



# SHOCK TUNING

USER GUIDE



# Table of Contents

[CLICK TO VIEW A SECTION](#)

<b>01.</b>	<b>Introduction »</b>	<b>3</b>
<b>02.</b>	<b>Glossary »</b>	<b>4</b>
<b>03.</b>	<b>Progressive, Digressive, &amp; Linear »</b>	<b>5</b>
<b>04.</b>	<b>Shock Basics »</b>	<b>7</b>
<b>05.</b>	<b>Click Settings »</b>	<b>8</b>
<b>06.</b>	<b>Slope Settings »</b>	<b>10</b>
<b>07.</b>	<b>Shock Histograms »</b>	<b>12</b>
<b>08.</b>	<b>Final Notes »</b>	<b>20</b>





# 01 INTRODUCTION



Motorsport is full of secrets. Teams at the top levels of racing go to great lengths to hide secret designs, car setup, and other tricks they want to hide from the competition. In many cases it's easy enough to uncover what's hidden as soon as the car hits the track, but absolutely nothing is kept as tightly under wraps as what is inside their shock absorbers. Shocks look relatively simple from the outside but often contain some of the more technologically-advanced components found on the entire car. Using just a piston and a fluid-filled cylinder, shocks handle the job of controlling ever-changing loads brought on by both the driver and the track, as well as helping maintain the most efficient aerodynamic platform possible.

Through the years since iRacing was released to the public we've been able to make the shocks more complex and versatile. Early on we only had simple shock "builds" that made the shock stiffer or softer, but today we're able to give you the option to build almost any shock package you could want using just a handful of adjustments. In some cases cars must stick to simple adjustments due to their real-world counterpart's series rules, but in many of the modern cars you can find a wealth of possibilities and speed with just a few clicks.



# 02 GLOSSARY

Racing shocks are very complex components, and with advancements in simulation modeling over the years we've been able to increase the complexity of our shocks to follow suit. This section outlines some terms that will be covered in the later sections and may be new to some users.

## **Compression or Bump**

The shock's Compression setting (also known as "bump"), is the setting that controls how much force the shock exerts during suspension compression, or when the shock is shortening from an external load.

## **Rebound**

Opposite to the Compression setting, Rebound controls the forces exerted from the shock while it is expanding. This occurs after external load is removed and the suspension is returning to its starting position.

## **Low-Speed**

Shock characteristics are divided into two ranges of shock shaft speed, usually with a change in behavior at the speed transition. Low-Speed refers to shock speeds seen during changes in driver inputs, like braking, throttle, or steering, usually under 1.5 inches-per-second.

## **High-Speed**

The High-Speed section of the shock's characteristics usually occurs over 1.5 inches-per-second, and handles sharp external loads that aren't created by driver input, such as bumps in the track surface or kerb strikes on road courses.

## **Overdamped**

A shock that doesn't allow the suspension to move like it should is known as an Overdamped system, commonly known as a "tie-down" shock. While this type of shock can be extremely helpful for controlling body heights, it can wreak havoc on load variation and often produce a slower laptime when used improperly.

## **Underdamped**

A shock that allows the suspension to move uncontrolled is known as Underdamped. This type of shock will soak up bumps easily, but will allow too much movement of the car's body, producing an inconsistent aerodynamic behavior at high speeds.

## **Load Variation**

The major consideration with shock tuning is Load Variation, or the cyclical change in load at the tire contact patch. High load variation means the tire is cycling between low and very high loads, which is very bad for mechanical grip because the tire is constantly working with different loads. Low load variation means the tire is seeing a more consistent loading throughout a corner. Achieving a low load variation through the shocks is the best way to find a consistent driver feel as well as the lowest lap time.

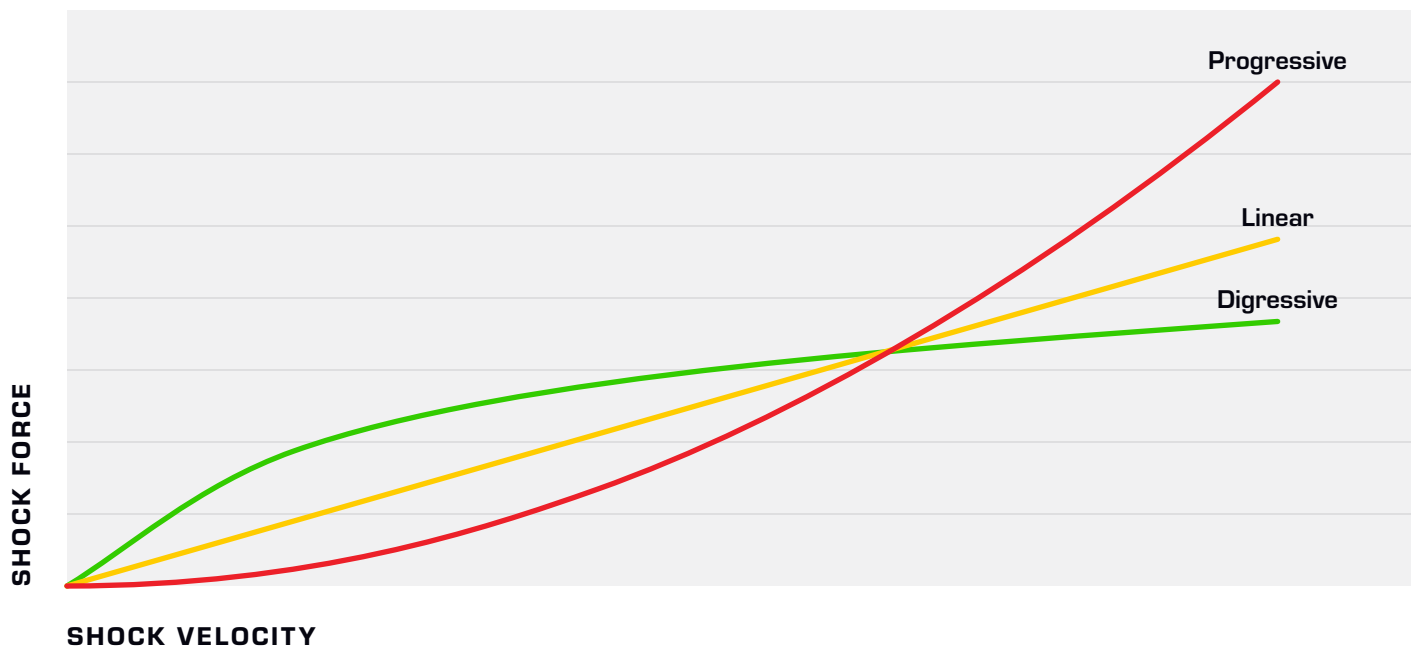


# 03

## PROGRESSIVE, DIGRESSIVE, & LINEAR

To fully tailor a shock package to a track's characteristics we need to understand shock profiles and how they can be used to deal with whatever situation we might encounter. While most of the shocks in the lower divisions on iRacing only have low-speed compression and rebound adjustments, which do not affect the shock profile, the upper division cars often feature Slope adjustments for compression, rebound, and even both in some cases. These slope adjustments will change the shock profile to suit the conditions with just a few small adjustments.usually under 1.5 inches-per-second.

