KITCAR CHAPTER FOUR

SOME HARD LESSONS ON SHOCKS, SPRINGS, and SWAYBARS

Beginning with shocks, to understand them we must first understand the terminology that describes them. They fall into two basic categories, coil-over and non coil-over. A coil-over is just that, the spring surrounds the shock body, where the non coil-over uses a separate and larger diameter spring. Both of these items make the non coil-over much bulkier and more difficult to design with. The coil-over is the logical choice and is used on most all performance applications where a simple and cost effective solution is required.

Most coil-overs are adjustable, meaning that one end of the spring perch can be moved to adjust the ride height of the car. This is a very useful feature but let us dispel a common myth here. This adjustment does NOT effect suspension performance, ONLY ride height. Certainly a correct ride height will have an effect on performance, but changing the spring perch DOES NOT change the shock or spring characteristics.

They can be steel or aluminum bodied, gas or fluid filled, or other options. Among these is adjustability. They can be non adjustable, single adjustable, or double adjustable. A non adjustable is just that, the characteristics of the shock in compression and rebound are set and are unable to be fine tuned. A single adjustable allows the shock's rebound characteristics to be changed. Rebound is when a shock returns or passes it's normal length after being compressed by a bump, cornering, acceleration, or braking (in other words when the shock is expanding). A double adjustable can also change compression characteristics (and in the same words when the shock is compressing).

The price of a double adjustable is a little higher but in out opinion worth it. Afco, a worldwide leader in shock technology, has just introduced their Pro Touring line of shocks that fit our requirements nicely. Any basic shock is going to run around $100 and for around $200 the Pro Touring shock comes with the additional value of built-in coil over capacity, double adjustability, and a beautiful machined aluminum body. For a lesser price there are also shocks available in that line that are non adjustable.

The Afco catalog has several pages explaining shock characteristics and adjustments more in detail than this but still in terms not too technical for the average builder to understand. We highly recommend it.

There are two more design considerations. First is the mounting option. Again there are two basic categories, bearing or polyurethane bushing. We decided earlier in our chassis design that we would use bearings and rodends to standardize and economize the construction, so we must select between the available ½"I.D. x 1" wide bearing and the 5/8" I.D. x ½" wide bearing, and this is our first hard lesson.

Initially it would seem that the ½" was a no brainer, as all of our suspension rodends and hardware are ½', and consistent and generic usually translates to easy and economical. We have also made the decision to use A&A Manufacturing for all the suspension mount points, including the shock mounts.

Their mount is $4.20 and beautifully engineered, and because of this we have no desire to fabricate our own. This mount uses 1/2" hardware as well so all appears good, until we realize that the 1" width of the ½" bearing will not allow it to physically fit into the bracket. A quick check of some of the other bracket brands reveals the same thing, and cutting up that beautiful engineering is not an option.

What if we went to the 5/8" bearing which was only ½' wide? We could use a reducer bushing from A&A to make it work with the ½" mount and with all of our ½" hardware. Ordinarily we would object to adding pieces and complication, but that bushing, at a whopping cost of 74 cents, solves the problem nicely and has a very positive side effect. Now we have the option of selecting several different lengths of spacer bushings that are required to complete the shock mount. This allows us to fine tune the fore and aft location of the shock. This may be very welcome later, as we know that the clearance between the shock and the rear axle is critically close on any independent rear suspension car, especially when only one rear shock and spring is used per side like our design.

The final design consideration, and another hard lesson, is the stroke and compressed-extended length of the shock. The stroke is the total travel of the shock, usually between 3" and 7". Most passenger cars have a 7" travel shock where most performance cars, whether mid-engine, Cobra, or other, usually have design characteristics calling for about a 4" stroke. Remember that this is total travel so on a correctly mounted 4" shock there is only 2" of compression. Improper chassis designs that do not place the shock mount so that the shock is at this "sweet spot" when at ride height will not work. Also, the coil-over adjustment will not compensate for improper bracket location.

In order to properly locate the bracket, the compressed-extended length is necessary. This is the dimension of the shock eye to eye when it is fully extended and when it is fully compressed. For instance, an Afco 4" Pro Touring shock has been selected for our chassis which is 11" compressed and 15" extended. The difference of these two numbers is the stroke (4") and the middle of them, which is 13", is the sweet spot. Our properly designed chassis has shock mounts 13" apart at ride height.

Everything looks great to this point and we proceed with chassis development. Having now located all of what are called "pick-up points", which are the points that the suspension components attach to the chassis, and which totally control the suspension characteristics, we can begin computer assisted suspension analysis. Several software packages are commercially available to builders allowing them to do this for themselves, but it can still be a hair pulling experience trying to keep track of and control all of the variables. We prefer to pay a little more and leave it to the expert, Robert Metcalf at Metcalf Racing.

$700 later we know that our "eyeballed" design was dead on, a fact that can be attributed to eyeballing numerous cars over the years, and that we need about a 300 pound spring in the front and about a 150 pound spring in the rear, both axles with about a 200 pound swaybars. We are glad to have the $700 worth of assurance there but this too is very close to what we would have eyeballed.

