# Leaf Springs Technical Information

Leaf springs are the oldest form of suspension in racing. Although they are the oldest, they seem to be the least understood. Leaf springs possess many desirable suspension features, such as dampening, forward bite, rollover steer, high anti-squat percentage, and high lateral stiffness. In addition, the leaf spring suspension is more forgiving on chassis set-up errors. Due to the fact of the popularity of the leaf spring system, we felt racers may want to understand more about how the suspension actually works.

We will cover the different aspects of leaf springs from free rate to installed rate, applications, hook up points and other performance enhancing factors.

There are four basic types of leaf spring systems in the racing industry today.

1. Multi-Leaf Spring – This type of leaf spring has more than 1 leaf in its assembly. It consists of a center bolt that properly aligns the leaves and clips to resist its individual leaves from twisting and shifting.
2. Mono Leaf Spring – Consists of one main leaf where the material's width and thickness are constant. Example – the leaf will be 2 1/2" wide throughout its length, and .323 in thickness throughout its entire length. The spring rate is lighter than other styles of leaf springs and usually requires a device to control positive and negative torque loads as well as requiring coil springs to hold the chassis at ride height.
3. Parabolic Single Leaf – Consists of one main leaf with a tapered thickness. This style is sufficient to control axle torque and dampening, while maintaining ride height. The advantage of this style is that the spring is lighter than the multi-leaf.
4. Fiberglass Leaf Spring – The fiberglass leaf spring is made of a mixture of plastic fibers and resin; it is lighter than all other springs. However, the cost is three times greater. The disadvantage is that they produce inconsistent spring rates. In addition, fiberglass springs are sensitive to heat. The resins break down when exposed to heat and heat cycles (produced from exhaust and/or brake systems) which will cause the resin in the spring to become brittle, resulting in the spring collapsing. Another problem occurs with inconsistent resin mix which will cause the leaf to splinter and break. Furthermore, the fiberglass spring is susceptible to damage from rocks and debris.

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**HOW TO EXAMINE AND CHOOSE YOUR HIGH PERFORMANCE LEAF SPRING**

Only use springs manufactured by companies such as LANDRUM SPRING that have a complete manufacturing facility. This insures properly made springs, guaranteed arch tolerances access to complete labs for testing and research with technical racing experts to understand your requirements.

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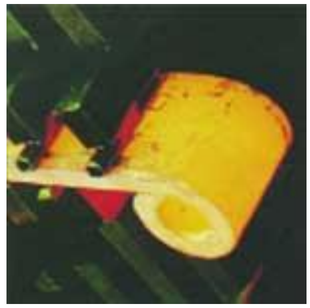
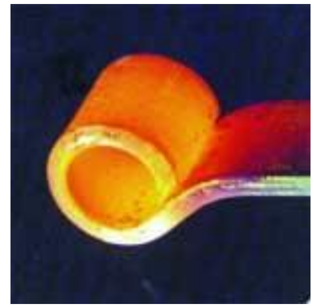
| <br>Scarfer-Eye Roller | <br>Main Leaf in Cambering Press | <br>Berlin Eye |

Examine the spring immediately upon receiving. Verify the leaf spring for consistency in the arch. A typical problem is a spring that has excessive arch in the center. When installing these springs, the arch will be pulled out, creating higher stress on the spring that will eventually decrease the life of the spring.

Multi-Leaf springs used for racing should have a clench clip type system. This system involves riveting the clips onto the leaves; the advantage is in preventing the clips from sliding up the leaf and becoming loose. The clip is installed by using a hydraulic press to assure proper tightness. An inconsistent clip, such as the Kwick Clip or Banding Clips with rubber insulation, will transfer into an inconsistent side bite. The disadvantages of banding clips with rubber linings is that the rubber will absorb grease and brake fluids leading to deterioration of the components. In addition, banding clips are frail and tend to break under impact or stress. These lightweight clips simply cannot withstand the tremendous forces encountered in racing leaf springs.

Multi-leaf springs used for racing should incorporate leaves that are “diamond trimmed” on each end, not leaves that are tapered on the ends. Tapered end leaves have a gradual decrease in thickness on each end. The tapering thicknesses are inconsistent which translates into inconsistent spring rates. Leaves that are tapered on the ends are generally used for “mass production” applications which do not require the close tolerances and consistency in the spring rate that racers demand. Squared end leaves produce high stress points in each leaf leading to premature failure of the leaf. Negative effects include limited number of spring cycles, loss of spring life, and loss in ride heights. Furthermore, the leaves should include Teflon inserts on each end to reduce inner leaf friction.

Ask your supplier what materials the spring consists of. LANDRUM SPRING has the proper mixture of chrome vanadium, carbon, manganese, silicon, nickel, molybdenum and tungsten. This not only insures consistent and proper spring rate, but also longer life (more cycles).