### SHOCK PROFILE CURVES



The chart above displays the three types of common shock profiles: Progressive, Digressive, and Linear:

#### Progressive

A progressive curve has low amounts of resistance at low shaft velocities but gains a lot of force quickly as velocity increases. This type of shock is very common in off-road vehicles to allow for good absorption of small bumps at low shock speeds, while the higher forces at high speeds will help to keep the chassis from hitting the ground over large bumps and jumps.

### **Digressive**

Digressive shocks build force quickly at lower shock shaft speeds but don't increase in resistance very much in the high-speed region. This is very common on high-performance street cars and pavement racing cars, and at the most extreme cases is known as a shock that "blows out" over big bumps because of its low resistance to sudden large impacts.

### **Linear**

Linear shocks produce a steady increase in force with increasing velocity.

The slope adjusters change the profile of the shocks from linear to digressive, with progressive shocks not an option in most cars (but that's okay!). Understanding these profiles and when to use them will help to make the tuning process simpler and faster.



# 04 **SHOCK BASICS**

Shocks have two main functions that affect the mechanical grip available from the chassis. First, shocks will attempt to control changing wheel loads and body pitch/roll as a result of driver inputs, such as braking, throttle, or steering through Low-Speed settings. Second, the shocks will act to absorb bumps and dips in the track surface, as well as hard kerb strikes, with the High-Speed settings. Overall, the goal is to reduce the “load variation” on the tire, or the amount the wheel load changes through the corners. Tires seeing high load variation can swing up and down as much as a few thousand pounds very quickly, leading to a reduction in available grip. Tires with low load variation have much lower swings and can maintain much better grip with the racing surface because the contact patch is not changing size rapidly. The less load variation we can get, the faster the car will go.

Low-speed adjustments are primarily concerned with managing the vehicle’s chassis movements. When you apply steering input the car will roll to one side or the other, compressing the outside suspension and putting the inside suspension in rebound. Braking will compress the front suspension and rebound the rear, while acceleration will do the opposite. All of these situations are controlled by the shock’s low-speed settings. Since these situations are a direct response to driver input, these settings have a significant effect on mechanical grip and the handling characteristics during these situations.

High-speed adjustments are strictly responsible for controlling the sudden loads seen by the suspension through bumps in the track surface, dips, or kerbs on road courses. While the low-speed settings are usually more oriented to the driver’s style, high-speed settings are usually tailored to the track.

iRacing’s shocks can cover a wide range of conditions and can be tuned to suit any situation or driving style. They can be set too stiff or too soft, resulting in a loss of potential grip at either extreme, so it’s very important to spend some time on the shocks and make sure they’re tuned properly.



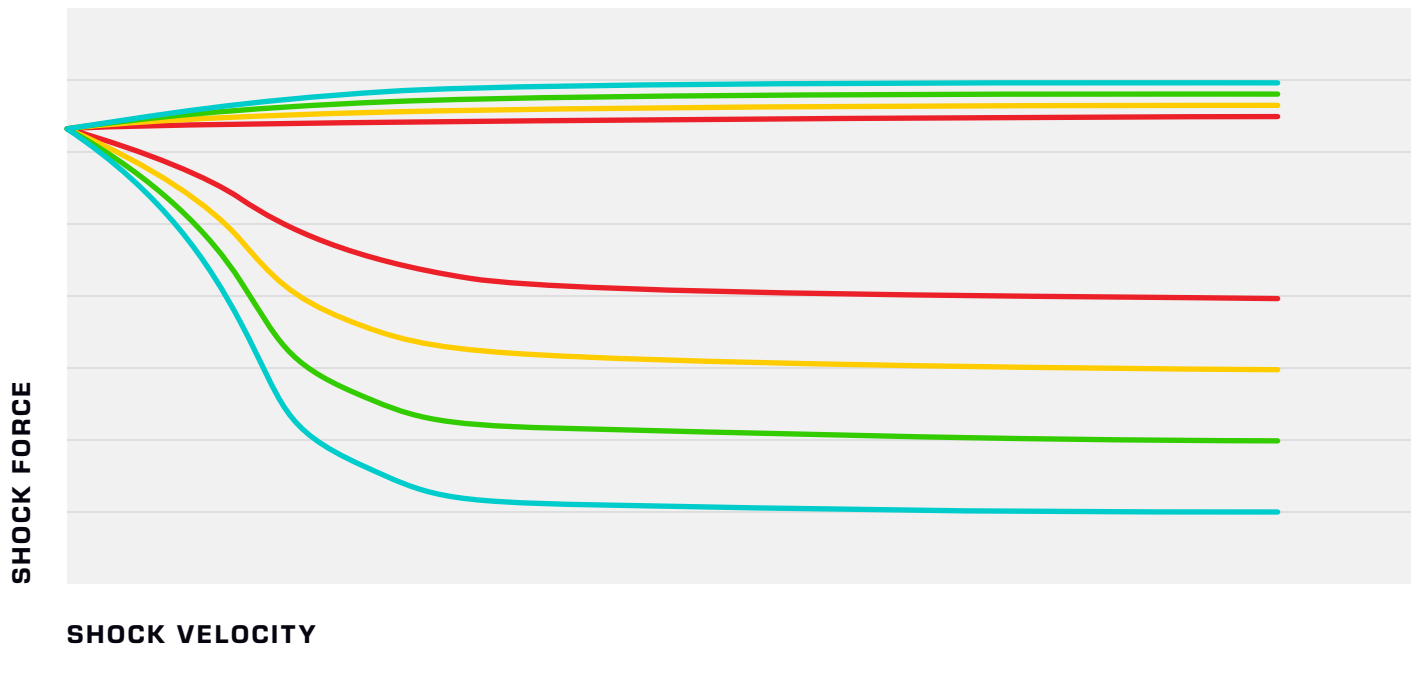


# 05 **CLICK SETTINGS**

The adjustments that most people are familiar with are the compression and rebound click settings, which alter the strength of the shock in either low- or high-speed. If a shock has only one adjustment in the garage, such as only Compression/Bump or Rebound, that adjustment will control the low-speed behavior of the shock with some influence on the high-speed behavior as well.

Below is a graph of the front shocks from the NASCAR NextGen vehicles in the iRacing service. For this graph, the slope settings [covered in the next section] were set to 1 and only the high- and low-speed click settings were changed. The upper section of the graph represents compression, the lower half represents rebound. While shocks are unique for each car, these shocks are a good representation of how the adjustments affect shock behavior.

## **CLICK CHANGES W/ CONSTANT SLOPE**



From this, we can see that the click adjustments affect the overall force from the shock but leave the shape of the high-speed section alone.



## LOW-SPEED (LS) ADJUSTMENTS

The low-speed settings are used to control suspension movement caused by changes in driver input. Think about the front shocks under braking and you have LS Compression. Similarly, the rear shocks are in LS Rebound under braking.

These low-speed adjustments can be used to control weight transfer in these situations and can have a direct influence on the car's handling characteristics on corner entry and exit. Since the car is usually not in transition through the center of the corner, shocks have very little effect on the handling through those areas.

