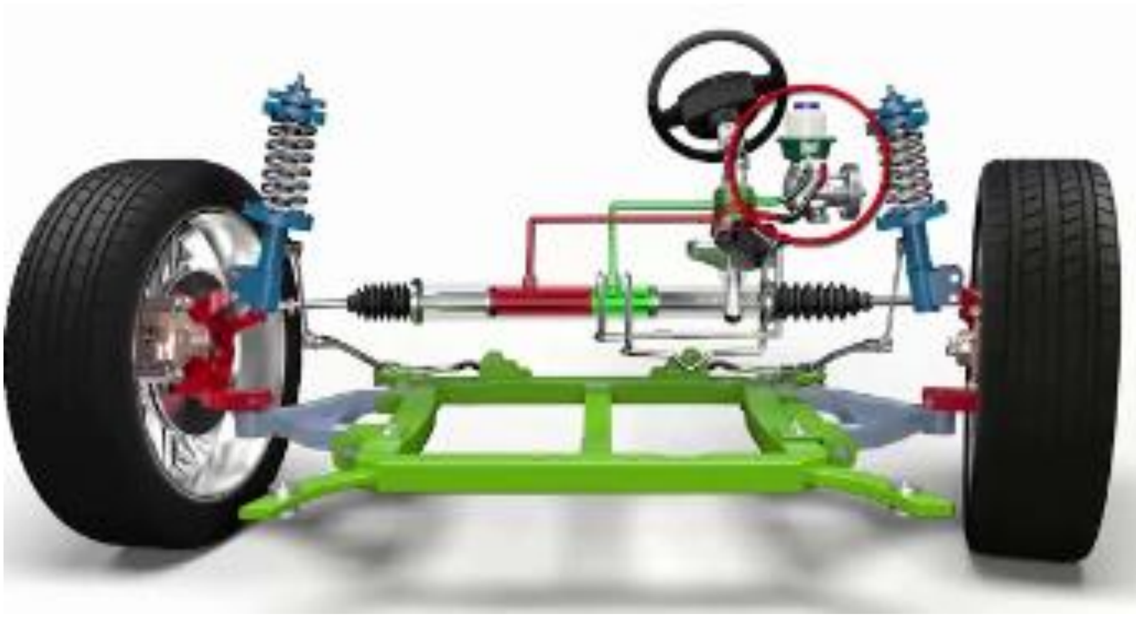
Automotive Mechanics

Level III

Based on October 2023, Curriculum Version II



Module Title: Maintaining Steering and Suspension System

Module Code: EIS AUM3 M06 1023

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Prepared by: Ministry of Labor and Skill

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Addis Ababa, Ethiopia

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Acknowledgment

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Acronym

EPS	Electric power hydraulic steering
GPM	Global Precipitation Measurement
HPS	Hydraulic power steering
KM	Kilo Meter
KPA	Kilo Pascal
KPA	Kilo pascal
LAP	Learning Activity Performance
mm	Millimeter
OEM	Original equipment manufacturer
OHS	Occupational Health Safety
PDI	Pre-Delivery Inspections
PM	Preventive maintenance
PSI	Per square inch
TTLM	Teaching, Training and Learning Materials

Introduction to Module

The steering system works with the suspension system to provide directional control with a comfortable amount of steering effort. It must do this while allowing for the necessary movement in the vehicle's suspension system. Some parts serve both systems.

This module is designed to meet the industry requirement under the automotive mechanics occupational standard, particularly for the unit of competency: maintaining steering and brake system.

This module covers the units:

- Introduction to Steering and Suspension System
- Inspection and Repair of steering systems
- Inspection and Repair of suspension systems

Learning Objective of the Module

- Understand Steering and Suspension System.
- Perform Inspection and Repair of steering systems
- Perform Inspection and Repair of Suspension System

Module Instruction

For effective use this modules trainees are expected to follow the following module instruction:

1. Read the information written in each unit
2. Accomplish the Self-checks at the end of each unit
3. Perform Operation Sheets which were provided at the end of units
4. Do the "LAP test" giver at the end of each unit and
5. Read the identified reference book for Examples and exercise

Unit One: Introduction To Steering and Suspension System

This unit is developed to provide you the necessary information regarding the following content coverage and topics:

- Overview of steering systems
- Overview of suspension systems
- Common Steering and suspension systems problems

This unit will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Understand steering systems
- Understand suspension systems
- Observe Common Steering and suspension systems problems

1.1 Purpose of Steering Systems

The steering system in a light and heavy-duty truck is expected to deliver precise directional control of the chassis at both gross and unloaded vehicle weight. It has to be able to minimize driver effort while retaining some road feel. Truck steering systems can be either manual or power-assisted. Most truck steering gear found on trucks today is power-assisted. Power-assisted steering on highway vehicles is required to function with full mechanical redundancy in the event of a loss of the power-assist system. Do not confuse power-assisted steering with the full power steering systems found on some off-highway equipment. This equipment often uses hydrostatic steering; in the event of a loss of hydraulic power, this will result in no steering capability.

1.2 Steering System Components

The steering system of the truck is made up of the steering wheel, steering column, steering gear, and steering linkages that actually move the steering tires.

1.2.1 Steering Wheel

The steering wheel is the driver's means to control the direction that the vehicle travels. It is therefore the primary input to the steering system. The steering wheel is formed from a strong steel rod that is formed into the shape of a wheel and supported by spokes.

Figure 1: 1 Steering wheel

1.2.2 Steering Column

The steering column connects the steering wheel to the steering gear.

The major components of the steering column assembly are a jacket, bearing assemblies, a steering column shaft, and wiring and contact assemblies for the electric horn.

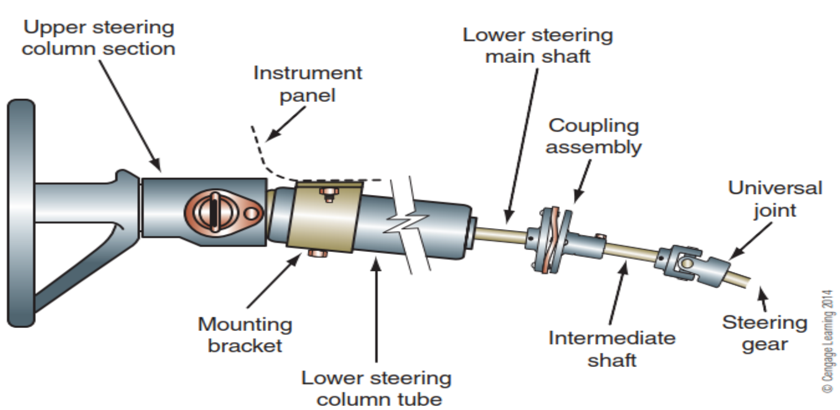


Figure 1: 2 Steering Column Assembly

1.2.3 Steering Gear

The steering gear is the central component of a car's steering system. The steering gear is responsible for transferring the motion of the steering wheel to your car's wheels. This, along with power steering (if applicable), allows for optimal handling and better steering with less input from the driver. The two kinds of steering gears are:

A. **Rack-and-Pinion** – This is the steering gear type for almost all regular cars. It uses a component called a pinion gear that is attached at the end of the steering column. The pinion gear turns as you turn your steering wheel, which then allows the rack gear to move as needed. This transfer of motion then moves the steering linkage that controls the steering knuckle and wheels. Rack-and-pinion steering systems allow you to turn with less motion from the steering wheel.

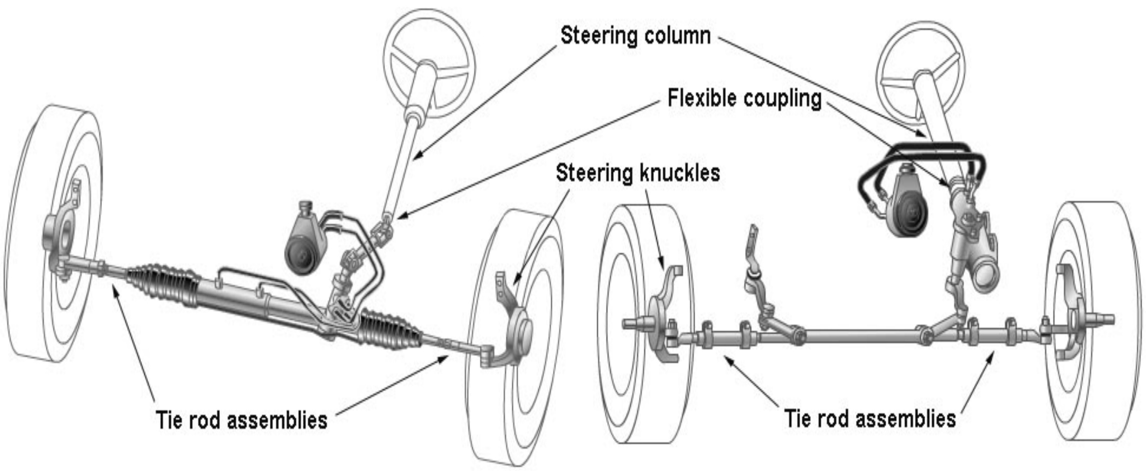


Figure 1: 3Rack-and-pinion and Conventional steering System

B. **Conventional Steering:** Conventional steering transmits the circular motion from the steering wheel through a gear that moves an arm through a back-and forth arc, acting on a set of linkages to steer the wheels. It is also referred to as "recirculating ball" or "worm gear" steering, for the type of gear it uses, or "parallelogram," "trapezium," or simply "linkage" steering, for the shape formed by the linkage set. This type of system can be found on most rear wheel drive cars, light trucks and full size vans.

1.2.4 Steering Linkage

A. **Pitman arm –** Usually splined to the sector (output) shaft with a press fit. Most sector shafts and pitman arms have a master or "blind" spline that permits installation in the

Figure 1:7 Conventional Steering

correct position only. The pitman arm is connected to the center link with a ball socket or pivoting bushing.

The ball socket or bushing may be either a part of the pitman arm or part of the center link. When the ball socket or bushing is part of the center link, the pitman arm is a non-wearing item and would only need to be replaced if bent or damaged. This is the more common arrangement.

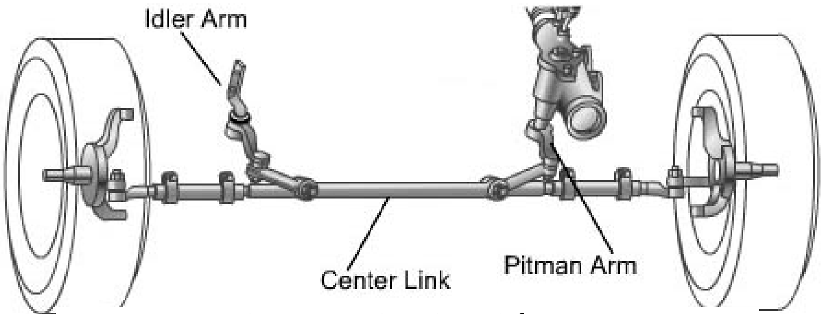


Figure 1: 5 Steering Linkages

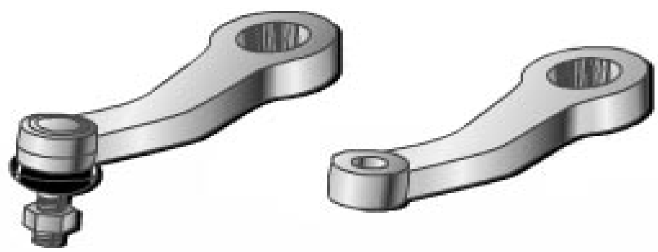


Figure 1: 4 Pitman arm with ball socket

B. Center link – Variations on this component may be called a drag link. The center link is attached to the pitman arm, idler arm, and inner tie rods, and connects the right and left sides of the steering linkage together. As with a pitman arm, the ball socket or bushing arrangement varies depending upon the design. Some center links have two ball sockets or bushings – one for the pitman arm and one for the idler arm, and some have none and are little **more** than a rod with tapered holes.

Figure 1: 6 This center link includes bushings for the pitman arm and idler arm

C. **Idler arm –** The idler arm bolts to the frame or sub frame and attaches to the center link to support the linkage. It corresponds to the pitman arm to complete a strong and symmetrical linkage set. There are many different designs of idler arms, and again, if the center link does not have a pivot socket or bushing at the connection, the idler arm will.

