either direction. Other options for altering the vehicle's ground clearance must be employed. Then include moving the upper or lower shock mount, changing to a different length shock, or changing tire diameter.

Adjustable Shock Mounts

Chassisworks manufactures many different styles of adjustable shock mounts to accommodate coil-over installation on both aftermarket and OEM chassis. If an adjustable shock mount cannot be used, then a longer or shorter coil-over will be required. Keep in mind that a shorter coil-over does lower the vehicle, but with a reduced amount of travel and a stiffer spring, making spring selection much more exacting and the possibility of a good ride more difficult. We do offer an optional 1"-extended upper shock eye to increase the length of any poly-eye VariShock without the need of an adjustable mount. (See photo)

Appropriate Shock Lengths

As a general rule, never use anything shorter than a 5"-travel rear shock. You also want to have at least 5 inches of front end travel. You can accomplish this with a 3.50" or 4.25" travel shock depending on the motion ratio of the front lower a-arm. As a practical matter a 4.25" travel front shock will give between 5.75" to 7.0" of front travel on most A-arms and has a lot broader selection of spring rates. As it has more travel, your installed length range varies up to .80" which will equate to a 1.25" range at the wheel to help you adjust your vehicle ride height without modifying the shock mount. That is why most Chassisworks designs use the 4.25" shock. It is clearly a better choice for performance cars.



1"-Extended Shock Eye

Drag Race Tuning

Required settings for drag racing applications vary greatly depending upon, vehicle weight, weight distribution, suspension geometry and travel, horsepower, and available traction. A properly tuned drag race suspension enables the vehicle to launch straight while transferring weight to the rear tires in an efficient, controlled manner. Extensive testing and adjustment is critically important when operating your vehicle at or near its performance limits. Testing must be done in a safe and controlled environment, such as a dedicated motorsports facility. It is generally better to tune suspension according to improvements in ET's (Elapsed Times) rather than for specific occurrences such as the amount of wheel stand. Due to differences in weight distribution, wheel base, tire size, and horsepower, not all vehicles leave the starting line in the same manner once their suspension has been optimized. Watch your ET's and if your times start to get slower return to the prior adjustment. Once you have completed the following procedures, only fine adjustments may be needed to tune for specific track conditions.

What Happens During Launch?

As a drag vehicle front suspension separates (the front of the car comes up) more weight is transferred to the rear tires to aid traction. How fast the front end rises is mostly controlled by the spring rate and front shock force. As the rebound valving of the shocks is softened it will be easier for the front end to lift. Not so obvious is if the car had a softer front spring, the front suspension will lift easier also. The explanation is quite simple. A heavier rate front spring will take more force to lift the front end a fixed vertical distance, than a lighter spring. If you have 500-lb/in front springs and the acceleration force transfers 1000 pounds of front end weight to the rear; 500 from each front spring, the front end lifts one inch. With 250-lb/in front springs, the same 1000 pound weight transfer will lift the front end a total of two inches. The lighter 250-lb/in rate benefits a drag car in two ways. The front end will move faster and farther because less force is required to initially extend the spring. And, it will rise higher, transferring more weight as the center of gravity rises, further assisting traction. However, too much weight transfer can hurt your ET by causing excessive wheel stands and lost forward motion.

Tuning Front Suspension with Spring Rate

A drag race car should run the lightest front spring rate possible, without letting the shocks bottom out when making a pass. As a general guideline, lighter springs allow the car to easily transfer weight, and settle faster down track. Changing spring rate affects ride height and the rate at which weight is transferred to the rear tires. A softer rate makes the front easier to rise during acceleration. A stiffer rate makes the front harder to rise during acceleration. If you are having trouble getting the front end to rise, you can soften shock rebound valving or change to a softer spring.

When using lighter rate springs, preload must be added by screwing the lower spring seat upward. Compressing the spring to achieve proper ride height will store energy in it. This is the very simple theory behind stored energy front drag-race springs. If you preload a spring, it is imperative that you verify that the spring has enough travel to not coil bind before the shock bottoms out. VariSprings feature a very high strength steel that allows them to be wound more coarse than traditional springs, which makes VariSprings travel farther before coil bind.

