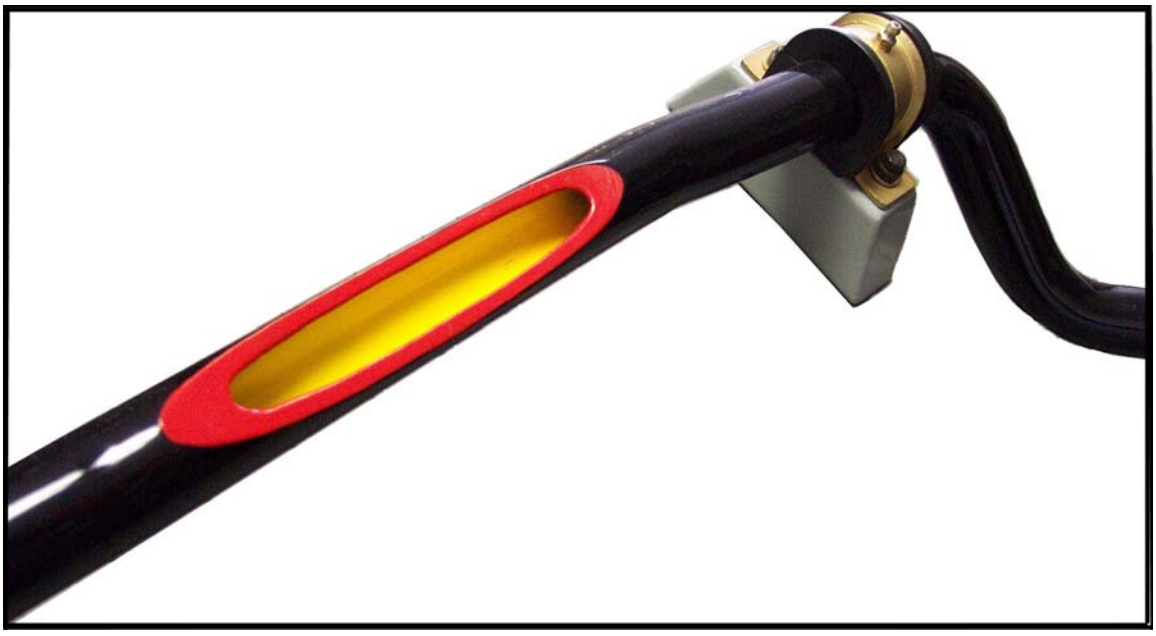
Hollow Sway Bar Design Philosophy

Race Car Technology for the Street Car



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Hotchkis Sport Suspension
12035 Burke Street Ste 13
Santa Fe Springs, Ca 90670
www.hotchkis.net

Hollow Anti-Roll Bars

Lightweight, Strong, Durable - The Future

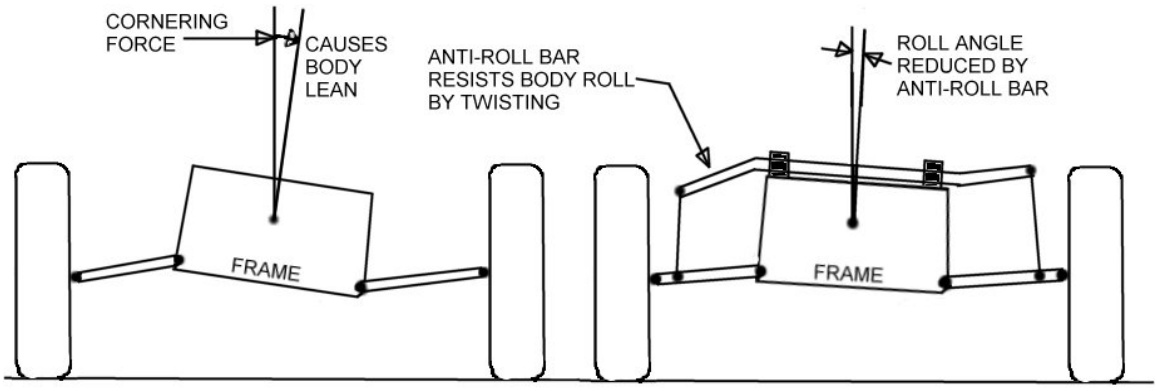
Introduction

Since the creation of the automobile, enthusiasts have had the desire to make vehicles better, faster and stronger. Each enthusiast has different tastes, desires and preferences, yet one thing stands out that everyone wants in the products they purchase. Everybody wants products that do what's advertised, and perform at their very best. Hotchkis Performance was created to offer the enthusiast this very ideal. At Hotchkis, we strive to create an integrated suspension that gives the user the best combination of strength and performance available.

Most car enthusiasts know how adding horsepower to their engine feels in driving the car. Modifying the transmission and the rear end, also gives the driver a definite 'seat-of-the-pants' gage to improvements. Cosmetic items such as paint, interior wheels, etc., are something everyone can see. The coveted Holy Grail of automotive performance has to be the suspension. Most people only have a basic grasp of what a suspension does, let alone what each component in the 'system' does. A suspension keeps the car suspended under all road conditions. It allows the driver to maneuver safely and confidently (we'd all like to think that was the case) and handle everything our modern freeways throw at us. No matter the vehicle, a well thought out suspension will give you safety and confidence while driving at any speed or aggressively carving through a winding mountain road.

