RIDE CONTROL DEFINED

According to Newton's First Law, a moving body will continue moving in a straight line until it is acted upon by another force. Newton's Second Law states that for each action there is an equal and opposite reaction. In the case of the automobile, whether the disturbing force is in the form of a wind-gust, an incline in the roadway, or the cornering forces produced by tires, the force causing the action and the force resisting the action will always be in balance.

Many things affect vehicles in motion. Weight distribution, speed, road conditions and wind are some factors that affect how vehicles travel down the highway. Under all these variables however, the vehicle suspension system including the shocks, struts and springs must be in good condition. Worn suspension components may reduce the stability of the vehicle and reduce driver control. They may also accelerate wear on other suspension components.

Replacing worn or inadequate shocks and struts will help maintain good ride control as they:

- Control spring and suspension movement
- Provide consistent handling and braking
- Prevent premature tire wear
- Help keep the tires in contact with the road
- Maintain dynamic wheel alignment
- Control vehicle bounce, roll, sway, dive and acceleration squat
- Reduce wear on other vehicle systems
- Promote even and balanced tire and brake wear
- Reduce driver fatigue

Suspension concepts and components have changed and will continue to change dramatically, but the basic objective remains the same:

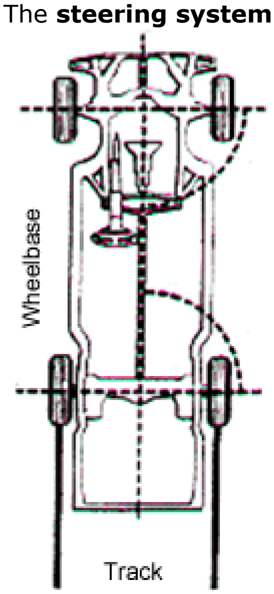
1. Provide steering stability with good handling characteristics
2. Maximize passenger comfort

Achieving these objectives under all variables of a vehicle in motion is called **ride control**

BASIC TERMINOLOGY

To begin this training program, you need to possess some very basic information. The chassis is what connects the tires and wheels to the vehicle's body. The chassis consists of the frame, suspension system, steering system, tires and wheels.

- The **frame** is the structural load-carrying member that supports a car's engine and body, which are in turn supported by the suspension and wheels.
- The **suspension system** is an assembly used to support weight, absorb and dampen road shock, and help maintain tire contact as well as proper wheel to chassis relationship.
- The **steering system** is the entire mechanism that allows the driver to guide and direct a vehicle.



The side to side distance between the centerline of the tires on an axle is called track. The distance between the centerline of the front and rear tires is called wheelbase. If the vehicle is in proper alignment, the wheels will roll in a line that is parallel with the vehicle's geometric centerline.

You should also understand that tires and wheels make vehicle motion possible. The amount of grip or friction between the road and the tires is the major factor that limits how the vehicle accelerates, maneuvers through corners, and stops. The greater the friction, the faster the car can accelerate, corner and stop.

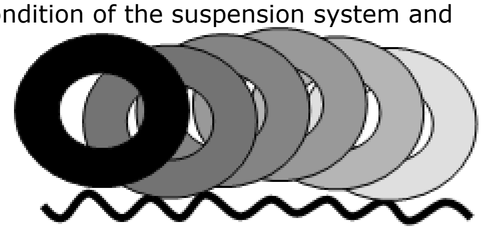
The tire to road contact of a vehicle is affected by several forces. Vehicle dynamics is the study of these forces and their effects on a vehicle in motion. Our discussion will concentrate on how these forces affect handling with some consideration given to how they affect acceleration and deceleration.

Fundamentals Of Handling

Vehicle geometry, suspension, and steering design all affect the handling of a vehicle. To better understand the term "handling," we can address the following fundamentals that contribute to good handling:

Road Isolation

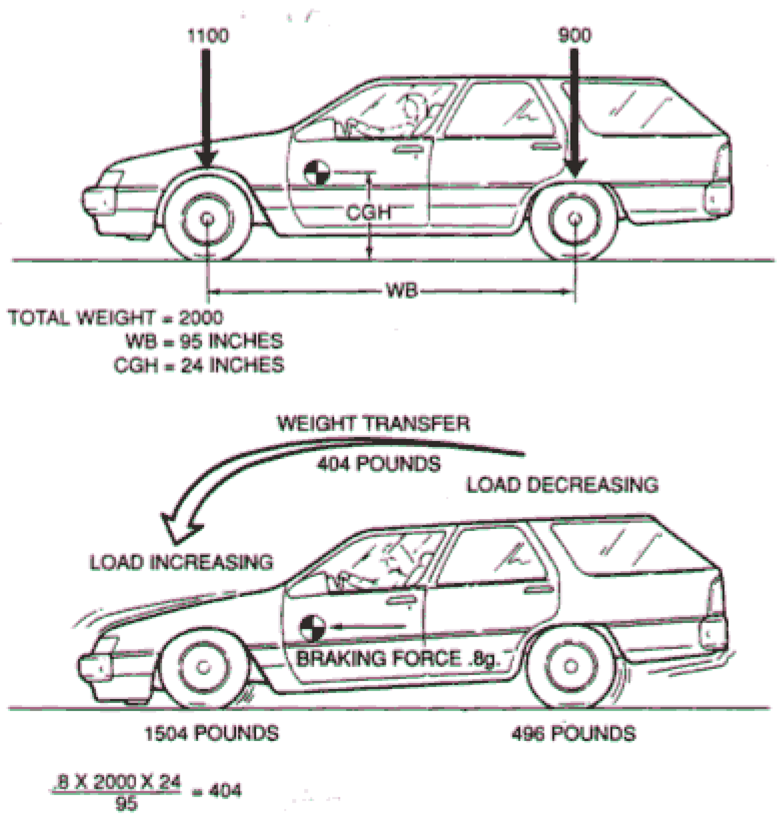
Road isolation is the vehicle's ability to absorb or isolate road shock from the passenger compartment. The degree to which this is accomplished is controlled by the condition of the suspension system and its components. A properly functioning suspension system allows the vehicle body to ride relatively undisturbed while traveling over rough roads. This is accomplished through the combined use of bushings, springs, and hydraulic dampers.