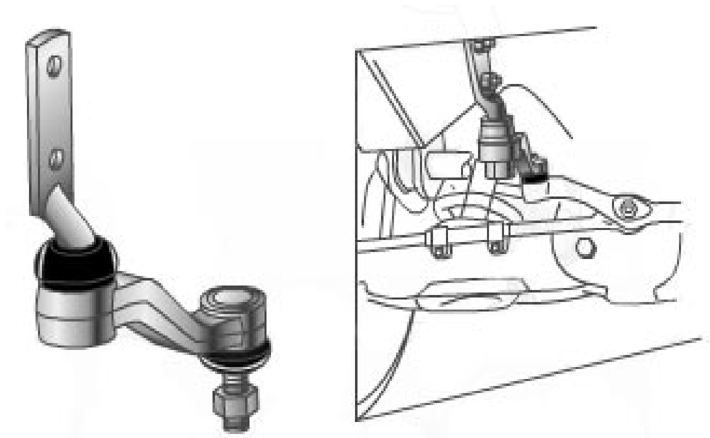


Figure 1: 7The idler arm on the left contains a pivot for the center link

D. **Cross Steer**: Straight axle trucks and some four-wheel-drive steering linkage designs use one long tie rod assembly that connects to both of the steering knuckles, or variations on this arrangement. Cross steer linkage and Haltenberger linkage systems may be found on light and medium duty trucks.

E. **Cross Steer Linkage**

- Has two tie rods and an adjusting sleeve connecting the wheels
- The left steering arm is connected to the steering gear with another tie rod assembly, sometimes called a drag link. The adjustment sleeve on this assembly is used to center the steering wheel during a wheel alignment.
- Note that the pitman arm attaches to the steering gear with a pinch bolt in this application.

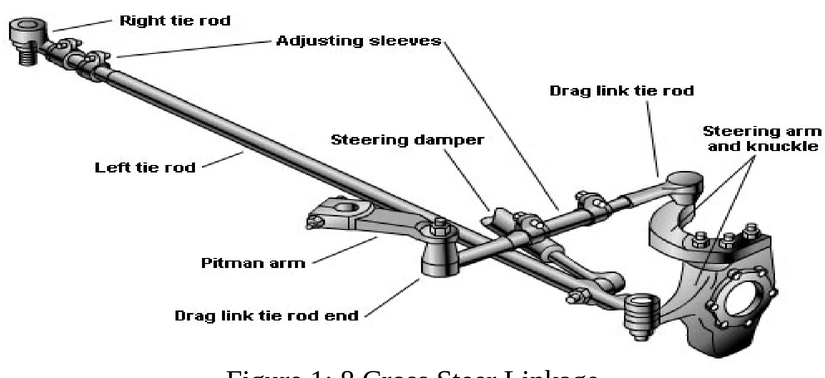


Figure 1: 8 Cross Steer Linkage

- **Power steering types**

Power steering helps reduce the amount of effort you need to put into turning. There are two types of power steering systems:

- **Hydraulic** – Hydraulic power steering systems is more common in older vehicles. They utilize a belt- or gear-driven pump that pressurizes the hydraulic fluid necessary to help you turn the steering wheel.
- **Electric** – Modern cars will typically be outfitted with an electric power steering system. These systems utilize an electronic motor to provide steering assistance. This motor will also shift the steering gear left or right depending on the input from the torque sensor.

- **Signs of a Bad Steering Gear**

- **Grinding noise when steering** – A faulty steering gear will often result in some noise. This is due to the wear on the inner components allowing for too much room between them.
- **Binding in the steering wheel** – Worn steering gear components will often make turning the steering wheel feel more difficult.
- **Loose steering** – typically caused by loose components within the steering gear.
- **Car drifts to one side** – A damaged steering gear can cause your steering to pull to one side, resulting in some drifting while driving. This is an especially dangerous issue that should not be ignored.
- **Power steering not working** – If you are used to power steering, you will definitely notice when it stops working in your vehicle as it will be significantly harder to steer. This can be due to a mechanical issue from the steering gear or a malfunction from the power steering computer if your vehicle uses an electric power steering system.
- **Dashboard warning lights turn on** – dashboard warning light configuration tends to vary slightly from vehicle to vehicle, but you may have one or more turn on if there is a problem with the steering gear. This will also produce a diagnostic code that your mechanic can reference when resolving the issue.
- **Hydraulic fuel leak** – Hydraulic fuel leaks will often cause problems for the steering gear. This leaks can come from multiple places from inside your steering gear and if ignored can cause permanent damage to your vehicle.

1.3 Types of Steering Systems

1.3.1 Manual-Steering Systems

The steering system is composed of three major subsystems: the steering linkage, steering gear, and steering column and wheel. As the steering wheel is turned by the driver, the steering gear transfers this motion to the steering linkage. The steering linkage turns the wheels to control the vehicle's direction. Although there are many variations to this system, these three major assemblies are in all steering systems.

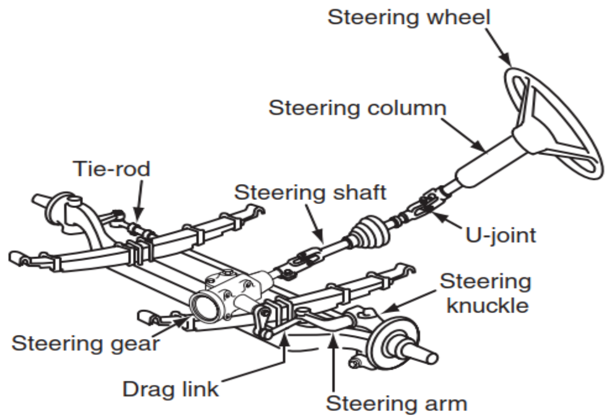


Figure 1: 9 Manual steering gear components.

1.3.2 Power-Steering Systems

Truck power-assisted steering systems are not so different from manual steering systems. As we said in the introduction to this chapter, any power steering system used in a highway vehicle must default to manual operation in the event of power-assist circuit failure. There are three basic types of power steering systems found in vehicles:

A. **Hydraulic power steering (HPS)** uses hydraulic pressure supplied by an engine-driven pump, known as the power steering pump, to assist the motion of turning the steering wheel. The power steering pump is turned by the accessory drive or serpentine belt and provides pressurized power steering fluid to the high side power steering hose which delivers it to the input side of the power steering control valve at the steering gear.

   Power steering fluid is drawn from the power steering fluid reservoir which is maintained at the appropriate level by a low side power steering hose that returns the fluid from the gear at a much lower pressure.

Figure 1: 10 Hydraulic power steering (HPS)

B. **Electric Power Hydraulic Steering (EPHS)** is a hybrid of hydraulic and electric. In this system, a hydraulic pump gets its energy from an electric motor instead of a belt driven by the engine. In EPHS the customary drive belts and pulleys that drive a power steering pump are replaced by a brushless motor. The power steering is driven by this electric motor, which reduces the amount of power that needs to be taken from the engine.

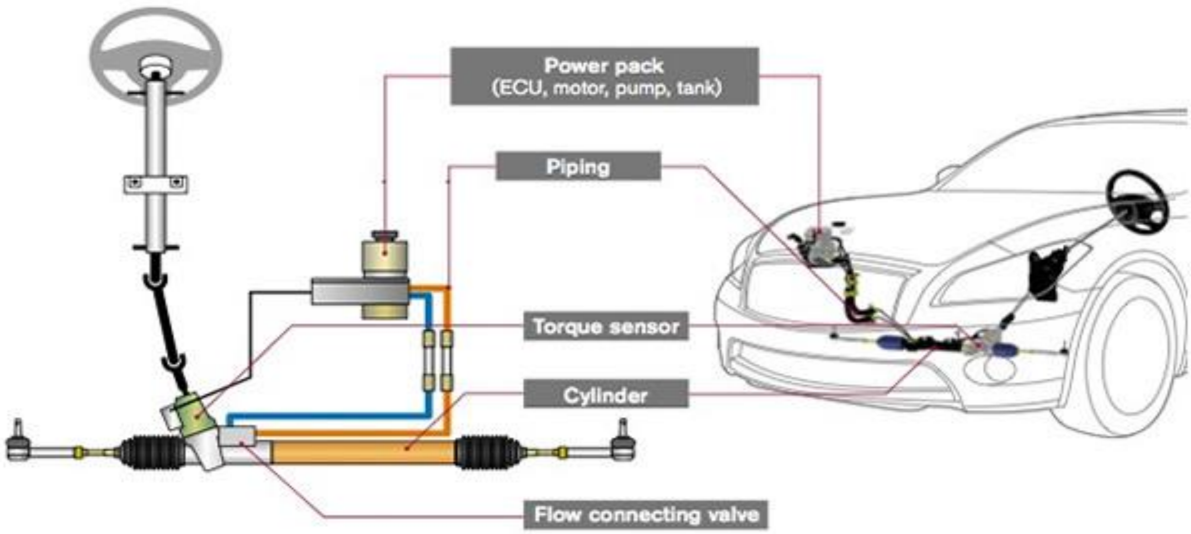


Figure 1: 11 Electric power hydraulic steering

C. **Electric Power Steering (EPS) system,** an electric motor replaces the hydraulic pump and a fully electric power steering system is established. The electric motor is either attached to the steering rack or to the steering column.

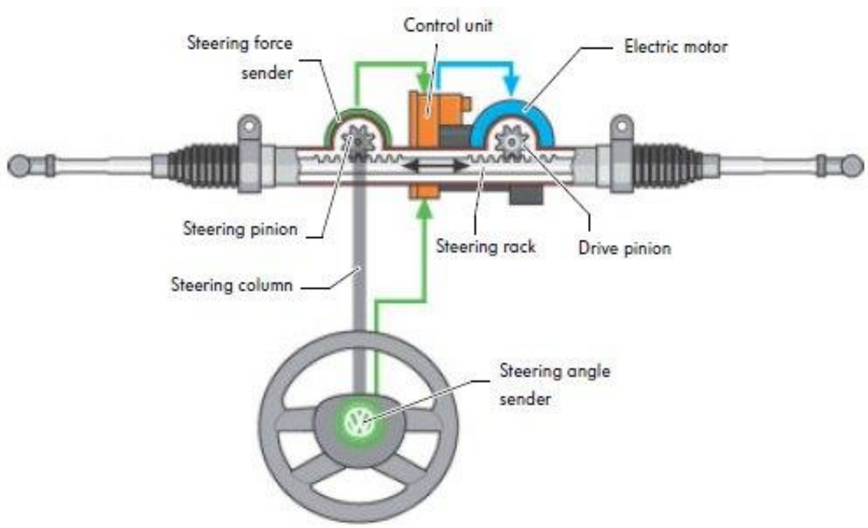


Figure 1: 12 Electric Power Steering

D. "Steer-by-wire" or "drive-by-wire"

This systems are also being designed and implemented. These systems eliminate the mechanical connection between the steering wheel and the steering system, replacing it with a purely electronic control system. This system frees up a lot of space in the dashboard that can be used for other things.

Figure 0:1: Steer-by-wire

E. Hydrostatic Steering

Fluid power systems are used in mobile applications to perform several operations, from load handling and hydraulic equipment control, to the translation and steering control of the vehicle. Hydrostatic steering is a hydraulic steering system that does not require mechanical steering linkage.

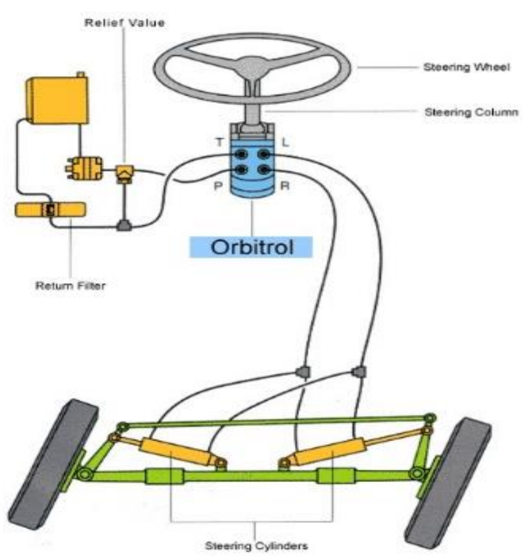


Figure 0:2: Hydrostatic Steering

1.4 Purpose of Suspension System

A suspension system supports the frame on a vehicle. It acts as an intermediary between the axles and the frame. The axles are subject to whatever forces they encounter when running down the highway. With no suspension, these forces would be transferred directly to the truck frame. Think of how rough it was to ride in one of those wagons you had as a kid. Given this kind of pounding and punishment, without the forgiveness of a suspension, the truck frame, its load, and the driver would not last too long. A suspension system plays a number of roles:

- It stabilizes the truck when traveling over smooth highway as well as over rough terrain.
- It cushions the chassis from road shock and enables the driver to steer the truck.
- It maintains the proper axle spacing and alignment.
- It provides a smooth ride both when loaded and unloaded.