For LS Compression adjustments, increasing the setting will cause the tire to be more loaded in a shorter amount of time. This is because the shock is resisting the compression movement of the suspension, so any increase in load must go through the suspension to the tire instead of being absorbed by the spring. Reducing the compression setting will allow the suspension to move easier, essentially storing forces in the spring and not transferring them to the tires as aggressively, resulting in a lower wheel load during these transitions. For example, increasing the Left-Rear LS Compression will increase understeer on throttle in a right-hand corner by loading the tire faster when throttle is applied.

**For LS Rebound adjustments**, increasing the value will load the adjacent tires when the shock is in rebound. For example if we increase the LS Rebound on the Left-Rear shock, this will load the Left-Front and Right-Rear tires under braking, helping the car turn into a left-hand corner. Conversely, adding LS Rebound to the Right-Rear shock will load the Left-Rear and Right-Front tires under braking, adding understeer to the car at turn-in for the same corner.

## HIGH-SPEED (HS) ADJUSTMENTS

The High-Speed compression and rebound settings control the shock forces above the low-to-high speed transition, around 1.5 in/s of shock velocity. At these velocities, the shock controls the large and sudden external forces typically associated with bumps in the track's surface.

As with Low-Speed adjustments, the compression setting controls the shock when it is seeing an external load and compressing, and rebound controls the shock when it is expanding after compression. Since the high-speed zone is reached by large and sudden forces, rebound velocity often mirrors compression velocity and thus the two should be set similarly. Excessive compression and low rebound can result in the suspension not absorbing a bump, expanding too quickly, and then landing on an overly-stiff suspension. Excessive rebound and low compression can produce a "locked down" suspension where it will compress over a bump but won't return to the starting state. Both of these produce very high load variation at the tire and will reduce overall grip.

Whenever the car hits a bump that puts the shock into the high-speed range, we want to both absorb the bump and keep the car from hitting the track. If the track surface bump is too large and the high-speed compression is too low, the suspension will collapse too quickly and the chassis will hit the track. If the compression is too high, the suspension will never absorb the bump at all and the tires will lose contact with the track. If we have the high-speed compression set properly, the car will both absorb the bump and the shock will help raise the chassis to clear the bump while the suspension is in compression. To achieve this, bumpy tracks will usually favor a higher high-speed compression setting.

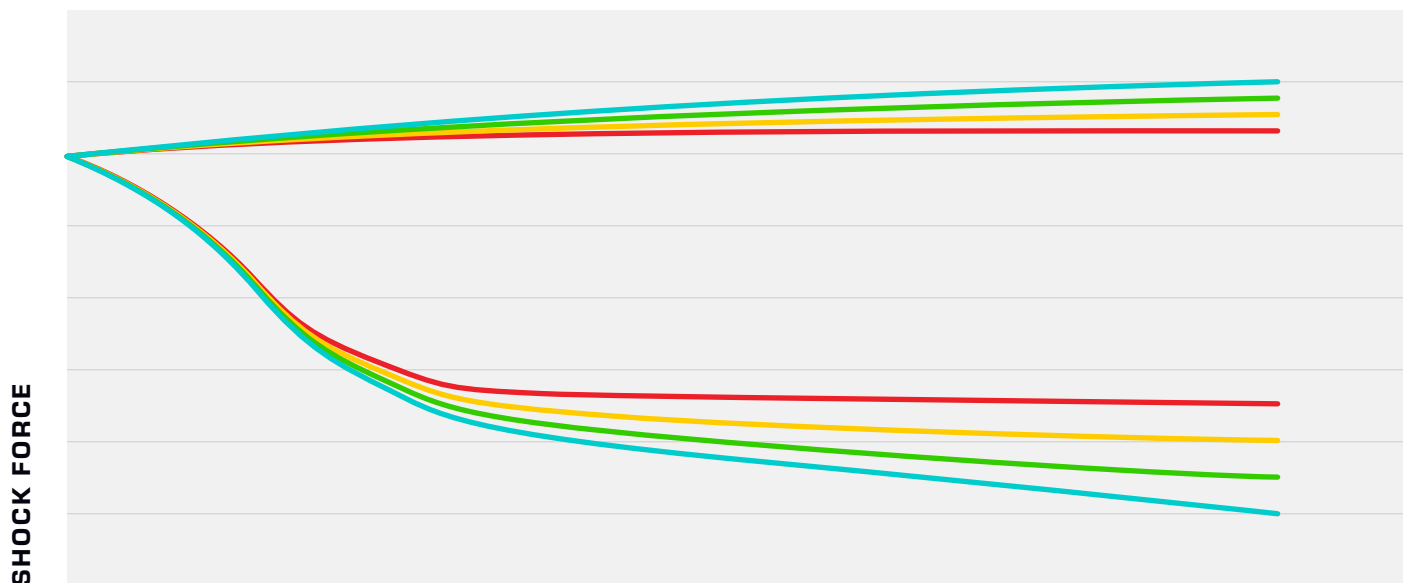
Smoother tracks have much smaller bumps that won't try to throw the car around, but the constant changes in load are usually enough to move the car's body around and affect aerodynamics. For these tracks, lower high-speed compression is better, as it will absorb the smaller bumps without trying to move the chassis out of the path of the bumps. This can sometimes result in minor contact with the track surface, but at smoother tracks that is less of a concern than maintaining an efficient aerodynamic platform.



## 06 SLOPE SETTINGS

In Section 03 we looked at the three major types of shock traces (Progressive, Digressive, and Linear) and situations where they're useful. The slope adjustment changes the shock's high-speed settings between Linear and Digressive without affecting low-speed adjustments, allowing a finer adjustment of the high-speed characteristics to suit a track. Again we'll look at the NextGen car's front shock traces set to a constant "clicker" setting, but with slope values changed for both Compression and Rebound. For other cars the rear shocks produce the same type of results for slope adjustments, however have a wider range on the compression side to maintain stability over bumps.

### CLICK CHANGES W/ CONSTANT LS CLICK SETTING



### SHOCK VELOCITY

In this picture, the red trace is the minimum slope setting while the blue trace is the maximum slope setting for each side of the shock graph. From this it's easy to see that these slope settings only affect the high-speed region of the shock, as the left-most part of the graph is the same for all four traces. In the high-speed section, we can see multiple changes in the shock's characteristics. On the compression side (upper half), the shock is purely digressive at low slope values and almost purely linear at high slope values. On the rebound side (lower half), we can see a progressive low-speed section that transitions into either a sharp digressive bend at low slope values or a transition to nearly linear at high slope values. In most cases, we would like to do rough tuning with both the compression and rebound side at similar slope values and change them if necessary once these have been roughed out.

As mentioned in the previous section, we want to tailor the high-speed section for a track type, bumpy or smooth and whatever is in between. For these we'll mostly be talking about what happens on the compression side, but the rebound side will likely be set fairly similar to the compression side:

### **Digressive (Low-slope) Shape**

For smoother tracks a more digressive curve is desirable. The car will see smaller, more high-frequency bumps that won't try to upset the car. When the shock is set to be digressive in the high-speed range, it will produce very little resistance to bumps at most speeds and will allow the suspension to easily soak up the bumps without moving the chassis and body around. Extremely smooth tracks, like Pocono or Circuit of the Americas, can use very low compression and rebound slopes, while bumpy tracks will see far too much suspension movement and chassis impacts on a low-slope digressive shock.