The springs support weight as the vehicle travels down the road. When a vehicle encounters a bump in the road, the bushings receive and absorb the inputs from the road, while the springs compress and store kinetic energy. This energy is then released, causing a rebound in the vehicle's weight. The rate at which the springs compress and rebound is controlled using a hydraulic damper, such as a shock absorber or strut. The result of this action is to limit the amount of road input felt in the passenger compartment.

Road Holding

Road holding is the degree to which a car maintains contact with the road surface in various types of directional changes and in a straight line. Remember that the vehicle's ability to steer, brake, and accelerate depends first and foremost on the adhesion or friction between the tires and the road.**Tire force variation** is a measure of the road holding capability of the vehicle and is directly influenced by shock absorber or strut performance. Shock absorbers and struts help maintain vertical loads placed on the tires by providing resistance to vehicle bounce, roll and sway during weight transfer. They also help reduce brake dive along with acceleration squat to achieve a balanced ride.



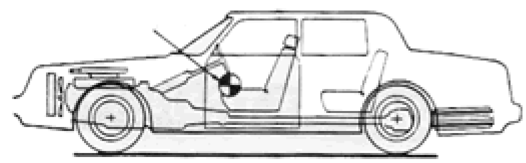
Worn shocks and struts can allow excessive vehicle weight transfer from side to side and front to back, which reduces the tire's ability to grip the road. Because of this variation in tire to road contact, the vehicle's handling and braking performance can be reduced. This may affect the safe operation of the vehicle and the safety of those riding inside. Therefore, shocks and struts are safety components.

Tire loading changes as a vehicle's center of gravity shifts during acceleration, deceleration, and turning corners. The **center of gravity** is a point near the center of the car; it is the balance point of the car.

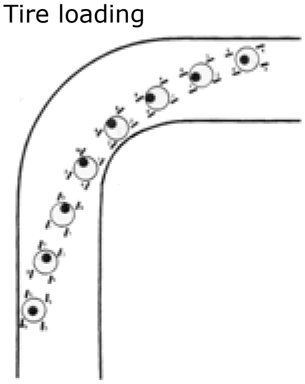
The size of the four contact patches of traction at the tires also varies with the changes in tire load. As the vehicle brakes, inertia will cause a shift in the vehicle's center of gravity and weight will transfer from the rear tires to the front tires. This is known as **dive**. Similarly, weight will transfer from the front to the back during acceleration. This is known as **squat**.

Consistently controlling vehicle weight transfer and suspension movement enhances the road holding capability of the vehicle and ultimately its safe operation.

Cornering Cornering is defined as the ability of the vehicle to travel a curved path. It is also referred to as cornering power or lateral acceleration. Many things can affect the cornering ability of a vehicle, such as:



- Tire construction
- Tire tread
- Road surface
- Alignment
- Tire loading



As a vehicle turns a corner, centrifugal force pushes outward on the car's center of gravity. Centrifugal force is resisted by the traction of the tires. The interaction of these two forces moves weight from the side of the vehicle on the inside of the turn to the outside of the car, and the car leans. As this occurs, weight leaves the springs on the inside and that side of the vehicle raises. This weight goes to the springs on the outside, and that side of the vehicle lowers. This is what is known as **body roll**

When the cornering requirement of a particular maneuver is less than the traction that can be provided by the tires, the car will go where it is pointed and steered. However, if the cornering force exceeds the available traction from the tires, the tires will slip across the road surface and they will skid.

Purpose Of The Suspension System

As we review suspension system components and how they work together, remember that a vehicle in motion is more than wheels turning. As the tire revolves, the suspension system is in a dynamic state of balance, continuously compensating and adjusting for changing driving conditions. Today's suspension system is automotive engineering at its best.

The components of the suspension system perform six basic functions:

1. Maintain correct vehicle ride height
2. Reduce the effect of shock forces
3. Maintain correct wheel alignment
4. Support vehicle weight
5. Keep the tires in contact with the road
6. Control the vehicle's direction of travel

However, in order for this to happen, all the suspension components, both front and rear, must be in good working condition.

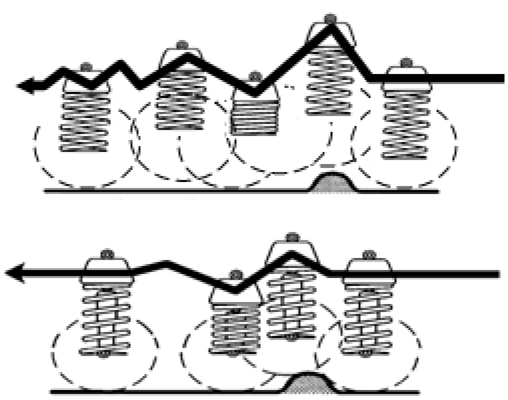
MAIN COMPONENTS OF A MODERN SUSPENSION SYSTEM

At this point, it's important to understand that the main components of a moving vehicle suspension system are the **Struts, Shock Absorbers, Springs and Tires**. We will first turn our attention to the design and function of springs. In the following section we will thoroughly examine the function and design of shock absorbers and strut assemblies.

The springs support the weight of the vehicle, maintain ride height, and absorb road shock. Springs are the flexible links that allow the frame and the body to ride relatively undisturbed while the tires and suspension follow the bumps in the road.

Springs are the compressible link between the frame and the body. When an additional load is placed on the springs or the vehicle meets a bump in the road, the springs will absorb the load by compressing. The springs are a very important component of the suspension system that provides ride comfort. Shocks and struts help control how fast the springs and suspension are allowed to move, which is important in keeping tires in firm contact with the road.

During the study of springs, the term **bounce** refers to the vertical (up and down) movement of the suspension system. The upward suspension travel that compresses the spring and shock absorber is called the **jounce**, or **compression**. The downward travel of the tire and wheel that extends the spring and shock absorber is called **rebound**, or **extension**.



When the spring is deflected, it stores energy. Without shocks and struts the spring will extend and release this energy at an uncontrolled rate. The spring's inertia causes it to bounce and overextend itself. Then it re-compresses, but will again travel too far. The spring continues to bounce at its natural frequency until all of the energy originally put into the spring is used.