In general terms, the worse a car hooks, the more shock extension travel it will need. If you need more extension travel, preload can be removed to lower ride height. Using this method will cause the car to have less ground clearance and reduce the amount of compression travel. If you are going to operate the shock at a ride height shorter than recommended, the upper chassis mounts must be relocated to correct any major vehicle ride height issues. It may take some work with spring rates and upper mount relocation to get the correct combination of vehicle ride height and front suspension travel for your application.

Prior to Testing

Make certain that wheelie bars are raised as high as possible while maintaining control and eliminating their influence as much as possible on suspension settings.

Initial Testing

First verify that the vehicle tracks straight before aggressively launching from the line. Begin with light acceleration and low speeds. If the vehicle tracks and drives acceptably at this level, make incremental increases in acceleration and top speed until the vehicle is safe at higher speed. Vehicles not tracking straight at speed should verify all chassis settings including but not limited to alignment, bump steer, tire pressures, etc. Once the vehicle drives in a safe manner at speed, move on to test launching.

Test launches should consist of only the initial launch with no subsequent gear changes. Begin with low rpm launches and gradually increase rpm and severity if the car launches acceptably. At this time we are only determining that the car launches in a controlled manner to avoid damaging components or the vehicle. The vehicle should leave in a straight

line without extreme wheel standing or harsh bounces. Sudden, uncontrollable front end lift should be corrected by making suspension instant center adjustments, if possible. More gradual front end lift can be corrected by adjusting the shock valving, if possible. If the car gradually wheel stands or bounces violently, adjust front suspension first, then rear. If there is rear tire shake, wheel hop or excessive body separation, adjust rear suspension first, then front.

After the car has been adjusted to launch straight, test launch and include the first gear change. Make any required adjustments and add the next gear change. Repeat until the car can be launched straight and driven at speed safely. The car is now ready for fine tuning to optimum results.

Front Shock Adjustment

Pay close attention to what is happening to the front end during launch. Your goal is to eliminate all jerking or bouncing movements during launch and gear shifts. Ideally the front end should rise in a controlled manner, just enough to keep the rear tires loaded, then continue the pass with smooth transitions at all times. Front end rise without any appreciable traction gain is wasted energy that should be used to propel the vehicle forward instead of up. While testing, document your ET's along with any changes made. If ET does not improve, return to previous settings.

Front Rebound (Extension) Adjustment Overview

Too light of a spring rate or shock rebound (extension) setting allows excessive front end chassis separation and may result in the front wheels jerking violently off the ground during launch. Also, during gear change, too light a spring rate or shock setting allows the car to bounce off its front rebound travel limiter and then bottom out in an oscillating manner. Too firm a spring rate or shock setting will prevent the front end from rising sufficiently, limiting the amount of weight transferred to the rear tires. Spring rates should only be changed if the shock valving range is not great enough to correct the issue. While testing, document your ET's along with any changes made. If ET does not improve, return to previous settings.

Front Wheels Lose Contact with Ground	Increase Rebound Stiffness	Violent chassis separation and may result in jerking the front wheels off the ground. Increase spring or shock stiffness, then test again.
Rear Tires Hook Then Lose Traction	Increase Rebound Stiffness	If weight transfer occurs too quickly the rear tires may hook then lose traction as the front end begins to travel downward. Slowing the rate at which the front end rises prevents the shocks from topping out too quickly and increases the duration of time that the rear tires benefit from the weight transfer. Increase spring or shock stiffness, then test again.
No Front End Rise	Decrease Rebound Stiffness	Too firm of a shock setting limits the amount of weight transferred to the rear tires, resulting in poor traction. Decrease spring or shock, then test again.

Front Bump (Compression) Adjustment Overview

After the launch or during a gear change, a firm spring or shock setting will cause the chassis to bounce off the front tire as the chassis settles down. Too light of a spring or bump setting allows the shock to bottom out and bounce off the stop travel bumper. Spring rates should only be changed if the shock valving range is not great enough to correct the issue. While testing, document your ET's along with any changes made. If ET does not improve, return to previous settings.

Front "Bottoms Out" After Launch	Increase Stiffness	If front suspension settles too fast after launch or gear change it may cause the front suspension to bottom out at the end of its downward travel. If the suspension bottoms out hard enough, rear traction may be lost. Increase spring or shock stiffness, then test again. If increasing shock stiffness cannot extend weight transfer duration long enough, a higher rate spring should be installed.
Hard Front End Bounce (After Launch or Gear Change)	Decrease Bump Stiffness	If the tires cause the front end to bounce upon landing, the shocks are too stiff. The front end should settle in a single, smooth motion. Decrease spring or shock stiffness, then test again. This can be a very subtle problem. Watch the front tire sidewall as it contacts the ground.