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| <br>Neophot Jena 21 Inverted Microscope | <br>Satec Impact Tester in action | <br>Digital Rockwell Twin Tester |

## WHAT’S EXPECTED OF A LEAF SPRING

Leaf springs perform the following tasks:

1. Holding the chassis at ride height
2. Controls the rate at which the chassis rolls
3. Controls the rear end wrap up
4. Controls axle dampening
5. Controls lateral forces such as side load, pan hard, or side bite rate
6. Controls brake dampening forces
7. Sets wheel base lengths during acceleration and deceleration

Due to all the loads leaf springs are under, it is one of the most stressed components on the race car.

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## WAYS TO ENHANCE PERFORMANCE AND LONGEVITY OF LEAF SPRINGS

Running dampening shocks not only will tighten the car on entry, but will also prolong the life of the spring. The leaf spring will last longer because the shock will assist in absorbing the dampening forces.

Driving style plays a major role in the life of a leaf spring. Slinging the car into the corner or spinning out puts an extreme amount of lateral force on the springs which in turn, causes premature failure.

Impact from tire hopping or grazing the wall can bend or unroll the main leaf eyes. This can cause an undesirable change in spring rate and wheel base settings.

Choosing too light of a spring rate will cause the spring to be in a higher stress situation, thus losing ride height. Furthermore, the spring will absorb all the weight transfer, and not plant the tire securely on the track. Too light of a spring rate will also cause the rear end to lose an excessive amount of pinion angle under acceleration, leading to a loss of forward bite.

When not racing, keep the springs unloaded by simply placing a jack stand under the chassis frame rail. This simple task will increase the life of the leaf spring dramatically.

If the leaf spring’s hook-up points are installed on the chassis incorrectly the misalignment will produce high stress loads on the spring. In turn, the life of the spring and the number of cycles is reduced.

Bushing choice will also affect spring life, and more importantly, spring performance. Rubber bushings tend to absorb more energy and loads from the chassis and rear end, therefore the springs tend to last longer. However, under racing situations, this may cause the chassis and rear end to have excessive movement, thus producing erratic handling.

Pivot bushings are bushings that were designed to remove the bind between the chassis and the spring. However, the negative effects of these bushings greatly outweigh their intended purpose. Our extensive testing has proven this component to produce very erratic handling characteristics. When the front bushing is allowing the front leaf spring to pivot, it transfers all the side loads and lateral forces to rear portion of the leaf spring and shackles or sliders, which were not designed to handle the additional stress. This leads to bent shackles, warped sliders and misaligned axis points. Furthermore, because the front eye is allowed to pivot, it does not have any solid displacement to drive the car forward.

Problems with front pivot bushings are:

- Loose on corner entry, loose coming off
- Tight on corner entry, loose coming off
- No forward bite
- Bent or warped suspension components
- Reduction of spring life due to high stress loads on the shackle end of the spring.

Urethane and aluminum bushings tend to transfer more energy and loads directly to the spring. This prevents undesirable chassis and rear end movement, thus creating favorable synergy between the chassis, springs and rear end. These bushings produce a solid rear housing displacement for added traction. Furthermore, these solid bushings control and enhance chassis performance by resisting chassis roll/torque. Solid bushings provide stable and predictable handling characteristics that lead to more consistent lap times.

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**LEAF SPRING RATE**

The rate of a spring is the change of load per unit of deflection (N/mm). This is not the same amount at all positions of the spring, and is different for the spring as installed. Static deflection of a spring equals the static load divided by the rate at static load; it determines the stiffness of the suspension and the ride frequency of the vehicle. In most cases the static deflection differs from the actual deflection of the spring between zero and static load, due to influences of spring camber and shackle effect.

Free rate is the rate of the spring when it is out of the chassis. The spring's length, width, thickness, number of leaves, hardness, bushings and clips determine the spring rate. The free rate is generally progressive, meaning that the leaf spring rate does not increase proportional to the rate of deflection.

Generally the spring rate will increase when the following is done or decrease on the opposite. The length decreases, the width increases, the thickness increases, the number of leaves increases, Brinell hardness increases, utilizing a harder durometer bushing.

Bushing choice can affect spring rates. Rubber bushings tend to promote softer rates than solid bushings.

Clips have a profound effect on spring rates.

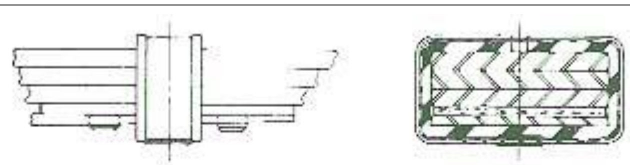

Figure 1
Band Clip

Springs with banding type clips (see Figure 1) with rubber insulation produce inconsistent spring rates due to the fact of various durometer hardnesses and the deterioration of rubber compounds. The rubber, many times, will fall out due to the rigor of racing. Also, common mishaps of spilling brake fluid or brake fluid contact from simply bleeding the brakes will deteriorate the rubber and break the composite down; therefore, the rubber will fall out and the clips will be loose and slide down the main leaf. Furthermore, band clips are frail and tend to break, stretch and fail under minimal contact (opponents right front fender hits your left rear spring).