Before we begin looking as the different suspension categories used on heavy vehicles, here are some suspension terms that we will be using:

- **Jounce** literally means “bump”: In suspension terminology, it is the most compressed condition of a spring. For instance, many suspensions use jounce blocks to prevent frame-to-axle contact known as suspension slam.
- **Rebound** is the reactive response of a spring after being jounced: It kicks back.
- **Unsprung weight,** an important factor in a suspension, refers to the weight of any chassis components not supported by the suspension, for instance, the axles.
- Ideally it is kept as low as possible because of the reaction effect, which is one of the reasons for spacing aluminum wheels.
- **Oscillation** is either rhythmic or irregular vibrations or movements in a suspension. For instance, a good suspension will minimize jounce/rebound oscillations by using dampening devices such as shock absorbers and multi leaf spring packs.

1.5 Classification of suspension system

A. Rigid Axle Suspension

In vehicles having a rigid axle suspension system, the right and left wheels are connected by a single axle which itself is fitted to the body and the frame via springs (leaf springs or coil springs).

Due to its great strength and simple construction, the rigid axle suspension system is widely used on the front and rear wheels of buses and trucks, and on the rear wheels of passenger cars.

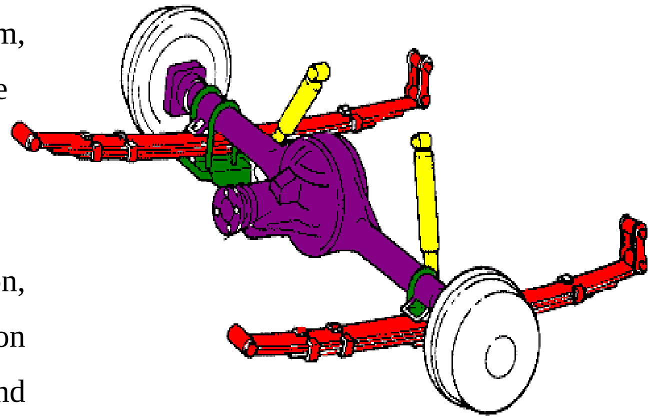


Figure 1: 13 Rigid Axle Suspension

B. Independent Suspension

In vehicles having an independent suspension system, the right and left wheels are not connected directly by an axle. The suspension is fitted to the body and the frame in such a way that both wheels can move independently without affecting each other. The independent suspension system is commonly used with the front wheels of passenger cars and small trucks and, more recently, with the rear wheels of passenger cars as well.

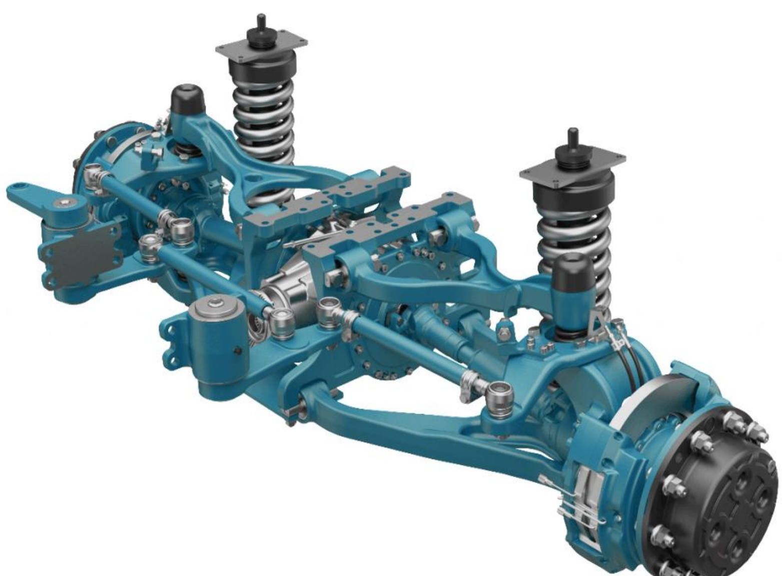


Figure 1: 14 Independent Suspension

1.6 Types of suspension system

1.6.1 Leaf Spring Suspensions

A leaf spring is a steel plate or stack of clamped steel plates. They have been used since the first vehicles hit our roads; for instance, they were key comfort components in horse-drawn buggies. Most leaf springs used in trucks today are manufactured from spring steel. Spring steel is middle-alloy steel that has been tempered; that is, heat treated. The result is to provide a leaf spring plate with considerable ability to flex without permanently deforming.

Principle of spring: A spring pack consists of a stack of tempered steel leaves clamped together by a center bolt. In theory, a multi-leaf spring pack is based on a diamond-shaped plate supported at either end. If such a shape were to be loaded in the center between the supports at either end, then the bending (deflection) that takes place would be proportional to the load applied.

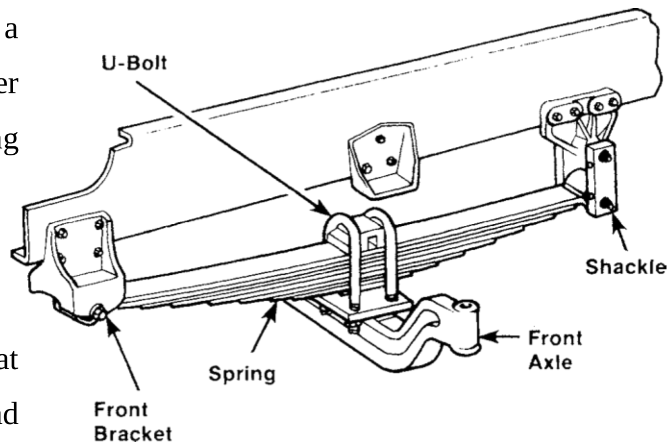


Figure 0:3: Semi-elliptical spring pack—constant

If you take a look at the spring pack shown in Figure 1:3, you can see that the shape is as if a diamond had been cut in half. This half-diamond shape has the same load stress characteristics as a full-diamond-shaped spring, so it is commonly used in springs. The half-diamond shape we just described is also known as a semi-ellipse. A term used to describe the shape of a typical multi leaf spring pack is semi-elliptical. Most multi leaf spring packs used in trucks and trailers are semielliptical.

A. Types of Leaf Spring Assemblies

Until relatively recently, leaf spring assemblies were used on a majority of truck and trailer suspensions. Although heavy-duty air suspensions have been around for over 50 years, recently they have become more common in transport applications. Many current truck suspensions use combination air/leaf spring suspensions. A combination suspension exploits the advantages of each type of spring to provide good unloaded and fully loaded suspension performance. For our purposes, we have divided leaf springs into two general types: **Constant rate and Progressive or variable rate auxiliary.**

a) Constant Rate

Constant rate springs are leaf-type spring assemblies that have a constant rate of deflection. For example, if 500 pounds deflect the spring assembly 1 inch, 1,000 pounds deflect the same spring assembly 2 inches. A typical constant rate spring is mounted to an axle saddle with U-bolts. The front end of the spring is pinned to a stationary bracket.

The rear end of the spring is pin mounted to a flex bracket known as a spring shackle. The shackle allows for variations in spring length between jounce and rebound. In the constant rate multi-leaf spring pack, individual spring leaves are clamped by a center bolt and the spring pack is secured to the axle housing by U-bolts. Some spring packs use spring clips to ensure that the alignment between the leaves in the stack is maintained.

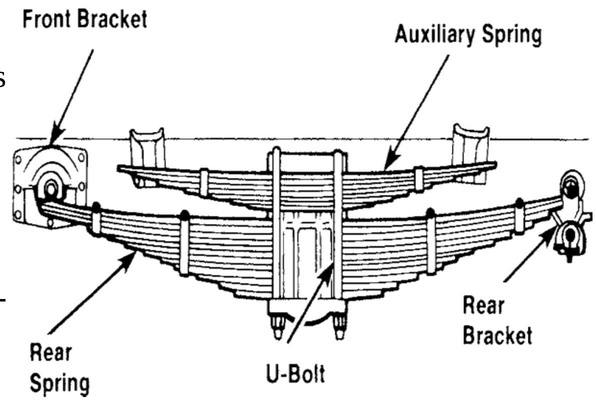


Figure 0:4: Constant Rate

b) Variable Rate

Variable rate springs are leaf-type spring assemblies with a variable deflection rate obtained by varying the effective length of the spring assembly. This is accomplished by using a cam bracket. As the spring assembly deflects, the point of contact on the bracket moves toward the center of the spring assembly, shortening the effective length. Variable rate spring assemblies also incorporate a progressive feature in that the lower spring leaves are separated at the ends. As the spring assembly deflects under load, these leaves come in contact, providing increased capacity and stiffness.

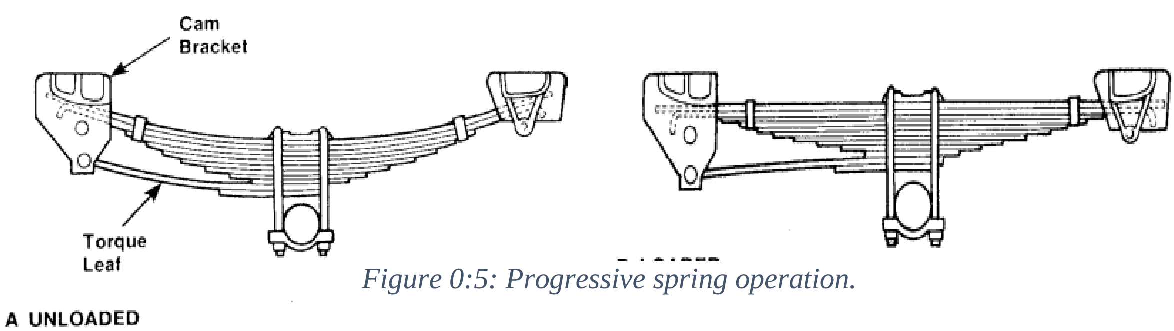


Figure 0:5: Progressive spring operation.

1.6.2 Equalizing Beam Suspensions

Equalizing beam suspensions are commonly used in rough service tandem drive applications. Equalizing beams flex on pivots, allowing a pair of axles to balance the forces that they are subjected to while still maintaining good tire-to-road contact. Two types of equalizing beam suspensions are used on heavy-duty trucks:

A. Leaf Spring Equalizing Beam

The leaf spring-type suspension uses a leaf spring pack on each equalizer beam. The springs are mounted on saddle assemblies above the equalizing beams and pivot at the front on spring pins and brackets. The rear of each spring pack has no rigid attachment to the spring brackets but is free to move forward and backward to compensate for spring deflection.

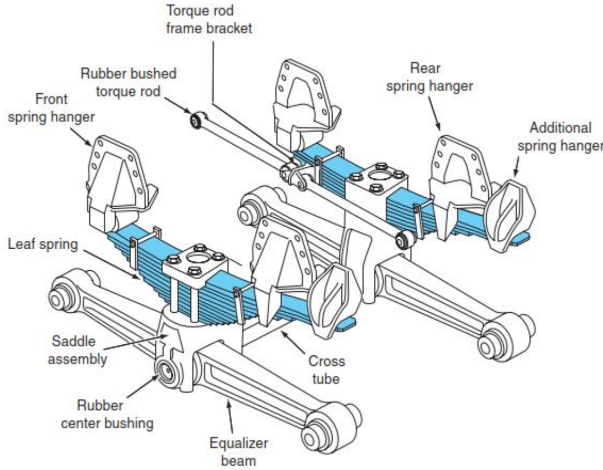


Figure 0:6: Leaf Spring Equalizing Beam

B. Solid Rubber Equalizing Beam

This type of suspension system uses solid rubber springs and is known as a solid rubber suspension. Solid rubber springs are sometimes known as rubber cushions. They fulfill the same role as leaf springs in supporting load and absorbing road shock. On these units, rubber load cushions are mounted on a saddle assembly at each side. Mounted between frame brackets and the suspension, each rubber block unit is secured by four rubber-bushed drive pins, each of which passes through the rubber cushion.