Anti-Roll Bars

One very potent product that yields a very good 'bang-for-the-buck' is a Stabilizer Bar, or more commonly referred to as an Anti-Roll Bar (ARB). One probably asks, "Okay, just *what* is it, and *what* does it do?" An ARB is a round



piece of metal, either solid or tubular, that connects both the left and the right sides of the suspension together. Typically cars will have one of these bars in the front and one in the rear of the vehicle. The bars react to body roll, or lean, by twisting. During a corner, the body of the vehicle tries to 'lean' or 'fall' over. As one side of the suspension compresses, the ARB resists this compression since it's connected to the other side of the suspension. You can think of it as both sides of the suspension help each other out when one of them compresses. Essentially you are increasing the overall spring rate or wheel rate of your suspension during cornering. More spring rate means less body roll. Less body roll means less transition time and a more level tire contact patch.

The Benefits of Upgrading from Stock

"Why should I change my Anti-Roll Bars from the stock ones?" Well it's pretty simple. Enthusiasts typically demand more from their cars than the average driver. They need improved handling, increased high-speed stability and better traction. Properly designed and tested Anti- Roll bars give a car, truck or SUV optimum handling potential and chassis balance. This is accomplished during testing by changing the roll couple (changing the stiffness of the front vs. rear Anti-Roll Bars) to achieve the optimum handling balance. Generally, neutral to slight understeer, but it depends on the application and vehicle. Auto manufacturers are out to give the average person the car that will suit most of their needs. If they install larger anti-roll bars, stiffer springs and lower the car, they will create more customers that are dissatisfied with their car than if they offer a 'detuned' car. They opt to cut cost, and raise customer satisfaction ratings by offering a decent, if not mediocre, car. This leaves considerable room for increases in the suspension's performance or 'tuning' using aftermarket parts.

Manufacturing of Anti-Roll Bars

Manufacturing a sway bar has been done by various methods throughout the years. The traditional method of making a bar is to take the raw bar stock, and bend it into the shape you want by using a press and bend dies. This is generally

a cheap way to make them, and there are several drawbacks to this method. The first such detriment is that each bend is done separately. With each bend the tolerance increases, i.e. inaccuracy, in making the part. This allows for increased human error in production. As cars become more complex, the packaging of the sway bar tightens. There is less room for error, and thus, the part needs to be more accurate to fit in the car. The second drawback is that all of the additional handling adds extra time to the manufacturing process. This can lead to extended production times and higher costs. One final disadvantage is that the press bends can add several extreme tooling dents or 'marks' to the product. Dents such as these are acceptable on a solid bar, but they make the part less eye pleasing to look at. Tubular material *cannot* be bent in this traditional way. The press will either kink or crack the tubing when bending the material.

Hotchkis Performance uses a "state of the art" high tech CNC (Computer Numerically Controlled) bending machine. This machine does essentially all of the bends in one handling process. Raw material is loaded into the machine, which then goes through a series of motions to produce a smoothly bent part. A computer keeps track of each bend in relation to all of the other bends. This produces a very high tolerance part, typically in the 0.050" range or tighter, and with consistent reliability. During the manufacturing run, a Laser Vector inspection system is employed to measure the parts being bent by the machine. This measures the shape of the bar, and compares it to a computer file of the part print. The laser's computer sends any necessary corrections directly to the bending computer. This is done because each batch of raw material varies and bends slightly different than another.

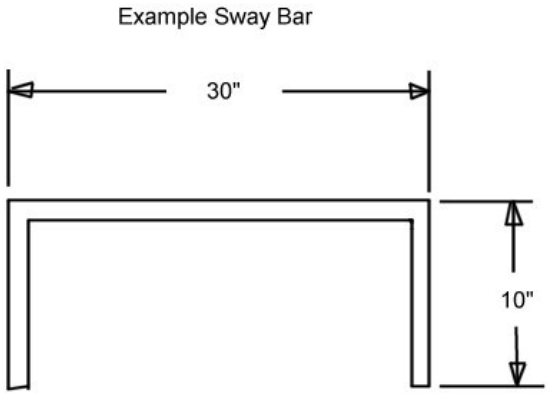
<u>Tubular Anti-Roll Bar Design Philosophy</u>

Many people are confused by the modern use of a 'hollow' ARB. Technological advancements in racing designs are finally being used by many suspension designers throughout the world. Companies, such as, Porsche, Daimler-Chrysler, Ford and others have started to include hollow anti-roll bars on

factory produced cars and trucks. There are many advantages to using a tubular ARB rather than a solid bar. The foremost advantage is the weight reduction that can be achieved by using hollow technology. For the suspension designer, the flexibility of using a tube greatly increases the ability to really 'fine-tune' the design. All one has to do is change the wall thickness of the material to give an incremental change in stiffness. A designer can then adjust the stiffness of a bar using the same vehicle packaging in this way for a number of different bars.