If the struts or shock absorbers are worn and the vehicle meets a bump in the road, the vehicle will bounce at the frequency of the suspension until the energy of the bump is used up. This may allow the tires to lose contact with the road.

Struts and shock absorbers that are in good condition will allow the suspension to oscillate through one or two diminishing cycles, limiting or damping excessive movement, and maintaining vertical loads placed upon the tires. This helps keep the tires in contact with the road.

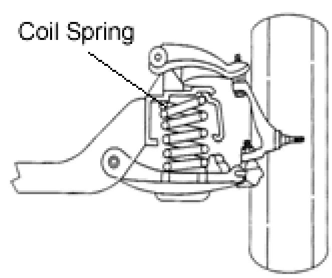
By controlling spring and suspension movement, components such as tie rods will operate within their design range and, while the vehicle is in motion, dynamic wheel alignment will be maintained.

Spring Designs

Before discussing spring design, it is important to understand sprung and unsprung weight. **Sprung weight** is the weight supported by the springs. For example, the vehicle's body, transmission, frame, and motor would be sprung weight. **Unsprung weight** is the weight that is not carried by springs, such as the tires, wheels, and brake assemblies.

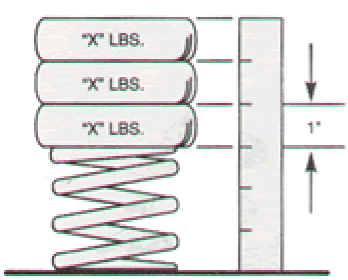
The springs allow the frame and vehicle to ride undisturbed while the suspension and tires follow the road surface. Reducing unsprung weight will provide less road shock. A high sprung weight along with a low unsprung weight provides improved ride and also improved tire traction.

There are four major spring designs in use today: coil, leaf, torsion bar, and air.



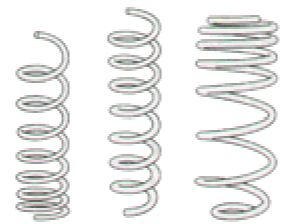
Coil Springs The most commonly used spring is the coil spring. The coil spring is a length of round spring steel rod that is wound into a coil. Unlike leaf springs, conventional coil springs do not develop inter-leaf friction. Therefore, they provide a smoother ride.

The diameter and length of the wire determine the strength of a spring. Increasing the wire diameter will produce a stronger spring, while increasing its length will make it more flexible.

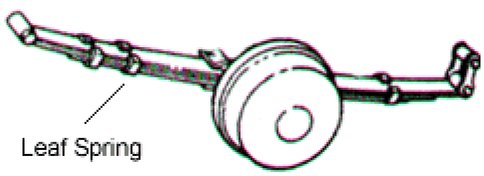


Spring rate, sometimes referred to as deflection rate, is used to measure spring strength. It is the amount of weight that is required to compress the spring 1 inch. For example: If it takes 100 lbs. to compress a spring 1inch, it would take to 200 lbs. to compress the spring 2 inches.

Some coil springs are made with a variable rate. This variable rate is accomplished by either constructing this spring from materials having different thickness or by winding the spring so the coil will progressively compress at a higher rate. Variable rate springs provide a lower spring rate under unloaded conditions offering a smoother ride, and a higher spring rate under loaded conditions, resulting in more support and control.



Coil springs require no adjustment and for the most part are trouble-free. The most common failure is spring sag. Springs that have sagged below vehicle design height will change the alignment geometry. This can create tire wear, handling problems, and wear other suspension components. During suspension service it is very important that vehicle ride height be measured. Ride height measurements not within manufacturer's specifications require replacement of springs.

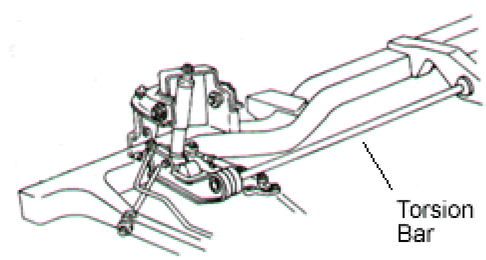


Leaf Springs Leaf springs are designed two ways: multi-leaf and mono-leaf. The multi-leaf spring is made of several steel plates of different lengths stacked together. During normal operation, the spring compresses to absorb road shock. The leaf springs bend and slide on each other allowing suspension movement.

An example of a mono-leaf spring is the tapered leaf spring. The leaf is thick in the middle and tapers toward the two ends. Many of these leaf springs are made of a composite material, while others are made of steel.

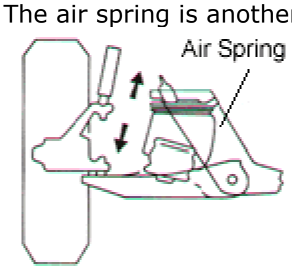
In most cases leaf springs are used in pairs mounted longitudinally (front to back). However, there are an increasing number of vehicle manufacturers using a single transverse (side to side) mounted leaf spring.

Torsion Bar Another type of spring is the torsion bar. The torsion bar is a straight or L shaped bar of spring steel. Most torsion bars are longitudinal, mounted solidly to the frame at one end and connected to a moving part of the suspension at the other. Torsion bars may also be transverse mounted. During suspension movement, the torsion bar will twist, providing spring action.



Air Springs

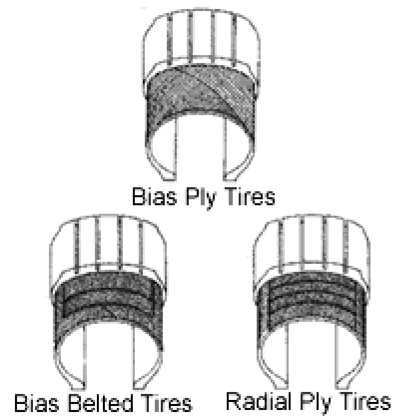
The air spring is another type of spring that is becoming more popular on passenger cars, light trucks, and heavy trucks. The air spring is a rubber cylinder filled with compressed air. A piston attached to the lower control arm moves up and down with the lower control arm. This causes the compressed air to provide spring action. If



the vehicle load changes, a valve at the top of the airbag opens to add or release air from the air spring. An onboard compressor supplies air.