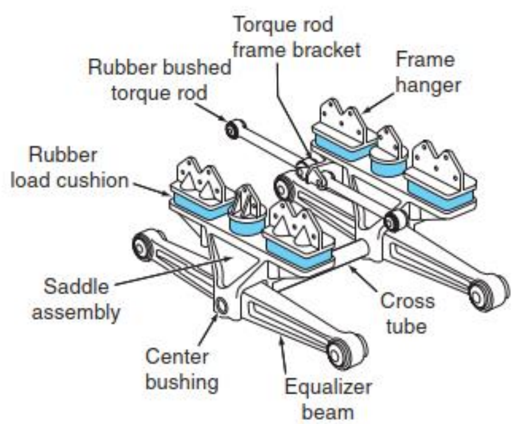


Figure 0:7: Equalizing beam suspension

1.6.3 Rubber Block and Torsion bar Suspensions

A rubber block and torsion bar suspension system uses a combination of both types of springs to maximize the advantages of each. They are known as combination rubber/torsion spring suspensions and have had a recent resurgence of popularity in both truck and trailer applications because of their versatility. This category of suspensions has some special advantages for vehicles required to negotiate rough, off-highway terrain along with normal highway operation.

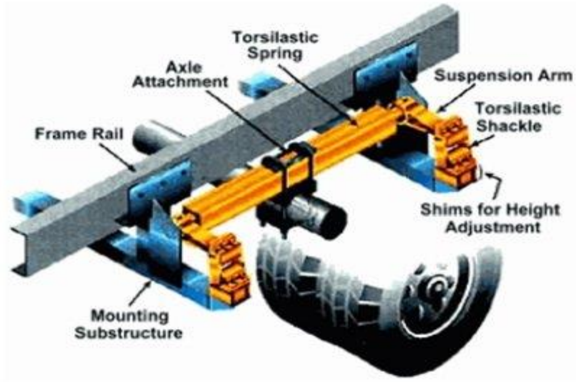


Figure 0:8: Rubber Block and Torsion bar Suspensions

1.6.4 Air Spring Suspensions

An increasing number of heavy-duty trucks and trailers are equipped with air spring suspension systems. These suspensions may be fully pneumatic (all air springs) or combination air/leaf spring suspension, The air bag or air spring suspension system provides a smooth shock- and vibration-free ride with a preset constant frame height. Using it in combination with steel leaf springs helps it to over-come some of its disadvantages.

Figure 0:9: Air Spring Suspensions

Air suspensions have been used as the rear suspension on highway tractors and on trailers for many years, but more recently they have gained acceptance on the front steer axle of trucks. The key to making air springs possible on front axles is to dampen the spring oscillations effectively so that steering control is not compromised. This is achieved on current systems by combining the air spring with steel or composite leaf springs and shock absorbers.

A. Air Suspension Components

An advantage of air spring suspensions is their simplicity combined with the ability to adapt to load and road conditions. The key to the adaptive capability of an air suspension is the height control valve. The major components of an air suspension system are:

a) Height Control Valve

An air spring suspension system is managed by a simple lever-actuated valve known as a height control valve (also known as a leveling valve).The height control valve automatically maintains chassis ride height. The height control valve is usually mounted at the rear of the truck frame, but other arrangements also are used. The valve has a lever rigidly connected to the rear axle assembly by means of a linkage rod. This height control lever controls air into and out of the air springs.

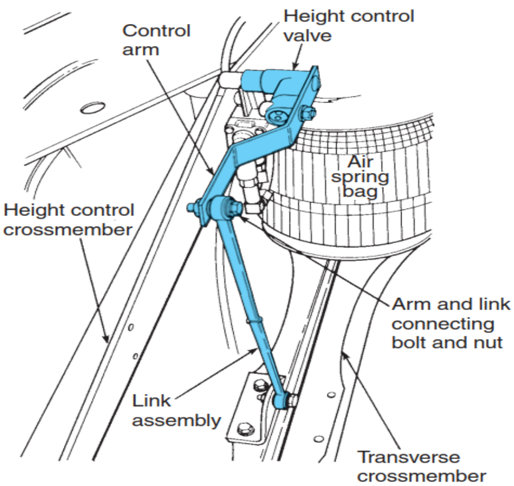


Figure 0:10: Height Control Valve

When the axle moves upward, as when passing over a road bump, the lever is forced upward. The reverse would occur if the axle dropped into a pothole. Moving the height control lever charges and discharges air to the air springs. To prevent rapid cycling, a delay mechanism is built into most height control valves.

b) Regulator

The air used in most air suspensions on trucks and trailers is regulated to a value lower than chassis system pressure. This means that the first device in a suspension circuit is a pressure regulator. Different values are used that vary according to OEM and application, but 90 psi (620 kPa.) is typical. Most regulators are combined with a pressure protection check valve used to prevent the suspension system from siphoning chassis air in the event of a serious leak.

Figure 0:11 Air suspension regulator

c) Air Lines

The air suspension uses air lines to connect all of the components of the system together. Air lines connect the air reservoir to the height control valve and from the height control valve. Also, air lines located.

d) Air Springs

The air springs or air bags used in air suspension systems are of either the reversible sleeve type or the convoluted type. The most common type of air spring in use today on trucks and trailers is the reversible sleeve type. The convoluted air spring is also available in three styles: single, double, and triple convolutions.

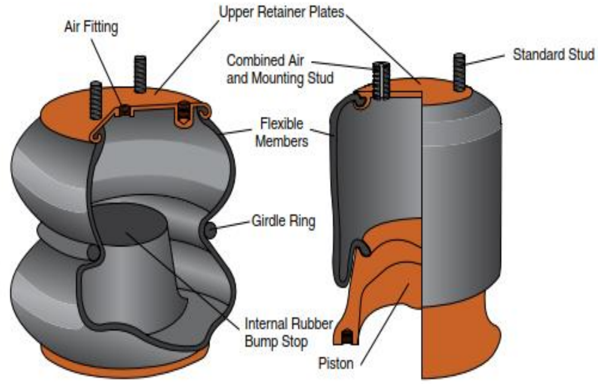


Figure 0:12: Components of reversible sleeve and convoluted air springs

e) Shock Absorbers

Shock absorbers are necessary on many types' of suspensions to reduce potentially damaging shock and vibration on heavy-duty trucks. There are three advantages of reducing or eliminating shock and vibration:

- Reduced wear to high-maintenance areas such as electrical systems, suspension parts, and cooling systems as well as premature wear to other components on the vehicle, with resulting downtime
- Reduced driver fatigue
- Reduced cargo damage

All of this is accomplished by stopping the vibration at its source: road shock transferred through the axle.

As a wheel passes over an imperfection in the road surface, the vehicles springs deflect (jounce) and respond by over returning (rebound). This causes the suspension to oscillate and will continue, slightly reduced, each time the spring deflects. These oscillations, coupled with road-induced shock, can cause severe damage to truck components. The jounce and rebound force dampening (resistance to movement) built into shock absorbers reduces component failures.

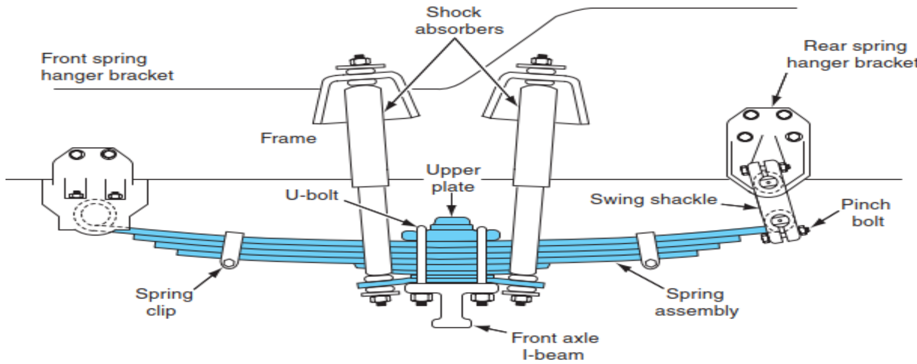


Figure 1: 15 Suspension System Assembly

1.7 Suspension Leveling Systems

Some vehicles have the capability to adjust their suspensions to maintain the proper attitude (ride height) of the vehicle regardless of how they are loaded. They use air shocks or air springs and an onboard compressor to adjust the suspension's height and rate.

Early leveling systems were operated with a manual switch. Later systems are automatic and rely on height sensors to determine the vehicle's attitude. The compressor is switched on, or air is bled out accordingly. System designs and operations vary.

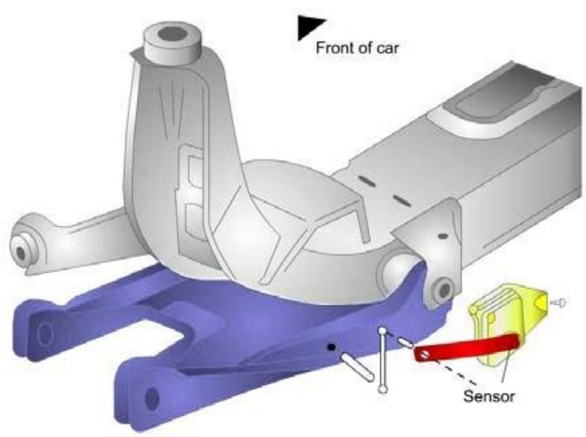


Figure 1: 16 Automatic And Rely on Height Sensors to determine The Vehicle's Attitude

A height sensor mounted on the frame. The actuating arm moves up or down with the suspension, varying a voltage signal at the electrical connection.

1.8 Electronically Controlled Suspension Systems

Suspensions are being produced that can change vehicle loading and ride characteristics very quickly, either automatically or on demand. These systems vary a great deal among manufacturers and model lines. Some luxury or high performance models have electronically controlled shock absorbers.

These systems vary the shock valuing according to vehicle conditions, as determined by a control module with inputs from a variety of sensors. The control module activates motors or solenoids that change the size of the valve orifices. The module may use inputs from numerous sensors, including:

- Height sensors located on the frame near the wheels
- Vehicle speed sensor
- Steering sensor – detects steering wheel rotational angle and speed
- Brake and door sensors
- Throttle position sensor

One type of electronically controlled shock absorber system uses a magneto- rheological fluid (MR) in the shocks, instead of changing the valuing. This fluid is synthetic oil that contains suspended iron particles. The shocks or struts contain a winding that, when energized, acts upon the particles, giving the fluid a thicker consistency for more damping action. The damping characteristics can be changed variably and instantaneously.

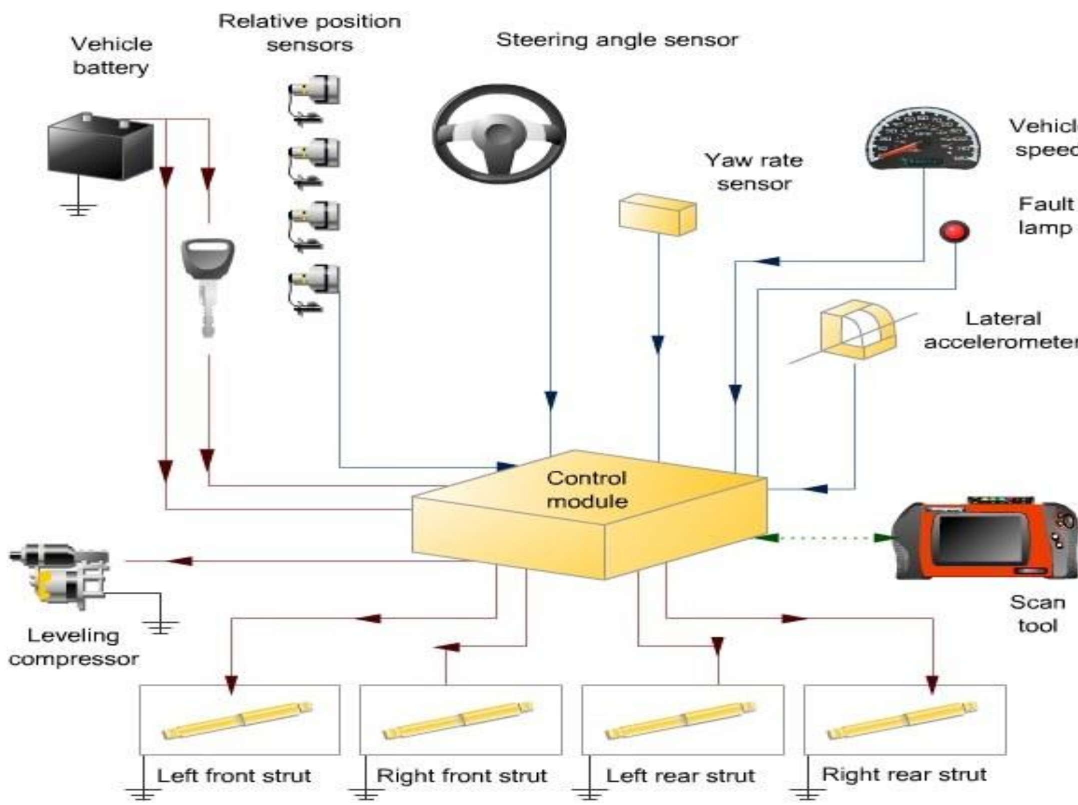


Figure 1: 17 Electronically Controlled Suspension Systems

1.9 Steering and Suspension Troubles

Most steering and suspension troubles fall into one of four groups. These are hard steering, handling problems, noise and leaks. Refer to Table 1 Steering and Suspension Trouble-Diagnosis Chart. Trouble-diagnosis charts and procedures for specific vehicles are in the vehicle service manual.