### **Linear (High-slope) Shape**

For bumpier tracks like the Atlanta Motor Speedway oval or the Belle Isle street course, the bumps in the track surface will be enough for the chassis to impact the track surface in the most extreme cases. For these cases a more linear shock is desired.

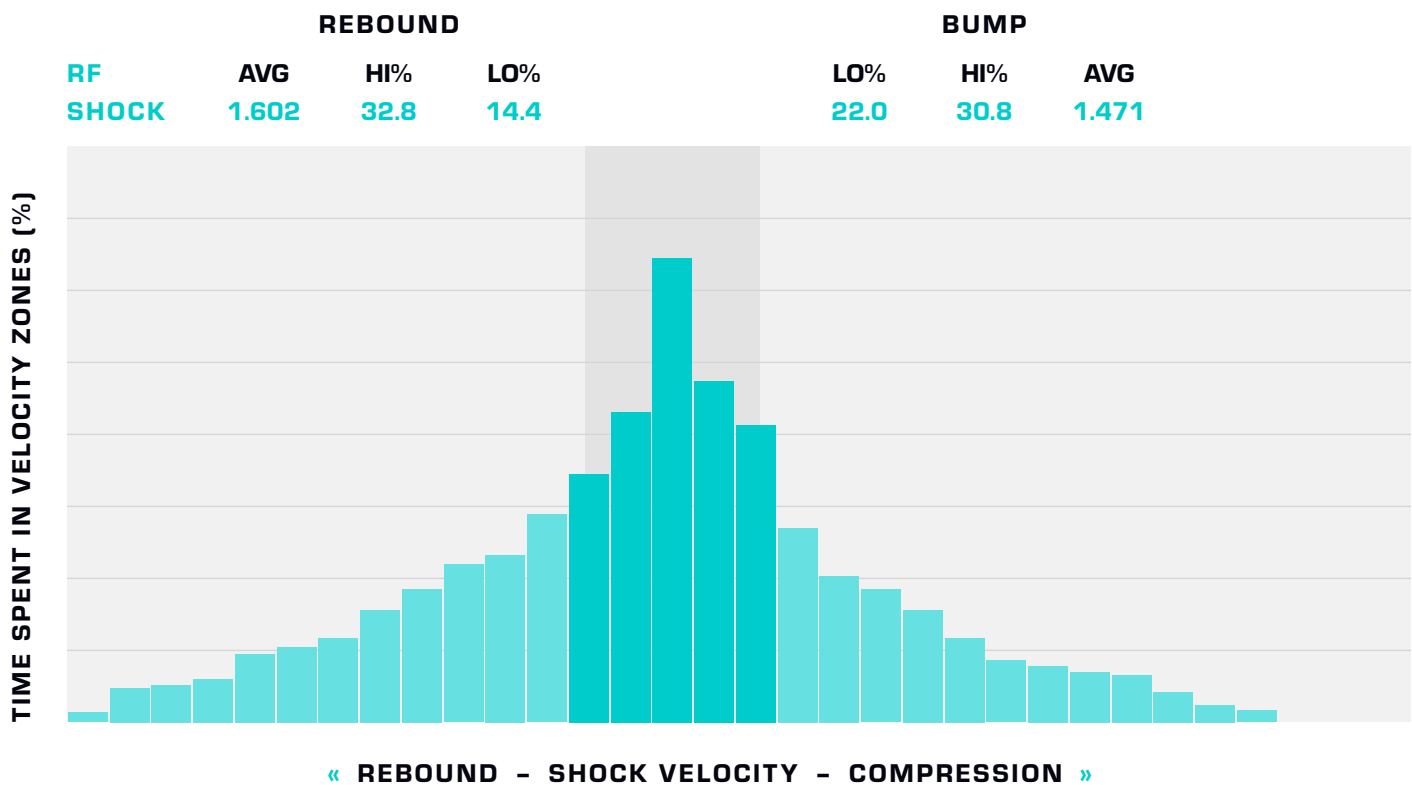
In either case, it's best to set the slope first to match the track conditions, and then alter the high-speed compression and rebound to fine-tune the shocks. If done properly, the car should absorb the bumps well without being thrown around.



# 07 SHOCK HISTOGRAMS

One method of shock tuning that works well for roughing-out both high- and low-speed settings is the Shock Histogram. This is a fairly common page, usually included as standard in telemetry workbooks.

## TYPICAL SHOCK HISTOGRAM



Above is a typical shock histogram display. Each bar represents a speed zone in the shock's velocity, with dark colors representing low-speed and light colors representing high-speed sections. For example, the center bar may represent the shock when it is between -0.5 in/s (rebound) and +0.5 in/s (compression). Bars to the right of center represent compression, bars to the left of center represent rebound. The farther from the center each bar is, the higher the speeds it represents. For example, the bars immediately left and right of the center bar represent 0.5-1.0 in/s of rebound and 0.5-1.0 in/s of compression, respectively. On most histograms, a shaded area towards the center will represent the low-speed region of the graph and these will be further defined by a darkened set of bars in the low-speed region.



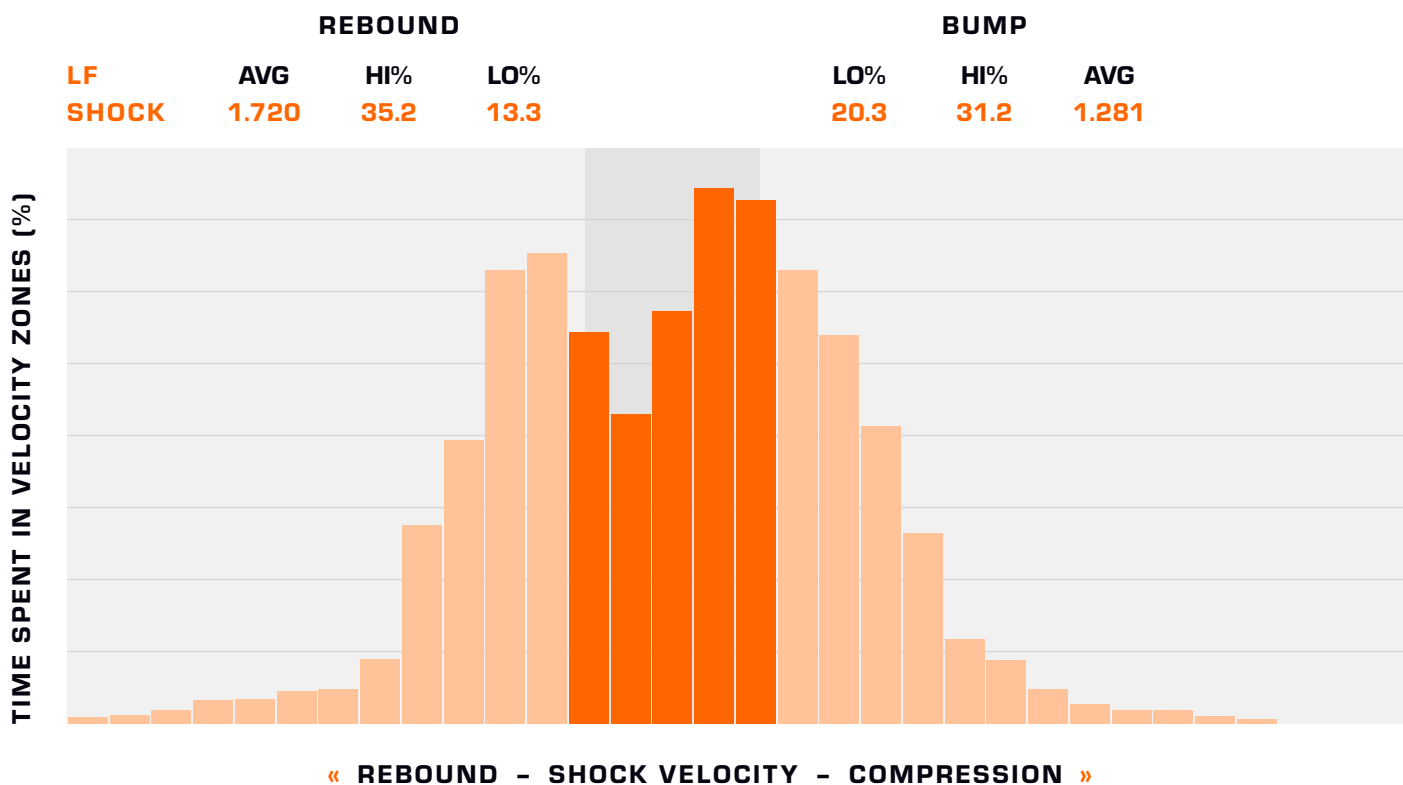
The y-axis, or height of the bars, is how much percentage of the time displayed is spent with the shock within a given bar. For example let's say a bar shows "30%" and the graph is showing an entire lap. This means that the shock is operating in this speed range for 30% of the entire lap. Ideally, we want the histogram to have low amounts of time spent in the outer regions (higher speeds) and more time spent towards the center with each side balanced against the other, like the image above. Ideally, the histogram should have a "curved triangle" shape like the one above.

