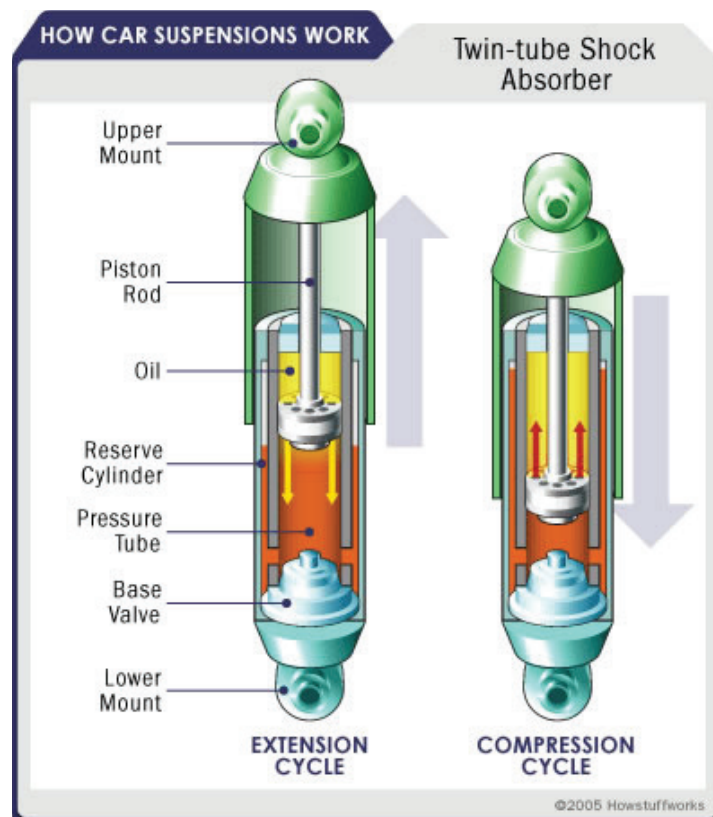


Shocks

By Larry Herman

Shock absorbers, or just plain shocks as they are colloquially known, are probably the least understood component of one's car. And to that point, even their American name is a misnomer; as part of their main function they do not "absorb" shocks. The English refer to them more accurately as Dampers because that is what they do. They limit or damp movement through hydraulic friction. The early shock absorbers like on the Model T were actually leather based disks that resisted rotational movement through dry friction, and had to be tightened up as they wore. Though they quickly disappeared with the advent of the hydraulic based shock, some British cars continued to use them up through the 1940s. Today's shocks are engineering marvels, with nitrogen pressurization, remote reservoirs, multiple velocity bleed disks, electronically adjustable valving, and even electro-magnetically altered (magneto rheological) fluid viscosity. But most of you are probably not as concerned with how they work as much as with what they do, and that is the goal of this article.

First let's start with a little nomenclature. The shock is made up of 3 basic parts, the body, the shock rod, and the internal piston and valves at the end of the shock rod. I have attached a picture of this. Movement which compresses the shock is called "Bump" or "Compression". Movement which extends the shock is called "Rebound". The rate that the shock compresses or extends is called the "speed" of the shock, and so high speed bump refers to quick compressions of the shock as would occur from suspension movement, and low speed bump would refer to slow compressions of the shock as would occur from body movement.



The shock absorber has a tough job to do. It has to limit the high speed (or high frequency) motions of the suspension as well as control the low speed (or low frequency) motions of the body. And it has to do this with no fixed anchoring point, because the shock is literally floating between 2 moving objects, the body and the suspension. In order to properly control the slow movements of the heavy body, the shock needs to have a lot of resistance, but if the shock is too stiff it will not allow the relatively light weight and quick moving suspension to properly follow the contours of the road. This is what makes shock design so challenging, and why they have become so complex. In order to accomplish proper control of both, the modern shock has special internal valves and bleed ports to allow a softer response to a quick movement generated by the suspension, and a harder response to a slow movement generated by the body. So far so good, right? The trick now is to understand how the dampening effects of the shock actually affect the loading of the suspension, which directly influences the grip and balance of one's car.