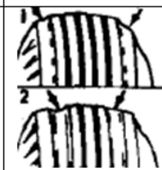
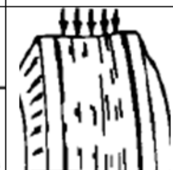
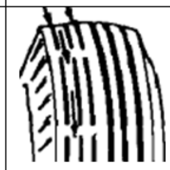
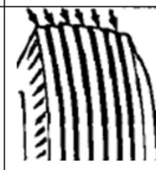
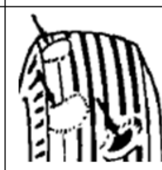
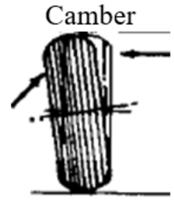
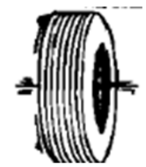
Table1: 1 Steering and Suspension Trouble-Diagnosis Chart

Complaint	Positive Cause	Check or Correction
1. Hard steering	a. Power steering inoperative b. Low or uneven pressure c. Friction in steering gear d. Friction in steering linkage e. Friction in ball joints f. Excessive positive camber g. Body or frame bent or misaligned h. Spring sag	Refer to vehicle service manual Inflate to correct pressure Lubricate, adjust or repair Lubricate, adjust or repair Lubricate or repair Align wheels Straighten Replace or adjust
2. Excessive play in steering	a. Looseness in steering gear b. Looseness in linkage c. Worn ball joints or steering-knuckle parts d. Loose wheel bearing	Adjust, replace worn parts Adjust, replace worn parts Replace worn parts Adjust
3. Wander	a. Mismatched tires or uneven pressures b. Linkage binding c. Steering gear binding d. Excessive toe-out e. Looseness in linkage f. Looseness in steering gear	Correct Adjust, lubricate, replace Adjust, lubricate, replace Align wheels Adjust, replace worn parts Adjust, replace worn parts Replace

Complaint	Positive Cause	Check or Correction
	g. Loose ball joints h. Loose leaf springs i. Unequal load in vehicle j. Stabilizer bar ineffective	Tighten Adjust load Tighten or replace
4. Pulls to one side	a. Uneven or low tire pressure b. Uneven caster or camber c. Tight wheel bearing d. Uneven springs (sagging, broken, loose attachment) e. Uneven torsion-bar adjustment f. Brakes dragging	Inflate to correct pressure Align wheels Adjust or replace Tighten, replace defective parts Adjust Adjust or repair
5. Push to one side while braking	a. Brakes grab b. Uneven tire pressure c. Incorrect or uneven caster d. Causes listed under item 4	Adjust, replace brake lining Inflate to correct pressure Align wheels
6. Shimmy	a. Uneven or low tire pressure b. Loose linkages c. Loose ball joints d. Looseness in steering gear e. Front springs too soft f. Incorrect or unequal camber g. Irregular tire thread h. Wheel imbalance	Inflate to correct pressure Adjust, replace worn parts Replace Adjust, replace worn parts Replace, tighten attachments Align wheels Replace worn tires, match threads Balance wheels
7. Tramp	a. Wheel imbalance	Balance wheels

Complaint	Positive Cause	Check or Correction
	b. Excessive wheel runout c. Shock absorbers defective d. Causes listed under item 6	Remount tire, straighten or replace Replace
8. Steering lookback	a. Tire pressure low or uneven b. Springs sagging c. Shock absorbers defective d. Looseness in linkage e. Looseness in steering gear	Inflate to correct pressure Replace, adjust torsion bars Replace Adjust, replace worn parts Adjust, replace worn parts
9. Poor return-ability	a. Friction in steering b. Friction in suspension c. Excessive negative caster d. Improper power-steering operation	Lubricate, adjust or repair Lubricate, adjust or repair Align wheels Clean, repair
10. Tire squeal or turns	a. Excessive speed b. Low or uneven tire pressure c. Improper wheel alignment d. Worn tires	Take curves at slower speed Inflate to correct pressure Align wheels Replace
11. Improper tire wear	a. Wear or tread sides from under inflation b. Wear at tread center from over inflation c. Wear at one side of tread from excessive camber	Inflate to correct pressure Inflate to correct pressure Align wheels

Table1: 2 Abnormal Tire Wear Chart

Condition	Rapid Wear At Shoulders	Rapid Wear At Center	Wear On One Side	Feathered Edge	Bald Spots	Scalloped Wear
Effect						
Cause	Under-Inflation Or Lack Of Rotation 	Over-Inflation Or Lack Of Rotation 	Excessive Camber 	Incorrect Toe 	Unbalanced Wheel  Or Tire Defect	Lack Of Rotation Of Tires Or Worn Or Out-Of Alignment Suspension
Correction	Adjust Pressure To Specifications When Tires Are Cool. Rotate Tires		Adjust Camber To Specifications	Adjust Toe To Specifications	Balance Wheels	Rotate Tires And Inspect Suspension

Self-Check

Part One: Select the best answer for the given statement

1. Technician A says if a vehicle's ride height is below specifications, a wheel alignment can still be performed. Technician B says if ride height is too low, the shocks and springs are weak and need to be replaced. Who is correct?

   a. Technician A b. Technician B c. Both A and B d. Neither A nor B

2. All of the following statements about front suspensions are correct except:
   a. Most strut suspensions eliminate the upper control arm and ball joint.
   b. The load-carrying ball joint is in the control arm on which the spring sits.
   c. The load-carrying ball joint on a MacPherson strut suspension is the lower joint.
   d. The no-load-carrying ball joint is called a following ball joint.
3. The suspension system performs all of the following functions EXCEPT:
   a. Supporting the weight of the chassis and drivetrain,
   b. Monitoring the tread wear of each tire.
   c. Holding the wheels and tires in the proper orientation.
   d. Absorbing the large road forces generated while driving on non-perfect roads.
4. What is used to load the leaves in a spring pack under tension to provide its self-dampening properties?

   a. spring clips b. U-bolts c. center bolt d. spring pins

5. In an air suspension, what happens to the air in the air bags when a height control valve lever is raised upward off horizontal?

   a. The air is exhausted. b. The bag is further inflated.

   c. The suspension air circuit is dumped. d. The chassis system pressure is reduced.

Part Two: Give Short answer

1) What are purpose of suspension system?
2) Discuss about the classification of suspension system?
3) Safety rules in mind when operating impact wrenches:
4) What are the general categories of suspension systems?
5) Discuss the following terms: Jounce, Rebound, Unsprung weight and Oscillation

Part Three: Part Identification

1. Identify the parts of this ____ rear suspension

A ____________________________

B. __________________________

C. __________________________

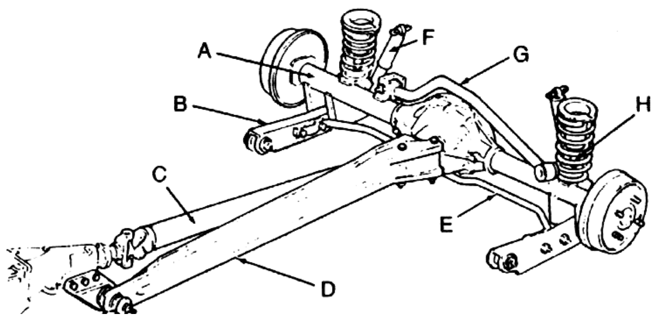
D. __________________________

E. __________________________

F. __________________________

G. __________________________

H. ____________________________



2. Identify the parts of this rear suspension

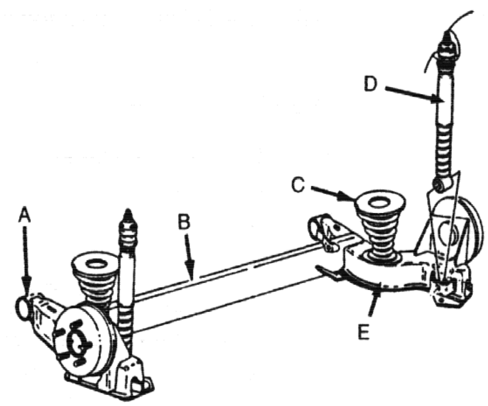
A.__________________________________

B._________________________________

C.__________________________________

D.__________________________________

E.__________________________________



3. Identify the parts of this rear suspension

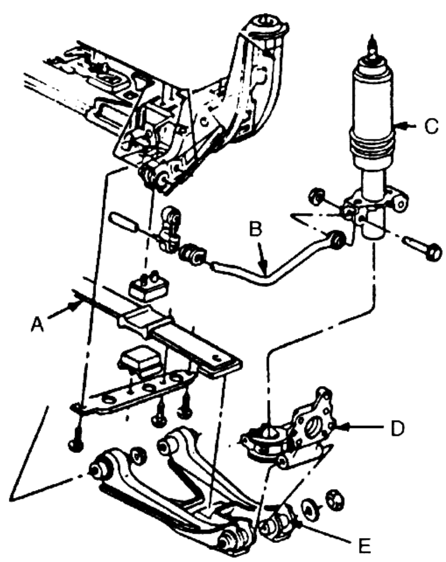
A. ________________________________

B. ________________________________

C. ________________________________

D. ________________________________

E. ________________________________



Unit Two: Inspection and Repair of Steering Systems

This unit is developed to provide you the necessary information regarding the following content coverage and topics:

- Steering Systems Inspection
- Servicing Steering System
- Wheel Alignment

This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Perform Steering Systems Inspection
- Perform steering system servicing
- Performing Wheel Alignment

2.1 Basic Inspection Procedures

When a steering problem is reported, systematically inspect the vehicle steering system, front and rear suspensions, and trailer suspensions. In most cases, a road test will be required, but never take a truck out onto a road until you are sure it is roadworthy. If a reported problem occurs only when the vehicle is loaded, you should test drive the vehicle loaded, and when you check out steering systems, remember that other chassis systems can cause steering problems. Perform the following sequence of checks when symptoms such as rapid tire wear, hard steering, or erratic steering indicate a problem in the steering system:

1. Check that the front tires are the same size and model. Ensure they are equally and adequately inflated. Underinflated tires cause hard steering. Overinflated tires reduce the road contact foot- print, reducing control.
2. If the steering problem occurs only when the vehicle is loaded, make sure that the fifth wheel is adequately lubricated.
3. Inspect the steering linkages for loose, dam aged, or worn parts. Steering linkage components include the tie-rod assembly, steering arms, bushings, and other components that carry movement of the Pitman arm to the steering knuckles. The wheels should turn smoothly from stop to stop through a full turn cycle.
4. Inspect the drag link, steering driveshaft(s), and upper steering column for worn or damaged parts.
5. Ensure that the steering column components, especially the U-joints, are adequately lubricated.
6. Check front axle wheel alignment, including wheel bearing adjustment, caster, camber angles, and toe-in.
7. Check the rear axle alignment. Rear axle misalignment can cause hard or erratic steering. If needed, align the rear axle(s).
8. Inspect the front axle suspension for worn or damaged parts.
9. With the front wheels straight ahead, turn the steering wheel until motion is seen at the wheels. Align a reference mark on the steering wheel with a mark on a ruler and then slowly turn the steering wheel in the opposite direction until motion is again observed at the wheels. Measure the lash (free play) at the steering wheel. Too much lash exists if the steering wheel movement exceeds: 2-3/4 inches (70 mm) for a 22-inch (0.56 m) steering wheel 2-1/4 inches (57 mm) for 20-inch (0.51 m) steering wheel

10. Turn the steering wheel through a full right and full left turn. If the front wheels cannot be turned to the right and left axle steering stops without binding or noticeable interference, the problem s likely in the steering gear.
11. Secure the steering wheel in the straight ahead driving position. Move the front wheels from side to side. Any play in the steering gear bearings will be felt in the drag link ball joint at the Pitman arm. If any bearing play exists, adjustments to the steering gear may be in order
12. Check the tractor fifth wheel. Lack of lubrication between the fifth wheel plate and trailer upper coupler can cause serious steering problems. This is most common in tractor-trailer combinations that seldom uncouple. With most fifth wheels, the tractor and trailer must be split to apply grease directly to the fifth wheel top plate.