This is the start of the next hard lesson and our eyeballs seem to be out of calibration. Like we did with shocks, let us first understand the terminology of springs. They also come in two general categories, a larger conventional diameter and the narrower coil-over diameter. Both are measured by their rate, which is the number of pounds that it takes to compress the spring one inch. There are also progressive rate springs but our 150 pound spring compresses 1" for each 150 pounds that it supports.

The other spring descriptive is it's beginning length. This will range from seven to fourteen inches and selection is determined by which length will fit the shock stroke selected. Afco recommends an 8" spring with our 4" shock as this is the tallest spring that will fit. Here is where our calibration goes bad, intuition says there is something wrong. Let us do some math. We know that we have about 1,200 pounds on the rear axle, 600 pounds on each side. This compresses our 150 pound spring 4", making the 8" spring only 4" tall at ride height.

Now let us introduce a term called coil bind. The definition is just that. When a spring is fully compressed and each coil is touching the next with no room in between, it is coil bound. The height of a coil bound 150 pound spring is 4 ½". It is coil bound before it ever reached ride height and we have not even considered how much more it will compress as the suspension works! The example using the front 300 pound spring is only slightly better. At least it does not coil bind at ride height but there is no room left for travel.

What is the solution? We must go to a 5" stroke shock which will allow use of a 10" tall spring that will not coil bind. Now the sweet spot changes from 13" to 13 ½" and our upper shock mount bracket must be raised ½" on the chassis. The chassis redesign is not that big a deal, especially caught early, but there is another problem. This changes the pick-up points that we programmed into our computer analysis. Let us do one more piece of math: subtract $700 for nothing.

Let's get over that and discuss three more important things while on the subject of springs. First, spring rate and effective spring rate are two different things. Spring rate we have discussed but effective spring rate takes into consideration the lever action of the lower a-arm and it's effect on the rate at the tire. Simply put, the farther inboard the lower spring/shock mount is from the ball joint, the less effective the spring and thus the spring rate is. It is a classic example of Archimedes and his lever. It is entirely possible, even probable, that two identical springs will not have the same characteristics on two different chassis. Keep this in mind during chassis design and spring selection. Our 300 pound front springs are mounted out nearly to the ball joint and this is generally desirable. Moving this mounting point inboard may now require a 600 pound spring to have the same effective spring rate at the tire.

Second, when the mounting is angled from vertical as is typically required for fitment, effective spring rate is decreased. This is again a simple matter of the Archimedes Principle and high school geometry, and again the Afco catalog addresses it in easy to understand terms.

Finally, Afco has a new line of Extreme Chrome Springs. These have 360 degree chromed and polished wire and are lifetime guaranteed. This along with the machined aluminum shock makes a beautiful presentation. Any spring is going to run at least $40 and these are retail at only $44.99.

Finally moving to the swaybars, they too have a rate measured somewhat similar to springs and a few terminologies are needed to understand them. They are divided into two parts, the bar and the arms, and the characteristics of both determine the overall characteristics of the bar.

Just like a spring, the bar is rated at pounds per inch. Unlike the spring, the inch is measured along the arc of the bar at the end of the arm. Correctly designed, the length of travel of this arc is roughly even with the vertical travel of the suspension and the bar rating is accurate enough for design purposes. Also just like the spring, the connecting point of the bar in relation to the ball joint will determine it's effective rate.

The rate of a swaybar is determined by the length of the arms, the length of the bar, and it's thickness. Back to the principles of leverage, a long arm increases leverage so the bar itself must be thicker to compensate. Likewise short arms will require a smaller diameter to achieve the same rating. It is entirely possible to have a very thick bar with long arms and it be the same rating as a thin bar with short arms. Remember that both of them require the same force to move them 1" in their arc at the end of the arm.

The length of the bar will also determine it's rating. Obviously it is much easier to torsion a three foot bar than it is to do the same with a one foot bar. That is a lot happening in a one foot span and the metal has to move considerably farther because the one inch twist is not spread out over three feet.

Let us dispel another common myth. A hollow bar does little if anything to change the characteristics of a solid bar of the same diameter. This is for the same reason that a solid bar is not stronger than a tube in chassis construction. When either one bends, the outside takes the stress and moves the most, therefore creating most of the resistance. The centerline hardly moves at all and the material there has little if any effect on the resistance. Hollow bars are strictly for weight savings. Hollow bars may sound impressive, but to our mind, the bang for the buck does not give a good return on the investment.

Formulas are available from the Society of Automotive Engineers to design, size, and rate swaybars but once more we prefer to leave that to the experts. Kerry Cannon at Cannon Spring will design and build about any swaybar for around $100. Typically we would like to use a more generic "off the shelf" item but our design simply will not allow it. Even if it would, we have to stop and consider that all of the stock items that were found start at about twice this price. Let us do another math problem: $100 x two swaybars = $200 and $200 x 2 swaybars = $400. We would rather get what we need than pay twice as much for something that would have to be made to work.

Now for the final thing, the swaybar mounts. Energy Suspensions has a urethane mount available for virtually any size bar that is simple, compact, and efficient. It doesn't hurt that they are also pretty and well priced. This could be the easiest component on the whole car to select and source. Let us end our hard lessons on that good note.

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