Tuning from this is fairly straightforward: If a bar is too low we want to raise it, and if a bar is too tall we want to shorten it. To raise a bar, simply increase the shock forces for that section. This will stiffen the shock and increase the time spent in that velocity range. Conversely, if we want to shorten a bar, just reduce the shock force for that section. This will soften the shock, allowing it to expand or compress faster, reducing the time spent in that range. Balancing the histogram will lead to reduced load variation and better controlled suspension. This may not necessarily reduce single-lap speed, but will help immensely with long-run pace and potentially open up avenues to find speed elsewhere.

Finally, values across the top of most histograms show a general representation of the shock's behavior. Values on the left represent rebound, values on the right represent bump. For rebound in the histogram above, we can see immediately that the shock is averaging 1.602in/s in rebound while spending 32.8% of its time in high-speed and 14.4% of its time in low-speed rebound.

On the next few pages are some examples of histograms that resemble a typical histogram with various conditions that may crop up in testing and practice.

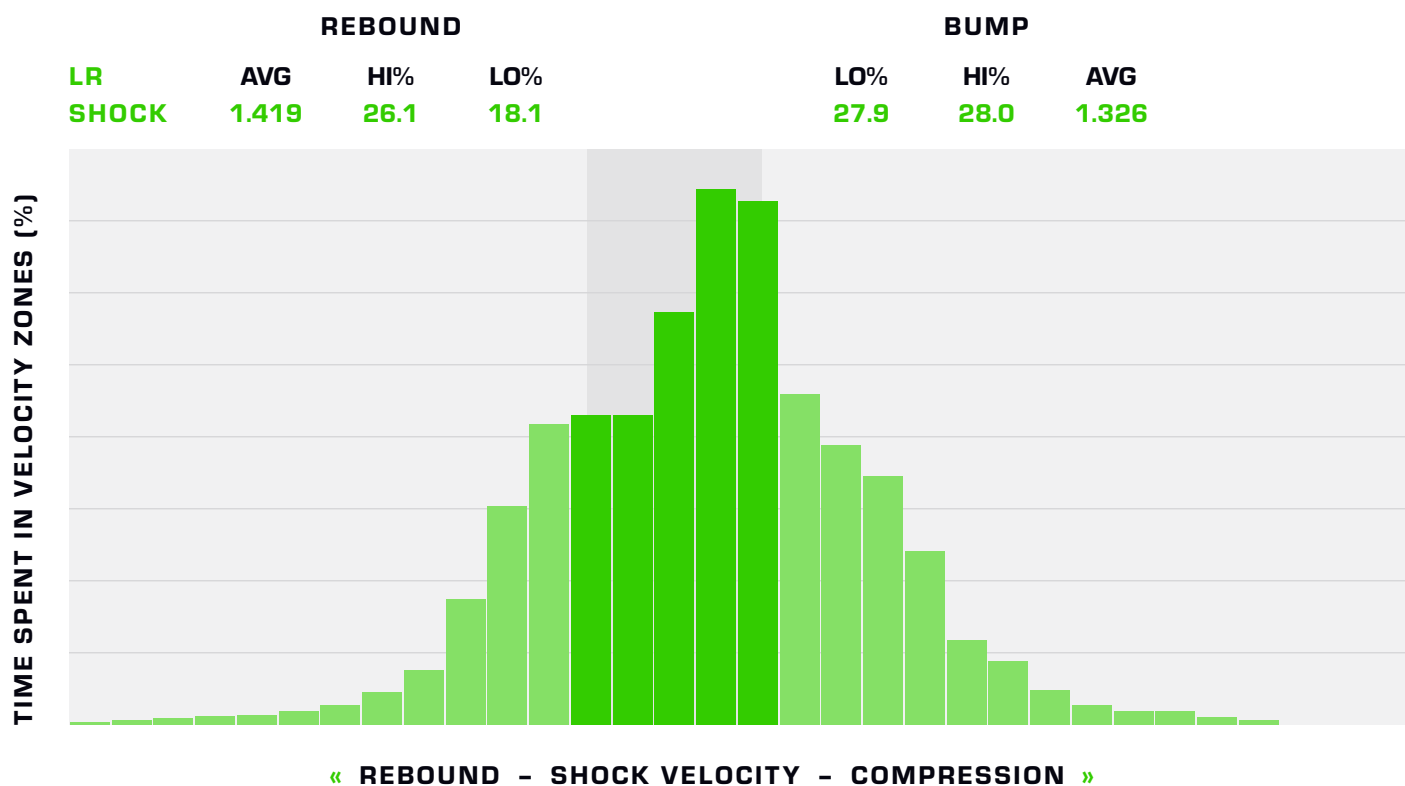
## EXAMPLE 01 EXCESSIVE HIGH-SPEED



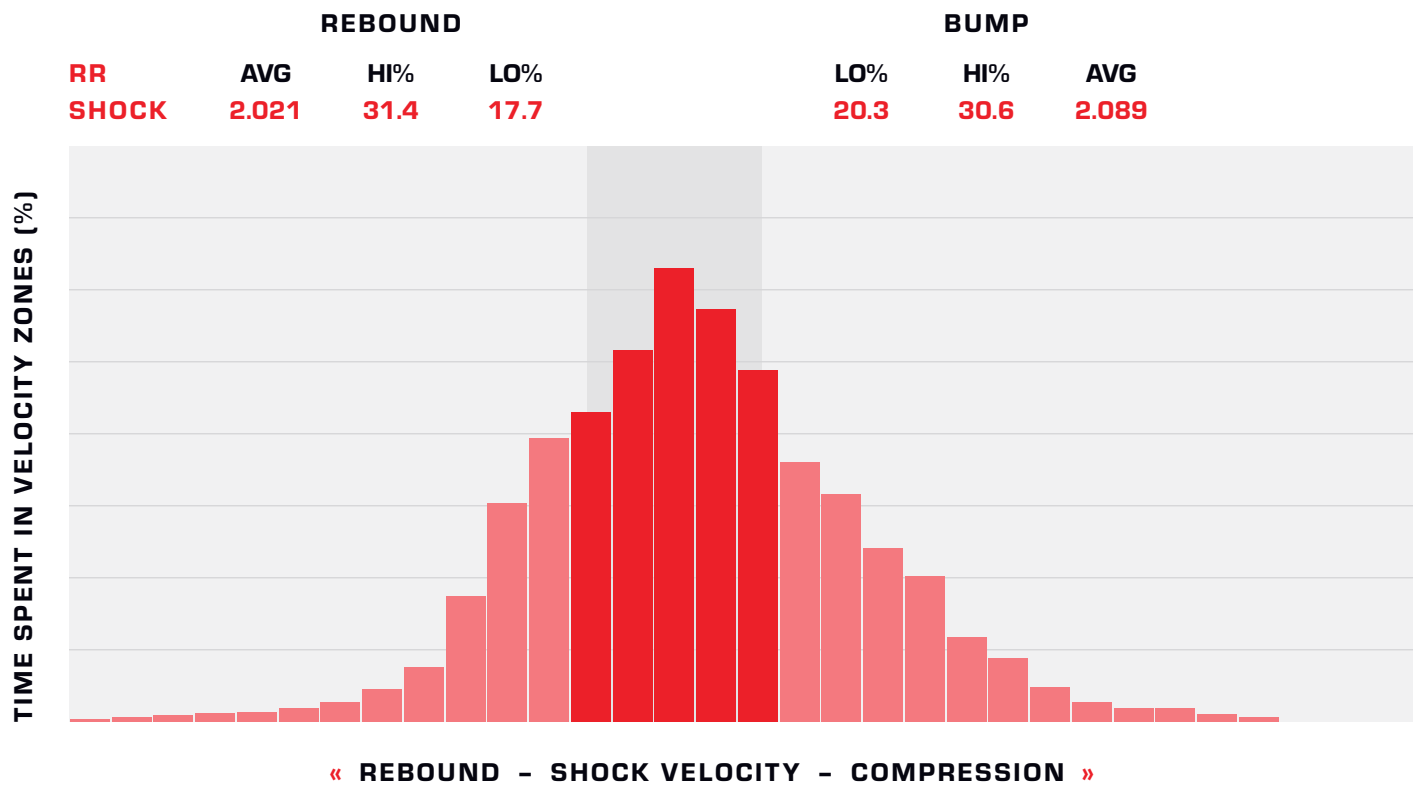
