Baseline Spring Rate and Handling 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)

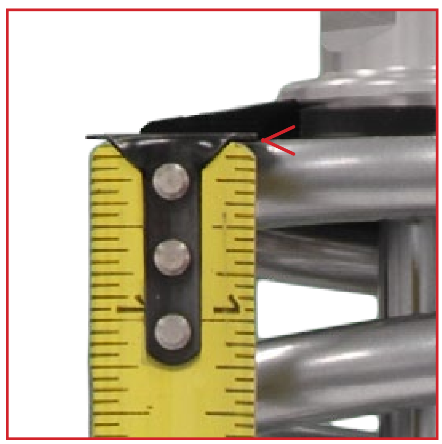
Based on our experience with vehicles and performance applications similar to your own, Chassisworks can recommended an “initial spring rate” to install on your vehicle, from which the correct baseline spring rate can be derived. In many cases our recommended initial spring rate will be the correct baseline 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

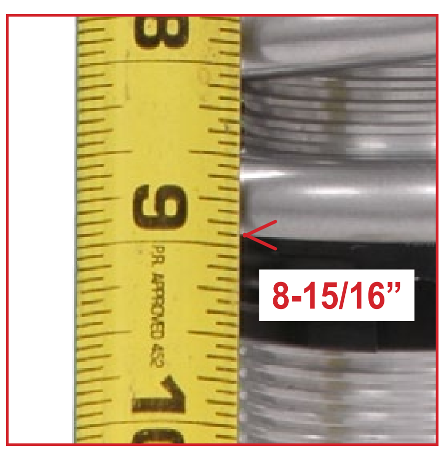
Chassisworks has developed a simple method to determine the correct baseline spring rate. This method requires installation of our initially recommended spring, followed by a couple quick measurements and some simple calculations. Before getting started, the vehicle must be 100% complete. This includes 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 x 500R = 1220

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

1220 ÷ 2.13T = 572.77B

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

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

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.
	(T) Spring Travel Used At Ride Height				*Installed Spring Length At Ride Height*		
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.
	(T) Spring Travel Used At Ride Height				*Installed Spring Length At Ride Height*		
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	*(T) Spring Travel Used At Ride Height*		Spring Free Length	*Installed Spring Length At Ride Height*	
	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 empolyed. 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)

1"-Extended Shock Eye

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.

Tuning for Ride Quality

Tuning for ride quality generally involves spring rates that are at or slightly below the baseline spring rate, matched with softer shock settings to achieve a smooth and comfortable ride. Use of adjustable shocks allows softer settings for regular street use that can easily be changed to a stiffer setting for mild performance use. When properly adjusted for street use the vehicle should feel settled without continued bouncing (too soft), excessive harshness (too stiff), or fore/aft pitching. The vehicle's cornering ability can be improved with the addition of a moderately-sized front anti-roll bar. A moderate-size anti-roll bar will reduce body roll during cornering without increasing ride harshness over uneven surfaces. We feel that this general approach yields a comfortable driving vehicle that can be easily moved toward more performance oriented driving when used with adjustable shocks. Testing and adjustment is required to attain desirable results.

Shocks Topping- or Bottoming-Out	Increase Stiffness	If the shocks are within their allowed installed-height range and repeatedly exceed the travel limits of the shock, increase spring rates or shock stiffness to reduce the amount of suspension travel.
Excessive Chassis Movement	Increase Stiffness	If vehicle exhibits rapid weight shifts or continues to oscillate more than one suspension cycle before settling, increase spring or shock stiffness, then test again. As stiffness is increased, road noise and vibration will also increase. Note: Stiffening the shock does not reduce the amount of lean or dive in a sustained turn or braking maneuver, but does slow the rate of weight transfer to minimize unexpected changes in the cars handling.
Harshness and Vibration	Decrease Stiffness	If excessive road noise, vibration, or harshness is experienced decrease spring or shock stiffness, then test again.
Fore/Aft Pitching **(constant speed 50-70 mph)**	Alter Front-to-Rear Stiffness Difference	If vehicle exhibits fore/aft pitching at highway speeds, the rear springs or shocks should be stiffened or conversely the front springs or shocks softened. Ideally the rear suspension should oscillate at a slightly quicker rate than the front to minimize pitching.

Tuning for Handling Performance

Corner Weighting for Handling Performance

Threaded spring seats also enable available traction to be maximized by corner weighting the vehicle. In corner weighting, the spring seats are threaded up or down to change the height of the spring, thereby increasing or decreasing the percentage of total vehicle weight carried by that spring. Ideally, the total weight that each diagonal pair of wheels shares should be equal to the opposite diagonal pair. The diagonal balance is ideal for vehicles requiring equal cornering performance in both left- and right-hand turns. Offsetting the balance can be used as an additional tuning aid if desired.