2.2 Inspection of Steering System

2.2.1 Steering Axle Inspection

Specific service procedures and maintenance intervals can be found in OEM service literature. The following procedures are general guidelines for periodic steering axle inspection:

A. A thorough **visual inspection** for proper assembly, broken parts, and looseness should be performed each time the vehicle is lubricated. In addition, ensure that the spring-to-axle mounting nuts and the steering connection fasteners are secure.
B. **Wheel Alignment.** Front steering wheel alignment should be checked periodically according to OEM-recommended service intervals (typically 3 months or 25,000 miles). If excessive steering effort, vehicle wander, or uneven and excessive tire wear is evident, the wheel alignment should be checked immediately.
C. **Steering Axle Stops**. Although steering axle stops should be checked periodically, they seldom need adjustment. However, if the steering turning radius is insufficient or excessive (resulting in tire or wheel contact with the frame), the stops should be adjusted.
D. **Tie-Rod Ends.** Tie-rod ends should be inspected each time the axle is lubricated. Check for torn or cracked seals and boots, worn ball sockets, or loose fasteners.
E. **Steering Knuckle Thrust Bearings.** The knuckle thrust bearings should be checked each time the hub/drum is removed. Knuckle vertical play should be adjusted each time the knuckle pin is removed for service, at each axle overhaul, or whenever excessive knuckle vertical movement is noted.

F. **Kingpins.** The kingpin and its bushings should be inspected whenever the pin is removed for service, at axle overhaul, or looseness is noted.

G. **Wheel Bearings.** The wheel bearings should be inspected for damage or wear each time the hub or drum is removed. Check for signs of wear and distress.

H. **Lubrication.** Steering axle components should be lubricated at least every 25,000 miles. Good quality chassis grease should be used. Kingpins, thrust bearings, and tie-rod ends should be lubricated at each preventive maintenance (PM) service interval. Those without grease fittings are usually permanently lubricated. Consult the OEM service literature for the recommended steering gear lubricant. This may be gear lube, engine oil, or hydraulic transmission fluids. Because most steering gear have a number of lubricant options, you should try to top up with the same lubricant that is already in the gear or reservoir.

2.2.2 Steering Knuckle Inspections

Steering knuckles account for a number of steering problems and many of these problems originate from lack of lubrication. The following tests should be performed to check out steering knuckles and kingpins.

Steering Knuckle Vertical Play

1. Mount a dial indicator on the axle beam.

2. Position the indicator plunger on the knuckle cap

3. Pry the steering knuckle downward.

4. Zero the dial indicator.

5. Lower the front axle to obtain the dial indicator reading. If the reading exceeds the OEM specification (typically 0.04 inch [1 mm]), inspect the thrust bearings. Replace them if necessary.

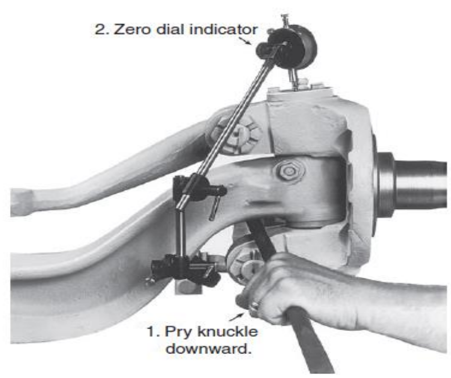


Figure 2: 1 Steering Knuckle Vertical Play

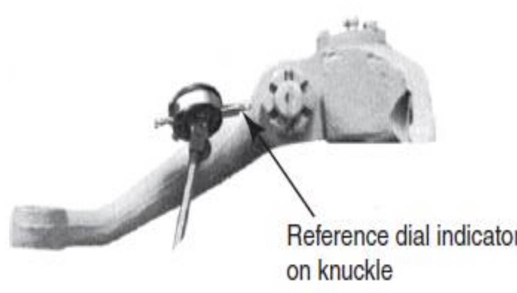


Figure 2: 2 Inspecting Free Play In The Upper Bushing

2.2.3 Kingpin inspection

A. Upper Bushing Free Play

1. Mount a dial indicator on the axle**.** Place the indicator plunger on the upper part of the knuckle, as shown.

2. Move the top of the wheel in and out with a push/pull motion. Have someone monitor the dial indicator readings. Readings that exceed the OEM specifications (typically 0.015 inch [0.38 mm]) indicate the need for bushing replacement.

B. Kingpin Lower Bushing Free Play

1. Mount the dial indicator on the axle. Reference the plunger on the lower tie-rod end socket of the steering knuckle
2. Move the bottom of the wheel in and out with a push/pull motion. Have an assistant read the dial indicator.
3. A dial indicator reading that exceeds the OEM specifications (typically 0.015 inch [0.38 mm]) indicates that the lower bushing should be replaced.

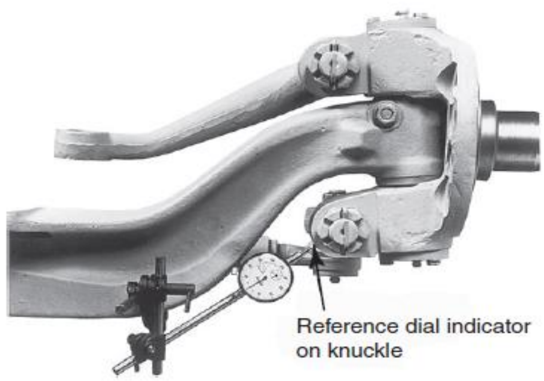


Figure 2: 3 Measuring Free Play In The Lower Bushing.

C. Kingpin Upper Bushing Torque Deflection

1. Mount the dial indicator to the axle, referencing the upper knuckle steering arm socket area
2. Have someone apply the foot brake. Try to roll the wheel forward and backward and note the deflection.
3. Readings in excess of the manufacturer's specifications (typically 0.015 inch indicate that the top bushing should be replaced.

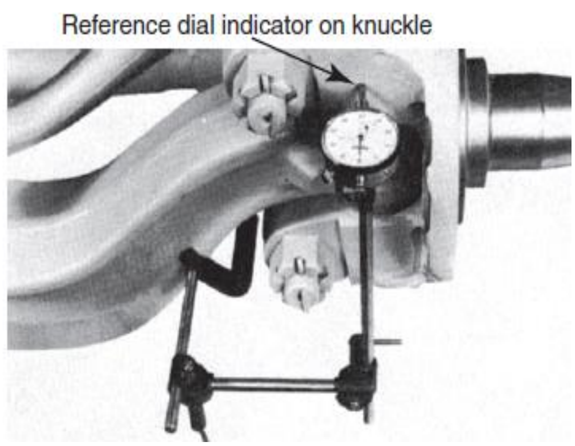


Figure 2: 4 Measuring Upper Bushing Torque Deflection.

D. Lower Bushing Torque Deflection Test

1. Mount the dial indicator on the axle and the plunger on the lower bushing area.
2. Have someone apply the foot brake. Try to roll the wheel forward and backward and note the deflection.
3. Readings that exceed the OEM specifications (typically 0.015 inch [0.38 mm]) indicate that the lower bushing should be replaced.

E. Measuring steering kingpin wear and vertical end

1) Apply the parking brakes, block the rear wheels, and use a floor jack to raise the front axle until the tires are off the shop floor.
2) Lower the vehicle so that it is supported securely on safety stands with the front tires still off the shop floor.
3) Mount a dial indicator on the front axle I-beam and position the dial indicator plunger on the inner side of the upper end of the steering knuckle. Zero the dial indicator.
4) While a helper moves the top of the wheel and tire inward and outward, observe the dial indicator reading. If the total movement on the dial indicator exceeds the specified kingpin bushing movement, the kingpin bushing must be replaced.
5) Mount the dial indicator on the front axle I-beam with the dial indicator plunger touching the inner side of the lower end of the knuckle. Zero the dial indicator.
6) Mount the dial indicator on the axle I-beam and position the dial indicator plunger on top of the upper knuckle joint cap.
7) Use a pry bar to force the steering knuckle downward. Check the reading on the dial indicator.
8) Next, observe the dial indicator reading while a helper uses a large pry bar to lift upward on the tire and wheel. If the dial indicator reading exceeds the truck manufacturer's specifications, remove the steering knuckle and inspect the thrust bearing. Replace this bearing if necessary and install the required shim thickness.

2.2.4 Tie-Rod Inspection

1. Shake the tie-rod or cross tube. Movement, or looseness, between the tapered shaft of the ball and the cross-tube socket members indicates that the tie-rod end assembly should be replaced.
2. The threaded portion of both tie-rod ends must be inserted completely beyond the tie rod split recess, as shown in Figure 2.5. This is essential for adequate clamping. If this is not so, components will have to be replaced. Check to see if the cross-tube or tie-rod ends are at fault.
3. Ball and socket torque (exclusive of boot resistance) should be 5 lb.in. or more on disconnected tie-rod end assemblies. Replace assemblies that test less than 5 lb.in. loose assemblies will adversely affect the steering system performance and might prevent adjustment of the steering assembly to the vehicle OEM alignment specifications.

4. If the tapered shank-to-tie-rod arm connection is loose or the cotter pin is missing, disconnect and inspect these components for worn contact surfaces. If either one is worn, replace it.

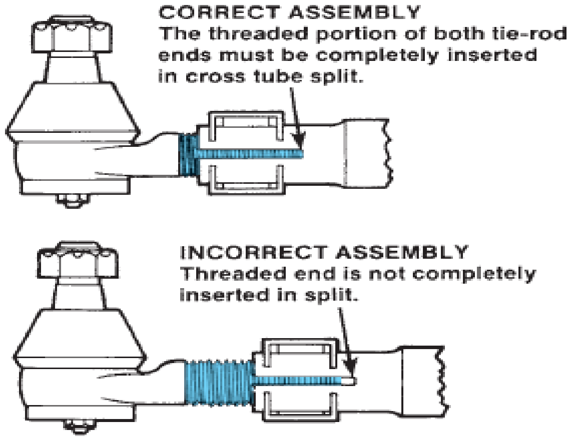


Figure 2: 5 Correct and incorrect tie-rod installation

2.3 Servicing manual Steering System

Steering system service normally involves the adjusting or replacement of worn parts. Service is required when the worm shaft rotates back and forth without normal pitman arm shaft movement. This would indicate that there is play inside the gearbox. If general troubleshooting and inspecting of a steering system suggest a problem in the steering axle, you can use the following procedure to identify worn or out-of-adjustment components.

2.3.1 Steering Knuckle Disassembly

1. Back off the slack adjuster to ensure that the brake shoes are in the released position and well clear of the drum.
2. Remove the hubcap from the wheel assembly, followed by the cotter pin, nut, washer, and outer bearing cone assembly on traditional wheel ends.
3. Remove the wheel and hub assembly.
4. Disconnect the air line from the brake assembly.
5. Remove the foundation brake assembly from the axle spider.
6. To disconnect the tie-rod end from the Ackerman arm, remove the cotter pin and slotted nut
7. Disconnect the tie-rod end using a suitable tool, such as a pickle fork
8. Disconnect the drag link from the steering arm by removing the cotter pin and slotted nut.

Figure 2: 6 To Remove A Tie-Rod, First Remove The Cotter Pin And Nut.

2.3.2 Kingpin Removal

1. Remove the cap screws and lock washers to remove the knuckle caps.
2. Remove the nut from the draw key; then, drive the key out using a hammer and brass drift
3. Drive the kingpin out with a hammer and brass drift.
4. Remove the steering knuckle from the axle beams and discard the thrust bearing.