Here we have far too much high-speed on both bump and rebound, evidenced by the high "shoulders" on either side of the darker low-speed bars. For this shock we would simply reduce all high-speed settings, possibly even slope by one or two clicks, in an effort to bring these sections down and increase the percentage of time spent in the low-speed sections.

## EXAMPLE 02

## EXCESSIVE LOW-SPEED COMPRESSION



In this histogram we can see that the high-speed sections are fairly well balanced, with 26.1% spent in high-speed rebound and 28% spent in high-speed bump. Low-speed, however, is very imbalanced, with 27% spent in low-speed compression and only 18.1% spent in low-speed rebound. For this case, we would increase low-speed rebound and decrease low-speed compression to attempt to balance these zones. High-speed can be adjusted slightly to balance the 2% between bump and rebound, but it's not necessary in this case.

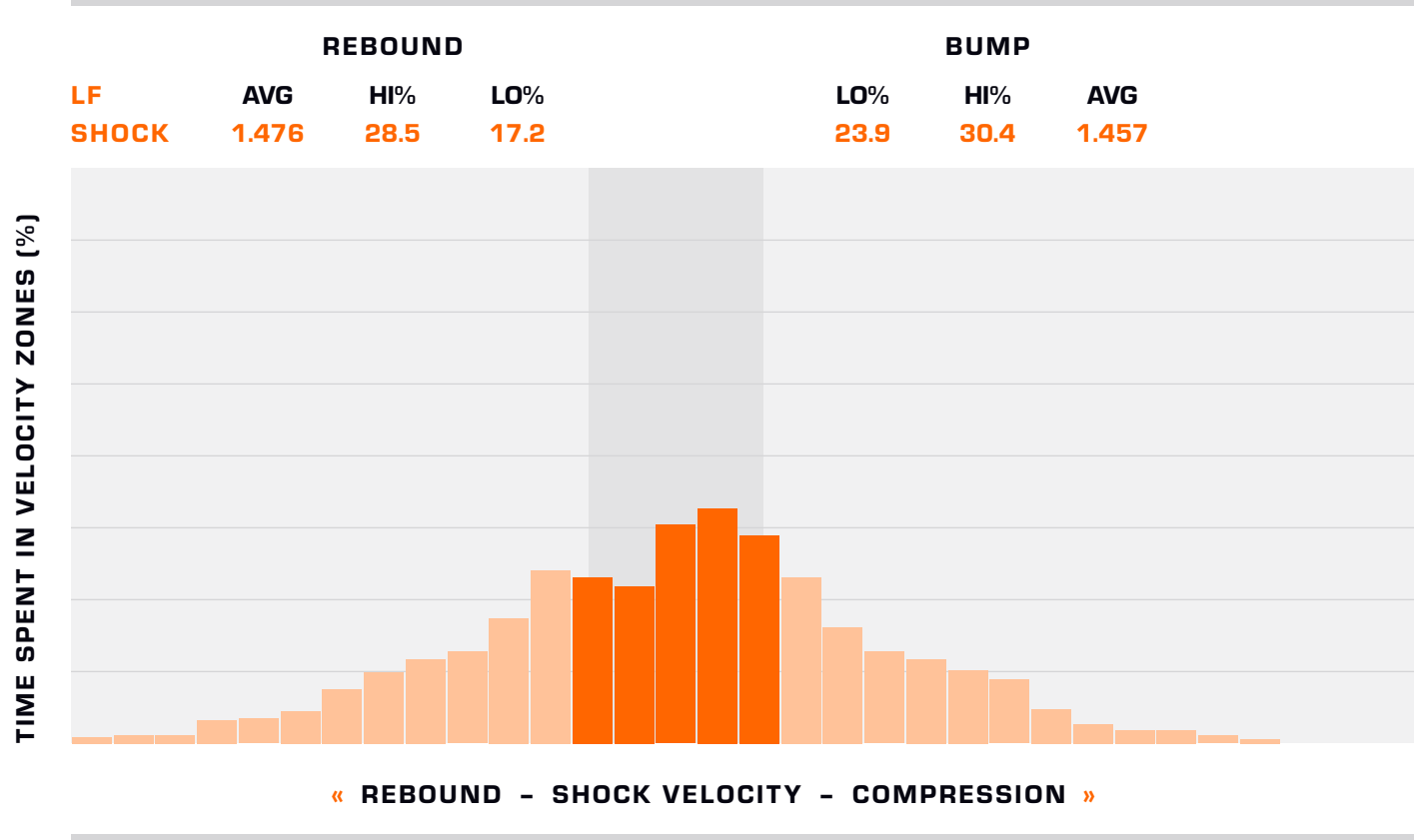
EXAMPLE 03  
**GOOD**

This shock is fairly good and is close enough that it can probably be left alone. We have nice, consistent upward curves on both the bump and rebound side, with the low-speed sections mostly balanced. If anything, we might reduce low-speed bump slightly, but if the feel is good it's probably okay to leave this shock as it is.