Tires as Springs

An often-overlooked spring is the tire. Tires are air springs that support the total weight of the vehicle. The air spring action of the tire is very important to the ride quality and safe handling of the vehicle. As a matter of fact, tires may be viewed as the number-one ride control component. Tire size, construction, compound and inflation are very important to the ride quality of the vehicle.



There are three basic types of tires: radial ply, bias ply, and bias belted.

Radial ply tires have ply cords, which run across the centerline of the tread and around the tire. The two sets of belts are at right angles. Some belts are made of steel wire; others are made of polyester or other substances. Today, radial tires come as original equipment on most passenger cars and light trucks.

Bias ply tires use cords that run at an angle across the centerline of the tire tread. The alternate ply cords cross at opposite angles. Bias belted tires are the same as bias ply, with the addition of layers of cords - or belts - circling the tire beneath the tread. Both of these types of tires will most likely be found on older model vehicles.

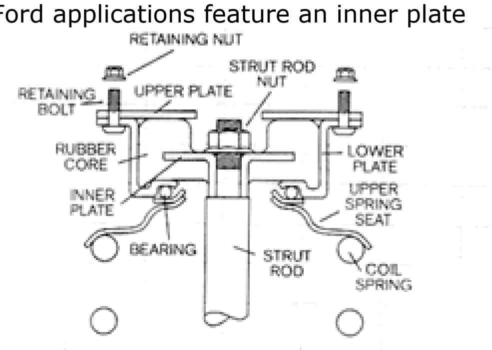
The air pressure determines the spring rate of the tire. An over inflated tire will have a higher spring rate and will produce excessive road shock. Over inflated tires will transmit road shock rather than reduce it. Over or under inflation also affects handling and tire wear.

When adjusting tire pressure, always refer to the vehicle manufacturer’s specifications, not the specification on the side of the tire. The air pressure specified by the vehicle manufacturer will provide safe operation and best overall ride quality of the vehicle. The tire pressure stamped on the side is the maximum pressure a tire is designed to hold at a specific load.

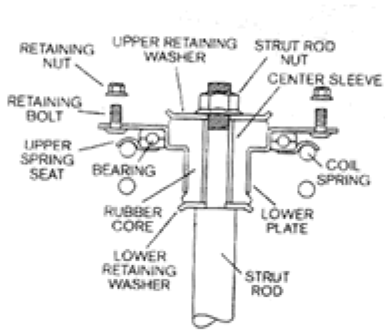
Strut Mount Design

Strut mounts are vehicle specific, and there are numerous designs in use today on both front and rear suspension systems. The three most common designs are inner plate, center sleeve, and spacer bushing.

The **Inner Plate Design** used by General Motors and some Ford applications feature an inner plate encased in molded rubber surrounded by upper and lower surface plates. The inner plate is designed so the strut piston rod cannot push through the upper or lower surface plate if the rubber core fails. This design generally does not require washers. Due to the fact that the upper and lower service plates mostly cover the rubber portion of the mount, it is difficult to see if the inner rubber bushing has failed.

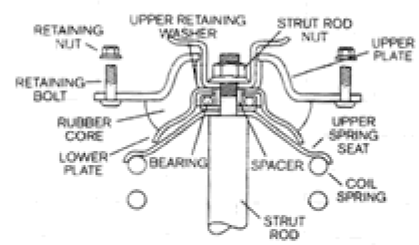


However, these components wear over time and with a thorough inspection a proper recommendation can be made. The bearing is located on the bottom of the strut mount and is not serviceable. Defective bearing will require replacement of the entire strut mount.



The **Center Sleeve Design** used by Chrysler features a center sleeve that is molded to the rubber bushing. This design provides increased side to side stability. The strut stem extends through the center sleeve. Upper and lower retainer washers prevent the strut rod from pushing through the strut mount. The bearing is a separate component from the strut mount. If inspection reveals cracks or tears in the rubber bushing, replacement is required. If the bearing is found to be defective it can be replaced separately.

The **Spacer Bushing Design** used by Volkswagen, Toyota, Mazda, Mitsubishi, and early Chrysler vehicles feature center positioning of the bearing and a separate inner bushing instead of a molded inner sleeve. The operation is similar to the style we just discussed except the bearing is pressed in the strut mount. The bearings, washer, and the upper plate retain the strut rod. If the rubber bushing is cracked, torn, or the bearing is binding or seized, the strut mount requires replacement.

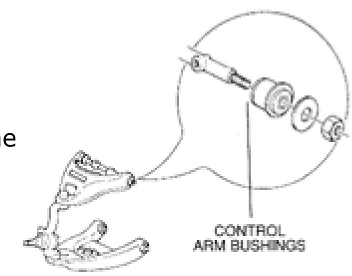


Anti-Sway Bars

Another important component of a suspension system is the anti-sway bar. This device is used along with shock absorbers to provide additional stability. The anti-sway bar is simply a metal rod connected to both of the lower control arms. When the suspension at one wheel moves up and down the anti-sway bar transfers the movement to the other wheel. In this way the sway bar creates a more level ride and reduces vehicle sway or lean during cornering.Depending of the anti-sway bar thickness and design, it can provide as much as 15% reduction in the amount of vehicle roll or sway during cornering.

Bushings

Bushings are used in many locations on the vehicle suspension system. Most bushings are made with natural rubber. However, in some cases, urethane compounds may be used. Bushings made of natural rubber offer high tensile (tear) strength and excellent stability at low temperatures. Natural rubber is an elastomeric material. Elastomeric refers to the natural elastic nature of rubber to allow movement of the bushing in a twisting plane. Movement is controlled by the design of the rubber element. Natural rubber requires no lubrication, isolates minor vibration, reduces transmitted road shock, operates noise free, and offers a large degree of bushing compliance. Bushing compliance permits movement without binding. Natural rubber resists permanent deflections, is water resistant and very durable. In addition, natural rubber offers high load carrying capabilities.