Figure 2:7 To remove the kingpin drive out the draw key

2.3.3 Adjusting Knuckle Vertical Play

1. If the vertical play in the knuckle exceeds the OEM specifications, adjustments can be made by removing or installing shims between the axle beam and the upper part of the knuckle. To do so, follow these steps:
2. Remove the cap screws, lock washers, and grease caps from the steering knuckle.
3. Remove the nut and draw key.
4. Partially drive out the kingpin, using a hammer and brass drift. Drive from the top down.
5. Remove the kingpin far enough to facilitate removal and replacement of the shims.
6. Adjust the shim pack to obtain the manufacturer's specified vertical play (typically 0.005 to 0.025 inch [0.127 mm to0.635 mm]).
7. With the correct shims installed, drive the kingpin back into the knuckle assembly.
8. Recheck the vertical play and readjust if necessary.

Figure 2:8 with the knuckle pin partially removed

9. With the adjustment complete, ensure that the kingpin flat is aligned with the draw key so it can be secured.
10. Install the draw key and nut. Torque the nut to the OEM specification.
11. Install the knuckle grease cap gasket (if applicable) or use a silicone compound on the grease cap mounting surface. Install the grease caps.
12. Install the cap screws and the lock washers. Torque the cap screws to the OEM specification.

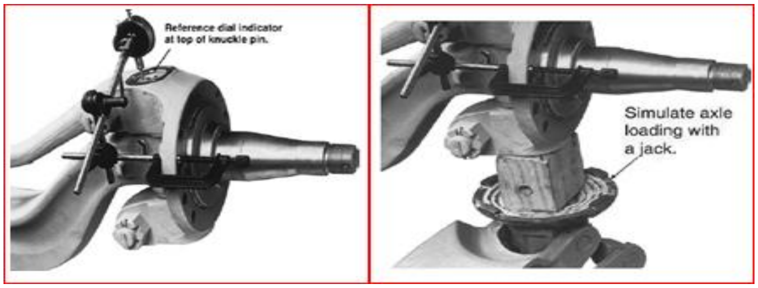


Figure 2:9 Simulate axle loading with jack

2.3.4 Assembling Steering Knuckle

Use the following procedure to assemble a steering knuckle assembly:

1. Lightly lubricate the thrust bearing areas of the steering knuckle, axle end, and kingpin bore of the axle beam
2. Position the thrust bearing on the knuckle with the seal facing up.
3. Mount the steering knuckle onto the axle beam.
4. Wedge the steering knuckle upward and fit shims to fill the gap at the knuckle upper end.
5. This step is a pre adjustment of knuckle vertical play.
6. Position the kingpin flat, aligned with the draw key hole, and start installing it by pushing it in by hand.
7. Install the kingpin into the knuckle and axle beam from the top. If necessary, tap the pin home using a hammer and brass drift.
8. To check knuckle vertical play, center the steering.

9. Mount the dial indicator to the flange and set the plunger to reference the top of the kingpin, Zero the dial indicator.
10. Simulate axle loading with a jack and note the dial indicator reading.
11. If the vertical play is outside of OEM specifications, either add or remove shims to set the specified endplay.
12. When the adjustment is complete, check the draw key opening and kingpin flat alignment.
13. Install a new draw key, using a soft face hammer.
14. Install the draw key nut and tighten it to the correct torque.
15. Apply silicone compound to the kingpin grease cap mounting surface, or install a gasket if applicable.
16. Install cap screws and lock washers to secure the grease cap.
17. Tighten the cap screws to the OEM specification.
18. Attach the drag link to the steering arm. Install and torque the nut to the OEM specification. Install the cotter pin.
19. Attach the tie-rod end to the Ackerman arm. Install and torque. Install the cotter pin.
20. Reinstall the brake and wheel assemblies, following the OEM service literature procedure.

Figure 2:10 Procedure to assemble a steering knuckle assembly

2.3.5 Kingpin Seal Replacement

1. Remove the grease seal from the knuckle upper arm.

2. Install a new seal, using a suitable pilot drift or mandrel that will not damage the seal as it is installed.

2.3.6 Ackerman Arm Replacement

1. Disconnect the tie-rod end from the Ackerman arm (or drag link from the steering arm).
2. Remove the cotter pin and nut from the arm at the knuckle end.
3. Drive the arm out of the knuckle using a suitable brass drift and hammer.
4. Install a new key in the slot provided in the Ackerman arm.
5. Install the nut and tighten it to the correct torque. Install the cotter pin.

2.3.7 Tie-Rod End Replacement

1. Disconnect the tie-rod end using a pickle fork.
2. Loosen the clamp nut, apply penetrating the threads, and unscrew the tie-rod end.
3. Install the new tie-rod end. Thread the end into the cross tube past the tube split.

4. Attach the tie-rod end stud to the tapered bore in the Ackerman arm. Tighten to the correct torque. Install the cotter pin.
5. Adjust toe-in using the procedure described earlier. Tighten the cross-tube clamp screw to correct the torque.

2.3.8 Kingpin Bushing Replacement

1. After removing the kingpin, drive the upper bushing out of the steering knuckle using a suitable piloted drift or mandrel.
2. Drive the lower bushing out in the same manner.
3. Remove all foreign material from the steering knuckle and axle beam.
4. Lightly lubricate the outside diameter of the bushing to assist installation.
5. Align the bushing seam
6. To install the bushings, first hand-start the bushing in the bore. Then, using a suitable piloted drift or bushing mandrel, drive the bushings home.

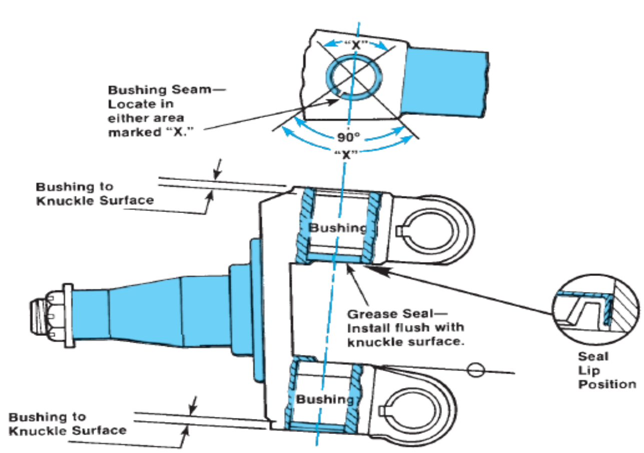


Figure 2:11 Bushing and seal installation.

2.3.9 Service Steering Gearbox

Manual steering gears tend to be reliable, usually requiring only routine maintenance through their service life. The housing is filled with lubricant but has few moving parts. Depending on service application, some adjustments will be required throughout the service life of a steering gear, but when these are specified to trucks today, it is almost always in highway applications.

Because of the increased physical effort required to steer a manual steering gear it makes little sense ever to spec them to non-line haul applications. Some typical adjustments required in manual steering gear are described here.

A. Worm and Sector Gear Set

When the vehicle is driving in straight-ahead direction, the steering gear should be in the center of its travel. This means that the sector gear (or roller) should be positioned at the center of the worm gear. Mesh between the worm and sector is at maximum in this over center position. The minimum clearance in the over center position produces tight response to steering inputs and good road feel at highway speeds.

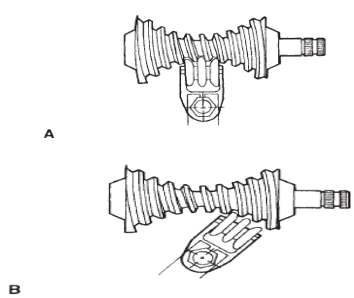


Figure 2:12 (A) Over center position; and (B) backlash area

B. Worm Shaft Preloads

Steering gear worm shafts are assembled with a specified amount of resistance to input turning effort by preloading the bearings that support the shaft. This preload is required to prevent random unwanted movements within the system.

Two types of preloads are used: worm bearing preload and total mesh preload. The worm bearing preload is end-to-end pressure on the worm shaft and its bearings. The total mesh preload is the result of the combined pressure of the sector shaft gear acting on the worm gear and the worm bearing preload. Both types of preloads are originally set to factory specifications and usually expressed in inch pounds of torque.

Preloads can be reset by the user as required. When preloads are out of adjustment, steering can be significantly affected. From a driver's perspective, this will mean constant corrections are required to drive a straight line. Insufficient preload permits lost motion within the gear set, meaning that the driver must turn the steering wheel farther than normal to get a response from the front wheels. On the other hand, excessive preloads result in hard steering, darting, and over steer.

- **Measuring and Adjusting Preloads**

Although incorrect preloads can cause the steering problems we have described, they are not the only cause of these conditions. Before checking steering gear preload, check the steering linkages for worn or binding areas first. If the steering linkage components check out okay, then proceed with the preload check.

a) Worm Shaft Preload Check

This test is performed with the sector shaft gear located in the backlash area.

1. Position the front wheels straight ahead. If possible, drive the vehicle in a straight line for a short distance, stopping at the location where service operations will be performed.
2. Disconnect the drag link from the Pitman arm and the steering column shaft from the steering gear input shaft.
3. Slowly turn the input shaft until the sector gear is close to the end of the worm gear.
4. Reverse the rotation of the input shaft a quarter turn. In this position, there should be no contact between the sector shaft gear and worm gear teeth.
5. Place an inch-pound torque wrench on the end of the input shaft. Turn the torque wrench back and forth within about a quarter-turn arc to record the torque in the area where the gear teeth are not touching. The output shaft should not turn.
6. If the preload reading of the moving shaft is within OEM-specified limits, proceed to the total mesh preload check. If the preload is above or below these limits, it will need to be adjusted.
7. Preload is adjusted by adding or removing shims between the gear housing and the cover plate.