EXAMPLE 04  
ALL FOUR SHOCKS

The four histograms below represent the four shocks from one car on a single lap.

LEFT FRONT SHOCK

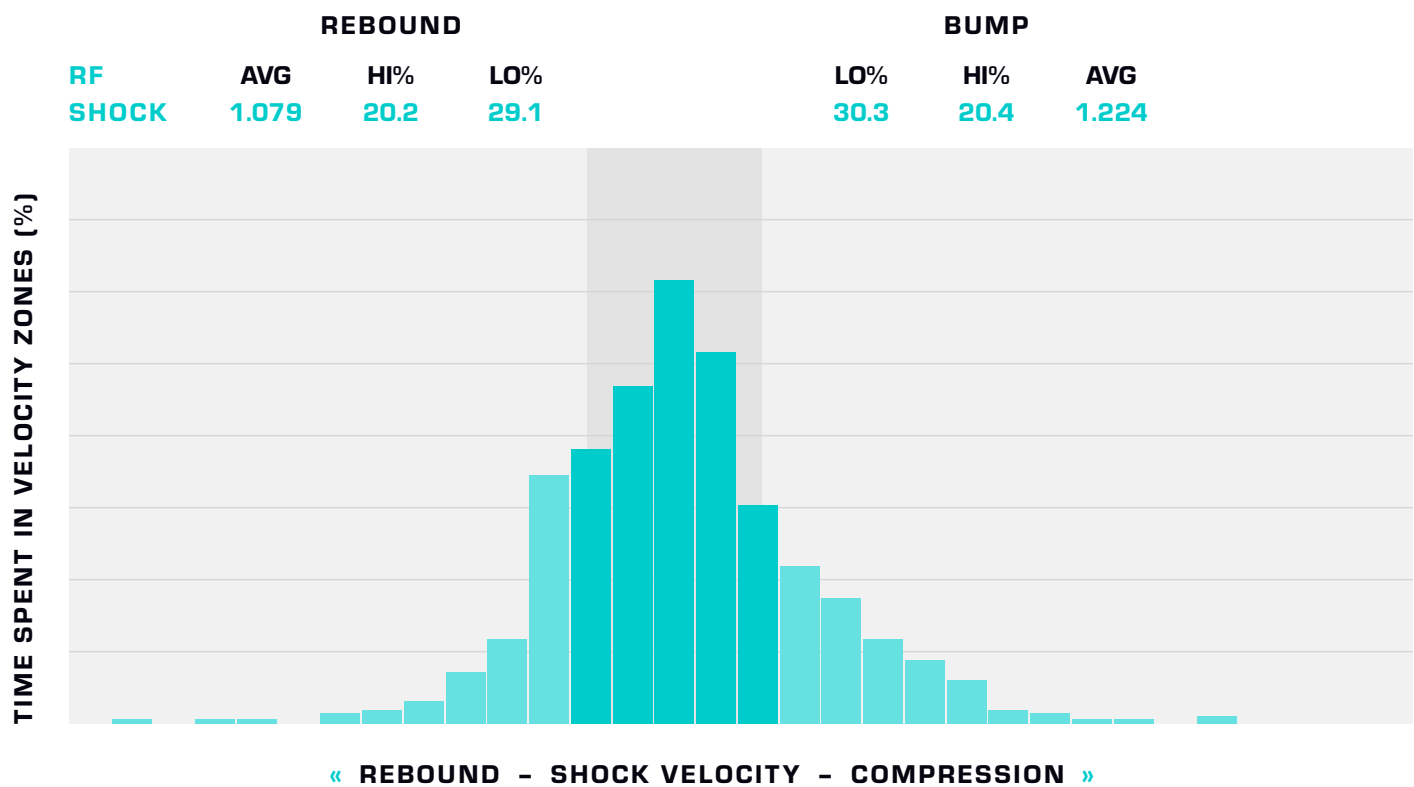


The Left-Front shock is nearly balanced in this case, but could benefit from a reduction in high-speed settings. Not much needs to be done to this shock.

NOTE: Histograms like this one that are relatively flat are perfectly fine, we're just looking for that balanced shape!