As with all suspension system components, control arm bushings are dynamic components, meaning that they operate while the vehicle is in motion. Control arms act as locators because they hold the position of the suspension in relation to the chassis. They are attached to the vehicle frame with rubber elastomeric bushings. During suspension travel, the control arm bushings provide a pivot point for the control arm. They also maintain the lateral and vertical location of the control arm pivot points, maintain dynamic wheel alignment, reduce transmitted noise, road shock, and vibration, while providing resistance to suspension movement.

During suspension travel the rubber portion of the bushing must twist to allow control arm movement. Control arm bushings that are in good condition act as a spring; that is, the rubber will spring back to the position from which it started. This twisting action of the rubber will provide resistance to suspension movement.

As previously stated, control arm bushings are dynamic suspension components. As the control arm travels through jounce and rebound, the rubber portion of the bushing will twist and stretch. This action transfers energy into the bushing and generates heat.

Excessive heat tends to harden the rubber. As the rubber bushing hardens, it tends to crack, break, and then disintegrate. Its temperature determines the life of a rubber bushing. Rough road conditions and/or defective shock absorbers or struts will allow excessive suspension movement creating more heat, which shortens the life of the bushings.

Rubber bushings must not be lubricated with petroleum-based oil. A petroleum-based product will destroy the bushings. Instead, use a special tire rubber lubricant or a silicone based lubricant.

Worn suspension bushings allow the control arm to change positions. This results in driveline vibration (primarily rear wheel drive rear control arm bushings), dynamic alignment angle changes, tire wear, and handling problems. Control arm bushing wear (looseness) will create a clunking sound while driving over rough roads.

SHOCK ABSORBERS

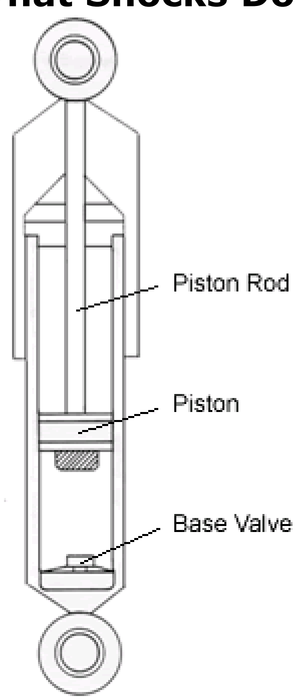
In the early 1900's, cars still rode on carriage springs. After all, early drivers had bigger things to worry about than the quality of their ride - like keeping their cars rolling over the rocks and ruts that often passed for roads.

Pioneering vehicle manufacturers were faced early on with the challenges of enhancing driver control and passenger comfort. These early suspension designs found the front wheels attached to the axle using steering spindles and kingpins. This allowed the wheels to pivot while the axle remained stationary. Additionally, the up and down oscillation of the leaf spring was damped by device called a shock absorber.

These first shock absorbers were simply two arms connected by a bolt with a friction disk between them. Resistance was adjusted by tightening or loosening the bolt.

As might be expected, the shocks were not very durable, and the performance left much to be desired. Over the years, shock absorbers have evolved into more sophisticated designs.

What Shocks Do



Let's start our discussion of shock absorbers with one of very important point: despite what many people think, conventional shock absorbers do not support vehicle weight. Instead, the primary purpose of the shock absorber is to control spring and suspension movement. This is accomplished by turning the kinetic energy of suspension movement into thermal energy, or heat energy, to be dissipated through the hydraulic fluid.

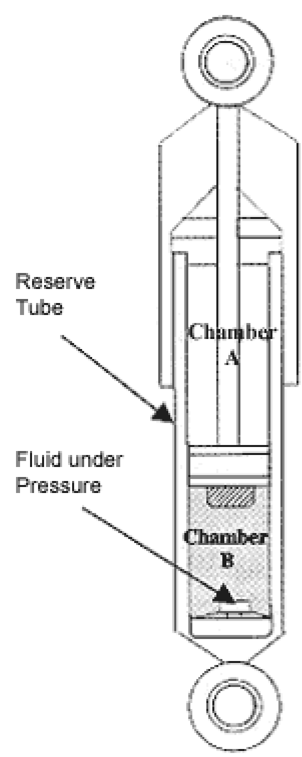
Shock absorbers are basically oil pumps. A piston is attached to the end of the piston rod and works against hydraulic fluid in the pressure tube. As the suspension travels up and down, the hydraulic fluid is forced through tiny holes, called orifices, inside the piston. However, these orifices let only a small amount of fluid through the piston. This slows down the piston, which in turn slows down spring and suspension movement.

The amount of resistance a shock absorber develops depends on the speed of the suspension and the number and size of the orifices in the piston. All modern shock absorbers are velocity sensitive hydraulic damping devices - meaning the faster the suspension moves, the more resistance the shock absorber provides. Because of this feature, shock absorbers adjust to road conditions. As a result, shock absorbers reduce the rate of:

- Bounce
- Roll or sway
- Brake dive and Acceleration squat

Shock absorbers work on the principle of fluid displacement on both the compression and extension cycle. A typical car or light truck will have more resistance during its extension cycle then its compression cycle. The compression cycle controls the motion of a vehicle's unsprung weight, while extension controls the heavier sprung weight.

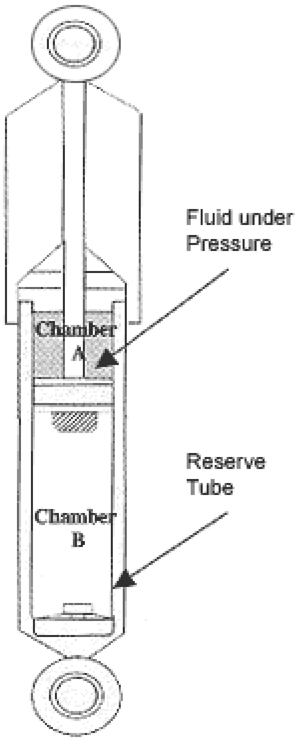
Compression cycle During the compression stroke or downward movement, some fluid flows through the piston from chamber B to chamber A and some through the compression valve into the reserve tube. To control the flow, there are three valving stages each in the piston and in the compression valve.