Digital scale sets are available specifically for corner balancing and provide the most accurate information. Before corner balancing, all tires must be at their correct pressure level and 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.

Example 1

Left Front	110 lbs	Right Front	110 lbs	**= 200 lbs**
Left Rear	90 lbs	Left Rear	90 lbs	**= 200 lbs**

Example 2

Left Front	115 lbs	Right Front	105 lbs	**= 200 lbs**
Left Rear	95 lbs	Left Rear	85 lbs	**= 200 lbs**

Handling Performance Tuning Strategy

Our preferred setup strategy for handling performance involves a modest spring rate, at or above the calculated baseline spring rate, adjustable shocks, and heavier-rate anti-roll bars to help control chassis movements. Generally, as the driver's and vehicle's ability to generate cornering and braking forces increases, spring rates should be increased to minimize the body roll and brake dive. Stiffer tuned suspension increases vibration transferred to the vehicle and passengers, but is usually tolerated for performance gains. There are alternate tuning approaches, but we feel that this strategy allows rapid adjustments without the requirement of multiple spring rate changes to find the correct combination of components.

As a vehicle approaches its cornering traction limit the handling characteristics of understeer and oversteer will become more apparent to the driver. Cornering balance is a result of the relationship between a multitude of factors including weight distribution, tire sizes and pressures, specific suspension geometries, spring rates, anti-roll-bar rates, and shock bump and rebound stiffness. Chassisworks' tuning strategy is to use front and rear anti-roll-bar adjustments and shock stiffness adjustments to bring the vehicle into balance. As a very basic rule of thumb; the softer end of the vehicle will have more grip, and the stiffer end of the vehicle will have less grip. So, if the vehicle has understeer, soften the front suspension or stiffen the rear. Or, if the vehicle exhibits oversteer, soften the rear suspension or stiffen the front. For our purposes, softening or stiffening the suspension will consist of adjustments or changes to shock valving and/or anti-roll bar spring rates.

When properly adjusted the vehicle should feel responsive, exhibit balanced cornering grip, and maintain traction over irregular surface conditions. As previously stated, there are a multitude of additional adjustments that can be made to adjust cornering balance. A very basic chart is provided but the pros and cons of making each adjustment is beyond the scope of this document. If you intend to operate your vehicle at or near its performance limits, it is extremely important that extensive testing and adjustment be conducted in a safe and controlled environment, such as a dedicated motorsports facility.

Excessive Chassis Movement	Increase Stiffness	If vehicle exhibits rapid weight shifts, increase spring or shock stiffness, then test again. Note: Stiffening the shock does not reduce the amount of lean or dive in a sustained turn or braking maneuver, but does slow the rate of weight transfer to minimize unexpected changes in the cars handling.
Reduced Traction or Skipping	Decrease Stiffness	If a reduction in traction during acceleration, braking, or cornering is experienced decrease spring or shock stiffness, then test again. This will be most noticeable on rough track surfaces.
Shocks Bottoming Out **(body roll, brake dive or squatting)**	Increase Stiffness	If chassis movement during cornering or braking allows shocks to bottom out, increase spring or shock stiffness, then test again. The urethane bump stop can be used to gauge shock bump travel by sliding it down the piston rod, against the shock body, then checking its position after testing. If increasing bump stiffness cannot extend weight transfer duration long enough a higher rate spring should be installed.
Understeer Condition **(Neutral throttle)** **Car turns less than expected; commonly referred to as push, plow, or tight.**	Change Stiffness Bias Toward Rear	If vehicle exhibits understeer when cornering at neutral throttle, rear springs, shocks, or anti-roll bar should be stiffened. Or conversely, front springs, shocks, or anti-roll bar, softened. A slight amount of understeer is considered safe and reduces the chances of spinning.
Oversteer Condition **(Neutral throttle)** **Car turns more than expected; commonly referred to as tail-happy or loose.**	Change Stiffness Bias Toward Front	If vehicle exhibits oversteer when cornering at neutral throttle, front springs, shocks, or anti-roll bar should be stiffened. Or conversely, rear springs, shocks, or anti-roll bar, softened. Oversteer increases the vehicles tendency to spin when cornering and requires driver experience and skill to manage safely. This condition should be avoided by novice drivers.

Additional Tuning Adjustments

The chart to the right provides a very basic view of how a given adjustment will affect the level of traction at the end of the vehicle on which the adjustment was made. 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.

Adjustment	More Grip	Less Grip
Spring Rate	Softer	Stiffer
Shock Valving	Softer	Stiffer
Anti-Roll Bars	Softer	Stiffer
Weight Distribution	Lighter	Heavier
Tire Size	Wider	Narrower
Tire Pressure	Lower	Higher
Roll Centers	Lower	Higher
Aerodynamic Downforce	More	Less

NOTE: For shock absorber tuning instructions see tuning guide shipped with shocks.

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**.

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