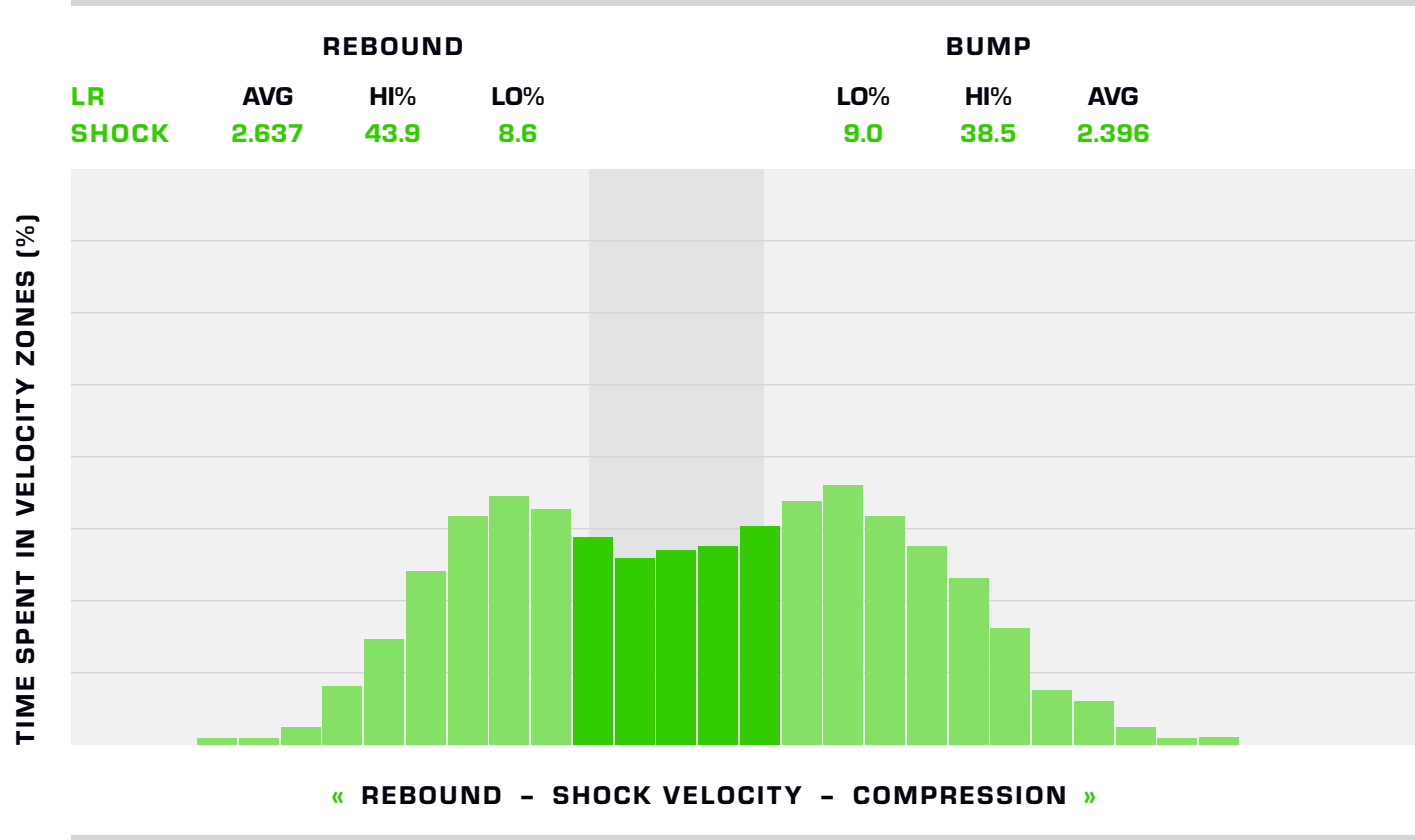


## RIGHT FRONT SHOCK



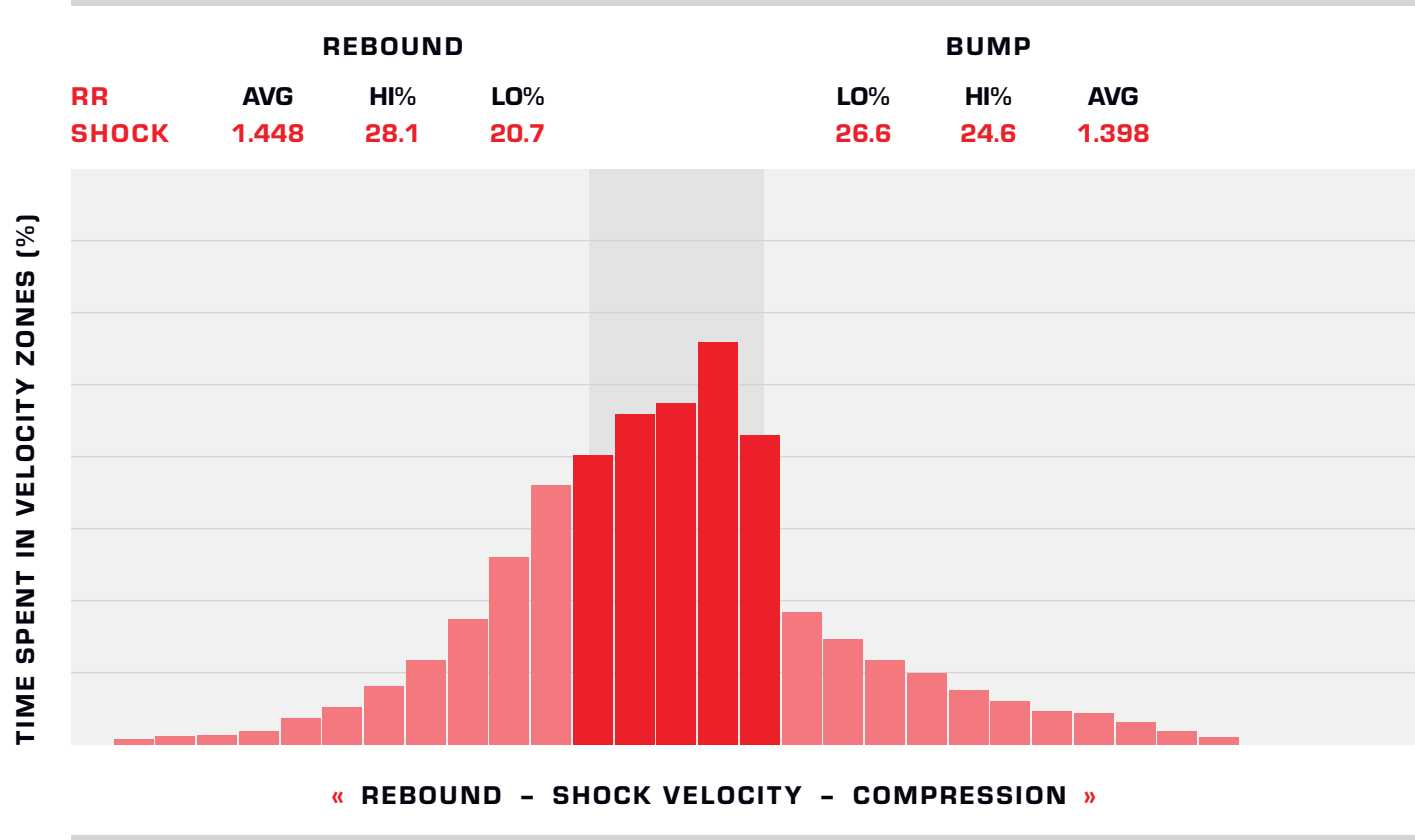
The Right-Front shock is spending most of its time in the low-speed region, which is fairly good. If we change anything on this shock, we might increase high-speed rebound slightly to raise all of the bars, or decrease the high-speed rebound slope, which will reduce the upper high-speed region stiffness and raise those bars.

LEFT REAR SHOCK



The Left-Rear shock has some problems. We need to decrease high-speed everything to drop the “shoulders” first, and then look at the slope settings to raise the center-most sections of the high-speed bars. Low-speed might be okay, however, as it does appear to be balanced but possibly influenced by the high-speed settings.

RIGHT REAR SHOCK



While the left-rear shock is a mess, the right-rear shock looks fairly okay. The rebound side looks very good, as does the low-speed section. For this shock, it might be good to make a run with the high-speed bump slightly higher to see how it affects the car.



## 08 **FINAL NOTES**

Shock tuning can look like a very daunting task at first, but with enough time and experience it can become the most crucial aspect of setup building. It's important to note that shocks are more of a fine-tuning point of the garage and not a foundational aspect of your setup, as even the best shocks cannot make up for bad spring packages or inefficient aero. Springs, heights, and alignments can get a car 90% of the way for most cases and shocks account for the final piece in a larger puzzle.

It's also important to understand that our shocks are intended to cover as many possibilities as possible with a finite amount of adjustment. In today's world we don't have the ability to provide every single shock adjustment available in the real world (and if we did it would require its own page in the garage!). Because our shocks must cover all types of tracks from bumpy to smooth, the range of adjustment is set so that they can do so. This means that, in most cases, the minimum values are too little damping and the maximum values are too much damping, so if you're looking to find that final bit of speed that you've been hunting for, there's a good chance it's sitting somewhere in the middle of the shock adjustment range. Take your time, go over the data, make adjustments, and the pace will come easily.