At the piston, oil flows through the oil ports, and at slow piston speeds, the first stage bleeds come into play and restrict the amount of oil flow. This allows a controlled flow of fluid from chamber B to chamber A.

At faster piston speeds, the increase in fluid pressure below the piston in chamber B causes the discs to open up away from the valve seat.

At high speeds, the limit of the second stage discs phases into the third stage **orifice** restrictions. Compression control, then, is the force that results from a higher pressure present in chamber B, which acts on the bottom of the piston and the piston rod area.



Extension cycle As the piston and rod move upward toward the top of the pressure tube, the volume of chamber A is reduced and thus is at a higher pressure than chamber B. Because of this higher pressure, fluid flows down through the piston's 3-stage extension valve into chamber B.

However, the piston rod volume has been withdrawn from chamber B greatly increasing its volume. Thus the volume of fluid from chamber A is insufficient to fill chamber B. The pressure in the reserve tube is now greater than that in chamber B, forcing the compression intake valve to unseat. Fluid then flows from the reserve tube into chamber B, keeping the pressure tube full.

Extension control is a force present as a result of the higher pressure in chamber A, acting on the topside of the piston area.

Shock Absorber Design

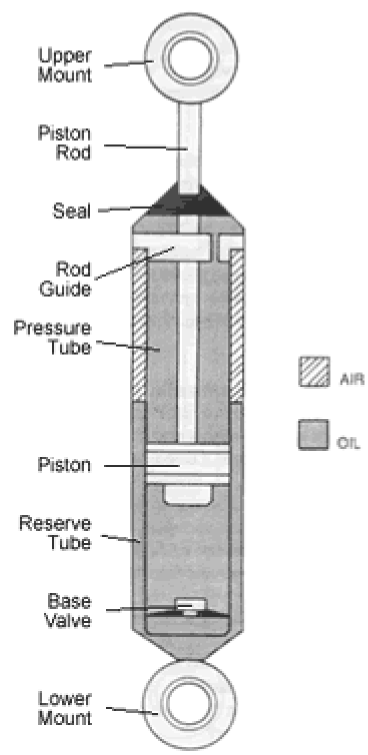
There are several shock absorber designs in use today:

- Twin Tube Designs
  - Gas Charged
  - PSD
  - ASD
- Mono-Tube

Basic Twin Tube Design The twin tube design has an inner tube known as the working or **pressure tube** and an outer tube known as the **reserve tube**. The outer tube is used to store excess hydraulic fluid.

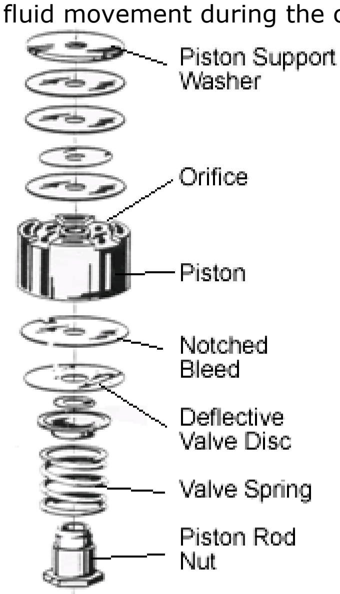
There are many types of shock absorber **mounts** used today. Most of these use rubber bushings between the shock absorber and the frame or suspension to reduce transmitted road noise and suspension vibration. The rubber bushings are flexible to allow movement during suspension travel. The upper mount of the shock absorber connects to the vehicle frame.

Notice that the piston rod passes through a rod guide and a seal at the upper end of the pressure tube. The **rod guide** keeps the rod in line



with the pressure tube and allows the piston to move freely inside. The **seal** keeps the hydraulic oil inside and contamination out.

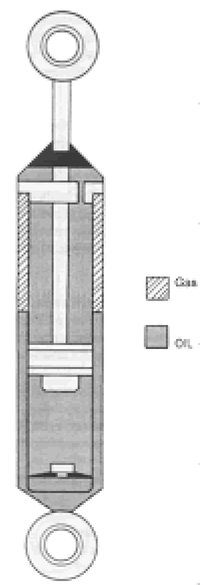
The base valve located at the bottom of the pressure tube is called a **compression valve**. It controls fluid movement during the compression cycle.



Bore size is the diameter of the piston and the inside of the pressure tube. Generally, the larger the unit, the higher the potential control levels because of the larger piston displacement and pressure areas. The larger the piston area, the lower the internal operating pressure and temperatures. This provides higher damping capabilities.

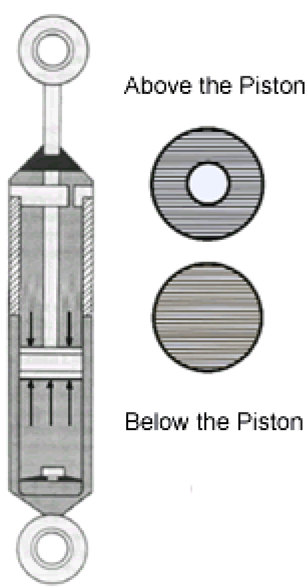
Ride engineers select **valving** values for a particular vehicle to achieve optimal ride characteristics of balance and stability under a wide variety of driving conditions. Their selection of valve springs and orifices control fluid flow within the unit, which determines the feel and handling of the vehicle.

Twin Tube - Gas Charged Design The development of gas charged shock absorbers was a major advance in ride control technology. This advance solved many ride control problems which occurred due to an increasing number of vehicles using uni-body construction, shorter wheelbases and increased use of higher tire pressures.



The design of twin tube gas charged shock absorbers solves many of today's ride control problems by adding a low pressure charge of nitrogen gas in the reserve tube. The pressure of the nitrogen in the reserve tube varies from 100 to 150 psi, depending on the amount of fluid in the reserve tube. The gas serves several important functions to improve the ride control characteristics of a shock.

The prime function of gas charging is to minimize aeration of the hydraulic fluid. The pressure of the nitrogen gas compresses air bubbles in the hydraulic fluid. This prevents the oil and air from mixing and creating foam. Foam affects performance because it can be compressed - fluid can not. With aeration reduced, the shock is able to react faster and more predictably, allowing for quicker response time and helping keep the tire firmly planted on the road surface.