While the springs are what suspend the car, and provide the overall resistance to body roll and suspension movement, shocks control those movements on an immediate basis. They also are what initially transfers load until the body has time to roll and transfer load to the springs. So shocks can be used as a tuning tool to affect grip and balance on initial movement of the suspension. It is that instant resistance to movement that causes the shocks to either load (on compression) or unload (on rebound) the suspension, and cause a resultant increase or decrease in grip. This is why racing shocks have evolved from a simple one way loose/tight adjustment to the 4 way control (low & high speed compression and low & high speed rebound) that can be found on top end racing units like Moton Motorsports, easily costing over \$3,000 per shock. So what exactly happens when you turn your car into a corner?

As we slow, turn the steering wheel and bend the car into a corner, the body starts to roll on the suspension and the shocks are immediately in play. The outside front starts to compress and the inside rear extends. This causes an increase in load on the outside front tire, and a decrease in load on the inside rear. The immediate shift in balance is determined by the relative stiffness of the front compression as compared to the stiffness of the rear rebound. As we continue in the corner, the springs will compress (and unload) their respective amounts based upon their rates, and the balance of the car will now change to the relative stiffness of the springs (and sway-bars). As we transition to the gas around mid-corner, the balance will shift back towards the shock bias, but this time it will be based on the rebound in the front and the compression in the back. Remember that shocks exert the most control on initial movement, and over time (measured in tenths to full seconds) the load transfers back to the springs and sway-bars.

Proper shock settings can be difficult to get right. If the shocks are too soft for the spring rates, the suspension will oscillate over bumps and the body will roll and wallow. Everyone has seen what a car looks like bouncing up and down when the shocks are worn out. The shocks have to be set stiff enough to control the quick movements of the springs as well as the large movements of the body. However, if the compression is set very stiff to limit initial body roll and keep the tires on the road over bumps, major impacts can raise the body and actually reduce the amount of grip until the suspension recovers. If the rebound is set very stiff to try and keep the body from wallowing and feeling floaty, then the suspension may not be able to extend quickly enough to maintain grip when the road drops away. This could occur over undulations or after initial contact with a bump. As spring rates are increased, the time and actual distance that a shock moves is decreased, so proper adjustment becomes even more critical. This is why racing suspensions typically require the use of externally adjustable shocks.

The last item that I want to touch on is how shock adjustments can actually affect car handling. It is probably one of the hardest concepts to understand because it is so complex and inter-related with the rest of the suspension (springs, sway-bars, etc.). There is also a lot of disagreement on the subject due to that. Using the basics, you can dissect what is happening and apply that to further your understanding. As previously discussed, the shock is floating between the body and suspension with no fixed point of attachment. This means that what affects the tire is transferred through the shock to the body, and what affects the body is transferred through to the tire. This occurs much like what happens with springs, except the effect is much quicker, and temporary. If you tighten the bump in order to reduce the amount of initial body roll, you do so at the risk of displacing the body over large bumps, reducing load and hence the grip on that tire. If you tighten the rebound to "clamp the body down" you do so at the expense of grip, because preventing the suspension from extending will again reduce load and hence the grip on that tire. Also realize that body roll will unload the tires more quickly with higher amounts of rebound. To some extent, however, this can be used to your benefit. If you are trying to reduce understeer on initial turn-in for example, a little more rebound in the back will cause a slight unload of the inside rear, and so can help the car turn-in better. Conversely, as you pick up the throttle in the turn and the car rolls back on the rear suspension, increasing the bump in the rear will cause the body to more quickly put pressure on the rear tires and create grip faster, reducing the tendency to oversteer.

Knowing whether or not you have too much overall bump or rebound is very much a trial and error process. If the car chatters too much over little bumps, and you lose grip after impact with big bumps, you may be over damped on the compression. If the car feels really tight, but seems to lose grip over undulations, and after dips or where the road falls away, you may have too much rebound. With remote reservoir shocks, canister pressure can play a part too. With most canister shocks, increasing the pressure will increase the force on the piston, adding to your spring rate and increasing the compression damping. Since every manufacturer is different, it is best to check directly with them concerning the effects of increased pressure on your particular brand.

For some of you, I am sure that your heads are quite full right now, and I hope that I have provided you with a little enlightenment on what can be a very dark subject. For others, I am sorry if I have left you wanting but this was Shocks 101, and the like I said, many books have been written on shock absorber technology and adjustments. Hopefully as you dig a little deeper, things will be a little clearer for you.