Clench clips (see Figure 2) have been proven to maintain a more consistent spring rate because of its ability to retain its clamping force.

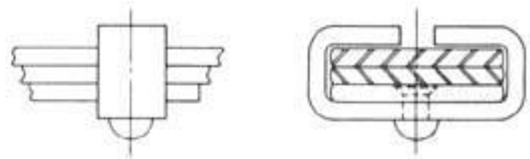

Figure 2
Clinch Clip

The leading edge of each leaf plays a role in determining spring rates. Through our research, diamond trimmed leaves produce the most consistent spring rate. Tapered leaves have inconsistent run out, thus inconsistent spring rates.

Installed rate is another rate all together. The installed rate is the rating of the spring as it is positioned within the chassis itself. Leaf spring rates can be increased or decreased based on the mounting positions and angles. For example, when the leaf springs are toed in (the front eye locations closer together than the rear mounts) the lateral rate or twisting resistance is increased, therefore one's side bite rate is increased.

The inboard mounting position of the springs play an important role as well. The closer the leaf springs are mounted together (inboard), the more pressure the chassis exerts on the springs through physical leverage. As a result, the inboard springs are mounted the softer the installed rate will be. The opposite occurs when the springs are mounted outward (closer to the wheels).

Installing the leaf spring directly to a fixed axle seat (no upper or lower rubber mounted pads which are common on GM's) will increase the overall spring rate, wrap-up rate and lateral rate, as well as the braking rate.

Shackle angle determines the rate as well. A shackle with a 3 degree layback incorporates a stiffer installed rate than a shackle at 25 degrees layback. In addition, as the spring is put under load the shackle angle increases; therefore, the spring rate decreases under travel. To determine the effective angle of a shackle, pull a string from the center of the front eye to the center of the rear eye of the spring, and then a line from the rear eye through the shackle pivot point. Measure the angle derived from the two lines. You can decrease the spring rate by increasing the angle, or increase the rate by decreasing the angle. Also, excessive torque of the shackle bolts will increase the installed rate.

LANDRUM SPRING and many of the top chassis manufacturers recommend that the shackles never extend straight back. This will produce a lock-up or binding effect and the car will perform erratically and unpredictably.

Shackle rigidity and length play a role in the installed rate as well. If the shackles are long and do not have any middle support or bracing, then the shackle tends to absorb more of the twisting instead of the spring; therefore, your lateral resistance is less. Also, the longer the shackle length, the slower the arc movement which decreases the rate of the spring change. The opposite holds true, the shorter the shackle, the faster the rate of change.

A common misconception is that arch affects free spring rate, which it does not. However, it does affect the installed rate. For example, if the main leaves are the same length and one spring has more arch, the spring with the most arch will have a stiffer installed rate. The reason – less shackle angle, more preload on each leaf, and a taller resistance line. Listed below are the effects of spring arch.

| **Less Arch** | **More Arch** |
|---|---|
| lowers chassis<br>lowers roll steer (tightens car on corner entry)<br>increase pan hard rate (may tighten car in center of corner)<br>lowers roll center (decreases chassis roll) | raises chassis<br>raises roll steer (loosens car on corner entry)<br>decrease pan hard rate (may loosen car in center of corner)<br>raises roll center (increases chassis roll) |

LANDRUM SPRING'S engineers have found that by using two of the same spring rates, but installing one of the springs with a higher arch (for example on the left rear) is not recommended. What happens is that the car responds as if it has a stiffer spring on the left rear; however, because it has more arch, the spring is under a higher stress load. Therefore, decreasing its long term effectiveness and life. When using coil springs on the rear, changes are made with spring rates not the free height of the coil springs. For example, if you want 250 lbs. on the left rear and 225 lbs. on the right rear, you should not install a taller spring on the left rear with the same spring rate as the right rear. One should use the same free height, but change rates. The same theory applies to leaf springs. To increase resistance on the left rear, one may incorporate a 225 lb. and a 200 lb. right rear leaf spring with matching arches. The wedge/bite will be determined by the rear spring split (different spring rate from left to right) combined with the front springs and the size of lowering blocks used. Furthermore, the life of the spring will be extended due to the fact it is not under high stress, but more importantly, handling will be consistent.

When should one use high or low arched springs? Higher arch springs tend to work better on the dirt tracks whereas the lower arch springs perform better on the asphalt tracks.

Also, by increasing the lowering block height, one will be raising the axle height or lowering the front eye which will increase chassis roll. This tends to tighten the car on corner entry and through the middle of the corner. When using lowering blocks, remain in the 1″ to 3″ range. Anything over 3″ tends to be excessive and decreases forward bite due to the fact that the torque wrap up or forward thrust resistance of the rear end increases, therefore not allowing any wrap up or torque dampening to occur.