An additional benefit of gas charging is that it creates a mild boost in spring rate to the vehicle. This does not mean that a gas charged shock would raise the vehicle up to correct ride height if the springs were sagging. It does help reduce body roll, sway, brake dive, and acceleration squat.

This mild boost in spring rate is also caused by the difference in the surface area above and below the piston. With greater surface area below the piston than above, more pressurized fluid is in contact with this surface. This is why a gas charged shock absorber will extend on its own.

The final important function of the gas charge is to allow engineers greater flexibility in valving design. In the past such factors as damping and aeration forced compromises in design.

Advantages:

- Improves handling by reducing roll, sway and dive
- Reduces aeration offering a greater range of control over a wider variety of road conditions as compared to non-gas units
- Reduced fade - shocks can lose damping capability as they heat up during use. Gas charged shocks could cut this loss of performance, called fade

Disadvantages:

- Can only be mounted in one direction

Current Uses:

- Original equipment on many domestic passenger car, SUV and light truck applications

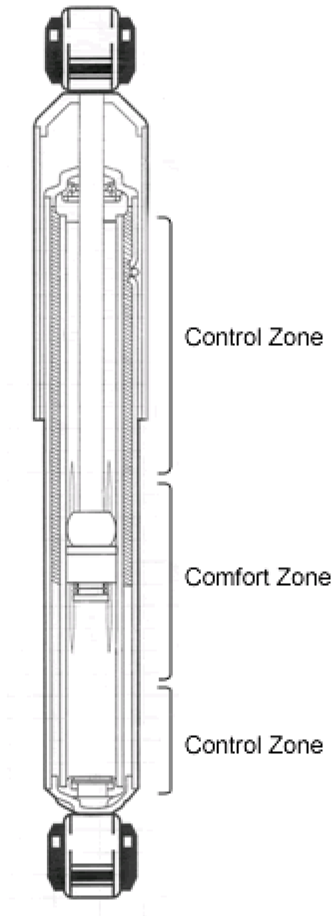
Twin Tube - PSD Design In our earlier discussion of hydraulic shock absorbers we discussed that in the past, ride engineers had to compromise between soft valving and firm valving. With soft valving, the fluid flows more easily. The result is a smoother ride, but with poor handling and a lot of roll/sway. When valving is firm, fluid flows less easily. Handling is improved, but the ride can become harsh.

With the advent of gas charging, ride engineers were able to open up the orifice controls of these valves and improve the balance between comfort and control capabilities available in traditional velocity sensitive dampers.

A leap beyond fluid velocity control is an advanced technology that takes into account the position of the valve within the pressure tube. This is called **Position Sensitive Damping (PSD)**.

The key to this innovation is precision tapered grooves in the pressure tube. Every application is individually tuned, tailoring the length, depth, and taper of these grooves to ensure optimal ride comfort and added control. This in essence creates two zones within the pressure tube.

The first zone, the **comfort zone**, is where normal driving takes place. In this zone the piston travel remains within the limits of the pressure tube's mid range. The tapered grooves allow hydraulic fluid to pass freely around and through the piston during its midrange travel. This action reduces resistance on the piston, assuring a smooth, comfortable ride.



The second zone, the **control zone**, is utilized during demanding driving situations. In this zone the piston travels out of the mid range area of the pressure tube and beyond the grooves. The entire fluid flow is directed through the piston valving for more control of the vehicle's suspension. The result is improved vehicle handling and better control without sacrificing ride comfort.

Advantages:

- Allows ride engineers to move beyond simple velocity sensitive valving and use the position of the piston to fine tune the ride characteristic.
- Adjusts more rapidly to changing road and weight conditions than standard shock absorbers
- Two shocks into one - comfort and control

Disadvantages:

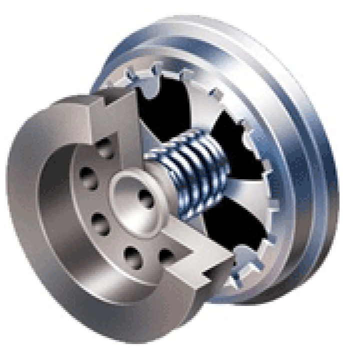
- If vehicle ride height is not within manufacturer's specified range, piston travel may be limited to the control zone

Current Uses:

- Primarily aftermarket under the Sensa-Trac brand name

Twin Tube - ASD Design

We have discussed the compromises made by ride engineers to bring comfort and control together into one shock absorber. This compromise has been significantly reduced by the advent of gas charging and position sensitive damping technology.



A new twist on the comfort/ control compromise is an innovative technology which provides greater control for handling while improving ride comfort called **Acceleration Sensitive Damping (ASD)**.

This technology moves beyond traditional velocity sensitive damping to focus and address impact. This focus on impact is achieved by utilizing a new compression valve design. This compression valve is a mechanical closed loop system, which opens a bypass to fluid flow around the compression valve.

This new application specific design allows minute changes inside the pressure tube based on inputs received from the road. The compression valve will sense a bump in the road and automatically adjust the shock to absorb the impact, leaving the shock with greater control when it is needed.

Due to the nearly instantaneous adjustment to changes in the road's condition, vehicle weight transfer is better managed during braking and turning. This technology enhances driver control by reducing pitch during braking and roll during turns.

Advantages:

- Control is enhanced without sacrificing driver comfort
- Valve automatically adjusts to changes in the road condition
- Reduces ride harshness

Disadvantages:

- Limited availability

Current Uses:

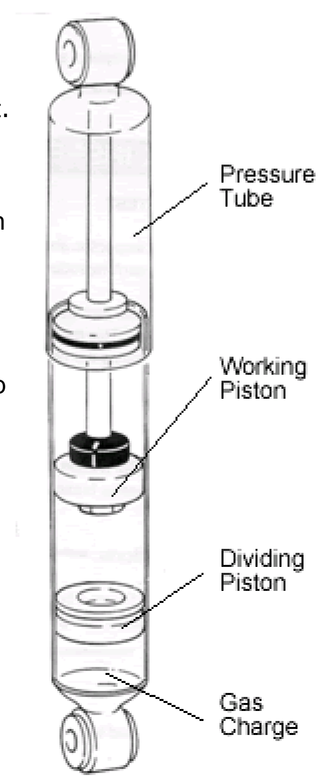
- Primarily aftermarket applications under the Reflex brand name.