Now, many misconceptions are floating around about the hollow bar designs. One major one is: that a solid bar is stiffer than a hollow one. This is only partially correct. If a solid bar and a hollow one of the *same* diameter are compared, then the solid bar *is* stiffer than the hollow version. By increasing the outer diameter of the hollow bar, and fine-tuning the wall thickness, you can yield the same performance while reducing weight. How many racing designers try to cut every ounce out of the chassis? They all do! Reducing weight acts like adding horsepower.

Another expressed concern is the durability of the part when using a hollow bar. Under the same loading, a properly designed hollow bar will see virtually the same stress levels that a solid bar does, yet provide the equivalent handling performance or improve upon it.



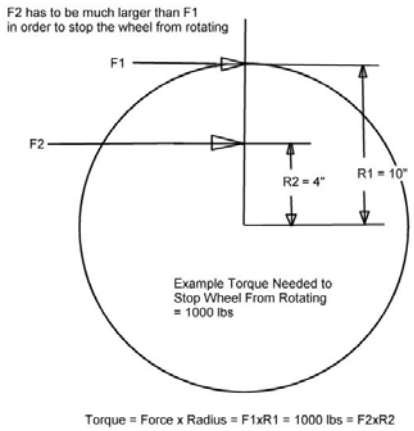
EXAMPLE

Given a simple sway bar design of 30" wide with 10" lever arms, one can calculate the differences between a variety of solid and tubular bars. (For simplicity, complex equations will not be listed, nor derived).

Variable	1” solid	1” x 0.25” hollow	1.062”x0.188” hollow	1.188”x0.188” hollow
Stiffness (lbs/in)	333	312	350	429
% Stiffer		-6.5 %	+5.5 %	+29 %
Stress (KSI)	51	54	51	45
% Stress Increase		+5.9 %	0 %	-12 %
Weight (lbs)	11.14	8.34	7.32	7.8
% Weight Increase		-25%	-34%	-30%

The chart displays the results of comparing a 1” solid bar to a 1” hollow bar with a 0.25” wall thickness. Compare the 1” solid directly to the 1” hollow bar. By removing a ½” hole from the center of the bar, the stiffness of the bar is reduced by ONLY 6.5 %! Anything less than 10 % change cannot be felt by most of the drivers out there. This results in a slight increase in stress by only 5.9 %. (We assume all bars are manufactured using the same material and subjected to the same 1000 lb load) Think about it this way: Take a rolling tire. If you’ve ever watched a tire turn, the tread moves very quickly, but the lug nuts do not turn as fast. To stop the tire from turning, you would grab the tread. It stops easier, without requiring as much force as it would to stop the wheel from its center. This same principle applies to an anti-roll bar. Another thing to note when comparing these two bars is that the hollow bar weighs ONLY 8.34 lbs, whereas the solid bar is 11.14 lbs. That’s a weight reduction of 25% for this part, yet it only loses 5.9 % stiffness!

Okay, lets illustrate the tire example. Let’s say, we have a rotating wheel and it takes 1000 lbs of torque (rotating resistance) to stop it from rotating. If the you try to stop the wheel rotating at the outside, let’s say 10” diameter. The equation for torque is T = Force x Radius, so to apply the 1000 lbs of torque, you have to put 100 lbs of force on the tread. Next, try to stop the same wheel, but at the lug nuts, say 4”, you have to apply 250 lbs of force! That’s quite a significant increase, so you’re better off using the tread. This is the same basic principle used in hollow sway bar theory.



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Having seen this illustration of hollow anti-roll bar design theory, let's try and design an equivalent bar that's the same effective stiffness as the solid bar. Due to raw material suppliers, the designer is limited to a set of standard wall thickness tubing. Any thickness outside the standard tubing sizes would cost too much in raw material to be marketable. By choosing a 1-1/16" diameter with a 0.188" wall thickness, a bar can be produced that is *5.5% stiffer* and is *stressed 0% less* than the solid bar, yet the bar *weighs 34% less* than the solid bar!

Consider that the 1" solid bar is a typical factory installed anti-roll bar. As enthusiasts, we want to increase the stiffness of the ARB to help with handling. By choosing a 1-3/16" diameter with the same wall thickness as the 1-1/16" diameter hollow bar, an increase in stiffness over stock of 56% can be achieved! The stress levels have dropped by 39% over the original sway bar. Weight reduction has also been gained by 30%. To the designer, these features are all advantages. With proper design the hollow bar reflects *gains of 56% in stiffness, lowered stress of 39%, and also 30% loss of weight!* It sounds like an all around good design choice to improve handling without making any real sacrifices!

Conclusion

All things considered, the use of a tubular anti-roll bar is an appealing design choice. The suspension designers have the flexibility to tune the handling properties to their exacting standards. This is accomplished by selecting the right combination of diameter and wall thickness. They can increase the stiffness of the bar, without the weight penalties normally associated with a stiffer solid Anti Roll bar. Hotchkis Performances Tubular ARB technology has brought the average enthusiast the same advantages that racing teams have had for years. Just be sure to keep all this in mind the next time you're following some winding highway into the mountains and trying not to fall out of your seat from too much body roll!