High Rate Rear Springs

It is common in drag race rear springs to use a spring rate higher than the baseline spring rate. There are two primary reasons. One is to overcome some of the additional weight loading due to weight transfer. The second is not very well understood, and has to do with the way the rear suspension affects how the suspension moves.

As the car is initially launched, many suspensions will actually compress at launch for a fraction of a second, slightly reducing traction. Higher rate springs will resist harder against compression and help prevent the loss of traction. VariShock also manufactures a unique line of specially valved shocks that more precisely remedies this situation.

As always, there are practical limits to how stiff of a spring can be used. If the spring gets too stiff, a very dangerous condition develops. The suspension essentially prevents any compression travel, making the tire sidewalls the effective springs, and eliminating much needed damping that helps to stabilize the vehicle. This can potentially be a catastrophic problem if the vehicle gets out of shape at high speed. As weight shifts to the outside of the vehicle, the tire side wall compresses then rapidly unloads throwing the vehicle in the opposite direction. In a properly setup vehicle, shock damping slows the dramatic side-to-side weight shift, allowing the driver more time to react.

Rear Shock Adjustment (Double Adjustable)

The goal is to maintain traction by controlling the rate at which torque and weight is transferred to the rear tires. Ideally the rear suspension should be as firm as possible before a loss of traction occurs. Changes to the vehicle such as ride height, tire size, weight distribution, or suspension link adjustments will alter the instant center location in relation to the vehicle's center of gravity. Any shift of either the instant center or center of gravity will usually require a shock setting adjustment to optimize traction. While testing, document your ET's along with any changes made. If ET does not improve, return to previous settings.

Rear End Squats	Increase Bump Stiffness	Some vehicles will squat during launches instead of pushing the vehicle forward. To assist in planting the tires, increase shock bump stiffness by one, then test again. Spring rates should only be increased if the shock valving range is not great enough to correct the issue.
Vehicle Separates from Rear End	Increase Rebound Stiffness	Some suspension geometries plant the tires so forcefully that the rear end of the vehicle rises away from the housing too rapidly. The vehicle may hook initially, then spin the tires once the shocks are topped out. Slowing the rate at which the rear end rises increases the duration of time that the rear tires benefit from the improved traction. Increase shock rebound stiffness by one, then test again. Spring rates should only be increased if the shock valving range is not great enough to correct the issue.
Loss of Traction with Minimal Chassis Movement	Decrease Bump/ Rebound Stiffness	A suspension system that is too stiff can hit the tires too hard, causing a loss of traction. Softening the suspension slows the transfer of weight and reduces the initial tire shock. Minimal chassis movement makes it very difficult to visually tell if the bump or rebound needs to be decreased. We suggest adjusting bump first and watch for a gain or loss in the ET. If ET does not improve, return to previous setting, then adjust rebound instead and test again. Spring rates should only be decreased if the shock valving range is not great enough to correct the issue.

Completion of Testing

When all adjustments have been completed, reset your wheelie bars as low as possible without affecting your ET.



WARRANTY NOTICE:

There are NO WARRANTIES, either expressed or implied. Neither the seller nor manufacturer will be liable for any loss, damage or injury, direct or indirect, arising from the use or inability to determine the appropriate use of any products. Before any attempt at installation, all drawings and/or instruction sheets should be completely reviewed to determine the suitability of the product for its intended use. In this connection, the user assumes all responsibility and risk. We reserve the right to change specification without notice. Further, Chris Alston's Chassisworks, Inc., makes **NO GUARANTEE** in reference to any specific class legality of any component. **ALL PRODUCTS ARE INTENDED FOR RACING AND OFF-ROAD USE AND MAY NOT BE LEGALLY USED ON THE HIGHWAY.** The products offered for sale are true race-car components and, in all cases, require some fabrication skill. **NO PRODUCT OR SERVICE IS DESIGNED OR INTENDED TO PREVENT INJURY OR DEATH.**

Chris Alston's Chassisworks
8661 Younger Creek Drive
Sacramento, CA 95828
Phone: 916-388-0288
Technical Support: tech@cachassisworks.com