Mono-Tube Design

These are high-pressure gas shocks with only one tube, the **pressure tube**. Inside the pressure tube there are two pistons: a **dividing piston**and a **working piston**. The working piston and rod are very similar to the twin tube shock design. The difference in actual application is that a mono-tube shock absorber can be mounted upside down or right side up and will work either way. In addition to its mounting flexibility, mono-tube shocks are a significant component, along with the spring, in supporting vehicle weight.

Another difference you may notice is that the mono-tube shock absorber does not have a base valve. Instead, all of the control during compression and extension takes place at the piston.

The pressure tube of the mono-tube design is larger than a twin tube design to accommodate for dead length. This however makes it difficult to apply this design to passenger cars designed OE with a twin tube design. A free-floating dividing piston travels in the lower end of the pressure tube, separating the gas charge and the oil.



The area below the dividing piston is pressurized to about 360 psi with nitrogen gas. This high gas pressure helps support some of the vehicle's weight. The oil is located in the area above the dividing piston.

During operation, the dividing piston moves up and down as the piston rod moves in and out of the shock absorber, keeping the pressure tube full all times.

Advantages:

- Can be mounted upside down, reducing the unsprung weight
- May run cooler since the working tube is exposed to the air

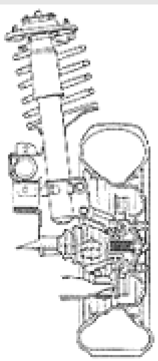
Disadvantages:

- Difficult to apply to passenger cars designed OE with twin tube designs.
- A dent in the pressure tube will destroy the unit

Current Uses:

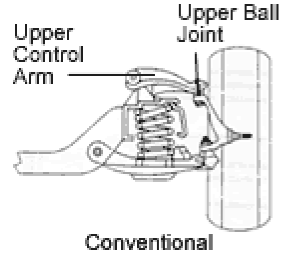
- Original equipment many import and performance domestic passenger cars, SUV and light truck applications
- Available for many Aftermarket applications

WHAT IS A STRUT



Now that we have a more thorough understanding of shock design, let's focus on the strut. The strut is a common damper type used on many of today's independent suspension, front wheel drive vehicles as well as some rear wheel drive vehicles.

A strut is a major structural part of a suspension. It takes the place of the upper control arm and upper ball joint used in conventional suspensions.
Because of its design, a strut is lighter and takes up less space than the shock absorbers in conventional suspension systems.



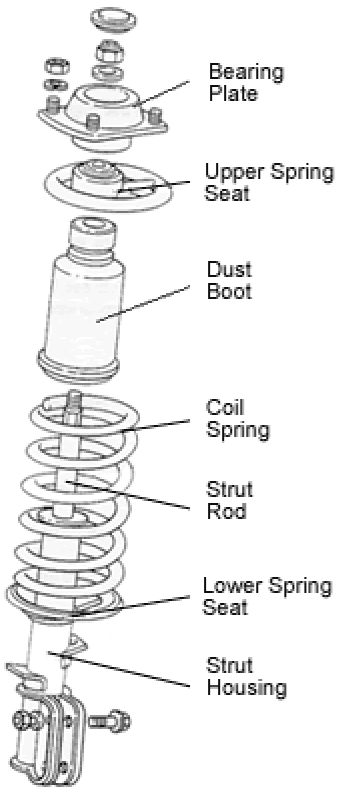
Conventional SLA Suspension

Struts perform two main jobs. First, struts perform a damping function like shock absorbers. Internally, a strut is similar to a shock absorber. A piston is attached to the end of the piston rod and works against hydraulic fluid to control spring and suspension movement. Just like shock absorbers, the valving generates resistance to forces created by the up and down motion of the suspension. Also like shock absorbers, a strut is velocity sensitive, meaning that it is valved so that the amount of resistance can increase or decrease depending on how fast the suspension moves.

Struts also perform a second job. Unlike shock absorbers, struts provide structural support for the vehicle suspension, support the spring, and hold the tire in an aligned position. Additionally, they bear much of the side load placed on the vehicle's suspension. As a result, struts affect riding comfort and handling as well as vehicle control, braking, steering, wheel alignment and wear on other suspension components, including tires.

Strut Components

Typically, struts consists of a **coil spring** to support the vehicle's weight, a **strut housing** to provide rigid structural support for the assembly, and a **damping unit** within the strut housing to control spring and suspension movement. The bottom of the strut body attaches to the steering knuckle, which in turn connects to a lower control arm through a lower ball joint.



The top of the strut is connected to the vehicle body through the **upper strut mount**, in some cases called a**bearing plate**. This bearing plate allows the strut to pivot as the wheels are turned. It must be flexible enough to handle slight angle changes and dampen movement of the upper end of the strut. This mount or bearing plate transfers vehicle load to the strut and spring, making the upper mount/bearing plate the load carrier and the lower ball joint the follower.

The **strut housing** holds the damping unit and fluid. It is made of heavy gauge steel so that it is rigid enough to provide structural support and withstand road shock.

The **piston rod** of the strut is much larger in diameter than the piston rod of the typical shock absorber. This is to withstand the side load on the strut shaft. A strut rod will measure up to 7/8 of an inch in diameter while the piston rod of a typical shock measures up to ½ of an inch in diameter.

A **coil spring** is located between the upper and lower spring seats. It is held there by tension. The lower spring seat is welded to the strut housing, while the upper spring seat is kept in place by the upper strut mount.

Struts also have a **jounce** (or compression) **bumper** located under the upper spring seat. The purpose of this component is to limit suspension travel by not allowing suspension components to hit together.

Finally, a large nut at the end of the strut rod holds everything together.

This article was presented by Pro Comp to help answer any questions you might have about lift kits. If you need more information, please call 4 Wheel Online toll free at 1-813-769-2451, or visit our website at http://www.4wheelonline.com/?ProComp_Suspension.