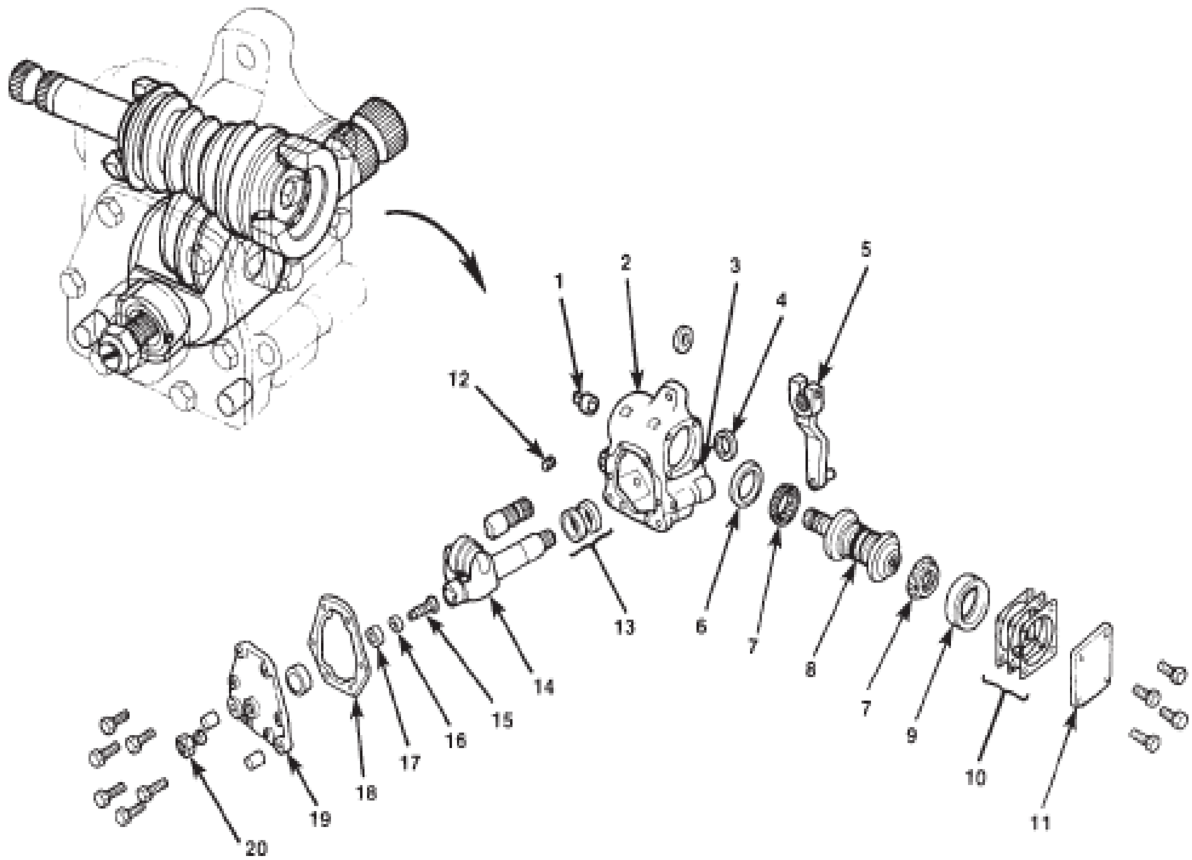


Figure 2:13 Exploded view of a typical manual steering gear

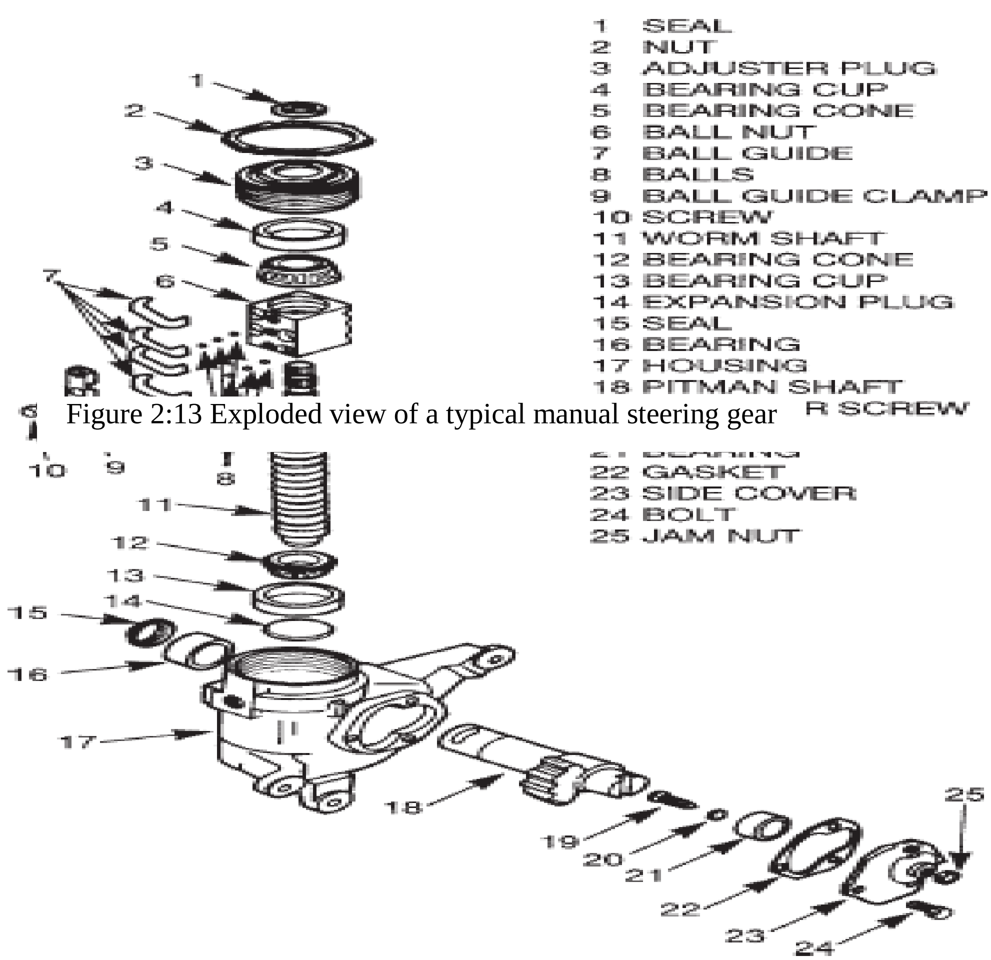


Figure 2:14 Exploded view of a typical re circulating ball-type manual steering gear

b) Adjusting Worm Shaft Preload

If you have already tested worm shaft preload and it is out of specification, you should use the following procedure to correct it:

1. Clean the outside of the steering gear.
2. Remove the fill plug and the drain plug from the steering gear. Drain the lubricant and dispose of it in an environmentally safe manner.
3. Remove the worm shaft cover screws and the worm shaft cover.
4. If worm shaft preload tested lower than specified (requires less torque to turn) shims will have to be removed. Removal of shims increases preload; adding shims decreases preload. Shims are available in a variety of sizes. Typical sizes include 0.002, 0.003, 0.005, 0.0075, and 0.010 inch. Remove only one shim at a time, as necessary, using a knife blade. The size of the shim to be removed or added will depend on the amount of lash. Use a micrometer to identify the thickness of the shims.
5. Assemble the worm shaft cover and shims.

6. Install the worm shaft cover screws. Make sure you have a light preload before final torqueing the fasteners.
7. Using a crisscross pattern or sequence, incrementally tighten the worm shaft cover screws to the OEM torque specification.
8. Recheck the worm bearing preload. If necessary, repeat the adjustment procedure modifying shim pack thickness as appropriate.

c) Full Mesh Preload Check.

Do not check the sector shaft full mesh preload unless the worm shaft bearing preload has been previously checked to be within the specifications. Checking sector shaft full mesh preload when the worm shaft bearing preload is out of adjustment will produce inaccurate measurements.

1. After checking the worm shaft bearing preload to be within specs, center the steering gear by turning the worm shaft from stop to stop, counting the number of turns required. Starting at the end of travel, turn back exactly half that number of full turns. This will place the sector shaft gear teeth in the approximate center of the worm gear.
2. Check the alignment mark on the sector shaft output stub. If the alignment mark is at a right angle to the worm shaft, the gear is centered, as shown in Figure 3–12. If not, turn the worm shaft using the input shaft until the sector shaft alignment mark is at a right angle to the worm shaft

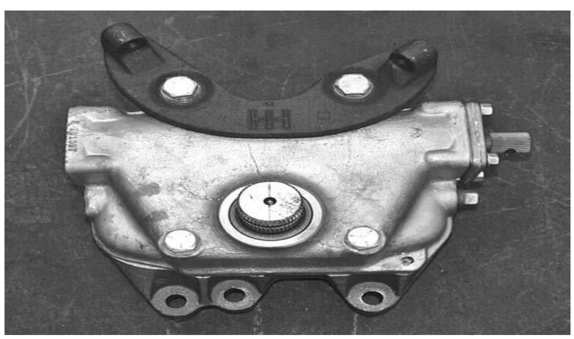


Figure 2:15 When the gear is centered, the sector shaft alignment mark is at a right angle to the input

3. Rotate the worm shaft with a torque wrench approximately 180 degrees through the center Position. Compare the torque reading with the manufacturer’s specification. If the sector shaft total mesh preload measurement is not within specifications, adjust the preload.

d) Full Mesh Preload Adjustment

1. If an adjustment is necessary, loosen the adjustment screw locknut

2. Center the steering gear.
3. Turn the slotted adjustment screw clockwise to increase the preload or counterclockwise to decrease the preload and then check the adjustment. Repeat until the preload is within specifications.
4. Hold the adjustment screw in place with a screwdriver while tightening the adjustment screw locknut to specifications.
5. Recheck the preload.
6. Fill the steering gear with lubricant, as follows:
   a. If not already done, remove the filler plug (and pressure relief fitting) from the steering gear housing. Thoroughly clean the plug.
   b. Add the recommended lubricant until it is within 1/2 inch of the filler hole.
   c. Install the filler plug (and pressure relief fitting) and tighten it to OEM specifications.
7. Center the steering wheel and reconnect the steering driveline and linkage.

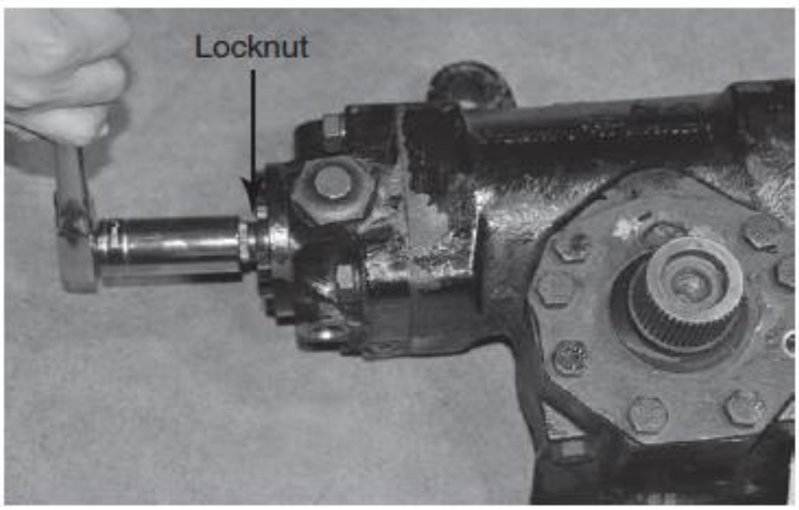


Figure 2:0-1: loosen the adjustment screw locknut

e) Adjust bearing preload

Worm bearing preload, also referred to as worm endplay, and is a measurement of how much force is required to turn the steering gear input shaft against the force, or preload**,** that the thrust bearings apply to the worm gear and shaft. Worm endplay, which is the distance the worm gear can move end-to-end between the thrust bearings, is directly related to preload. The higher the force the bearings push against the worm gear, the less endplay there is, and the more force it takes to turn the input shaft and worm gear. Worm bearing preload is adjusted by one of two methods: turning an adjustment nut or screw or installing selectively sized shims. Either adjustment method increases or decreases the worm endplay

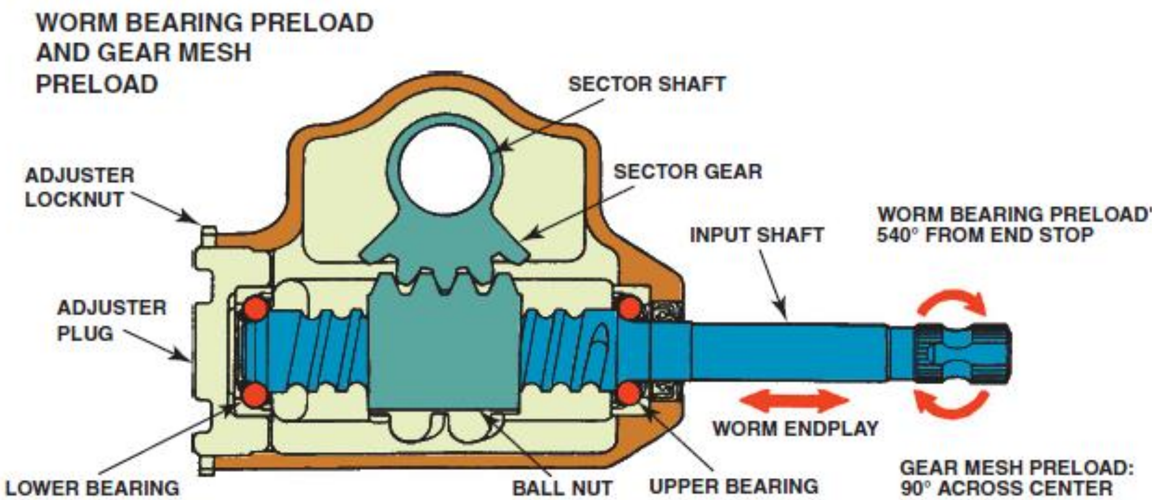


Figure 2:17 Worm Bearing Preload

Worm endplay is a linear measurement, made in fractions of inches or millimeters, of how far the worm gear and shaft can slide axially. Worm bearing preload is a measurement of how much force it takes to overcome bearing pressure in order to turn the input shaft. Preload is a torque, or turning force, measurement made in inch-pounds or Newton-meters. Because endplay and preload are related, one measurement affects the other.

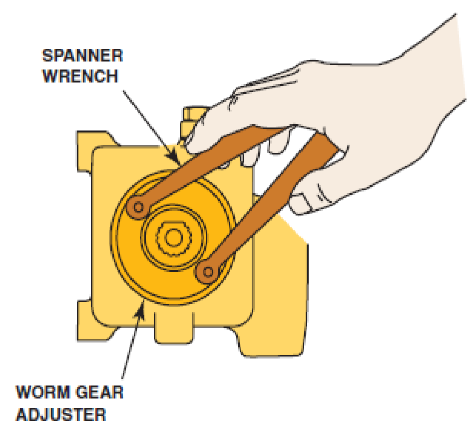
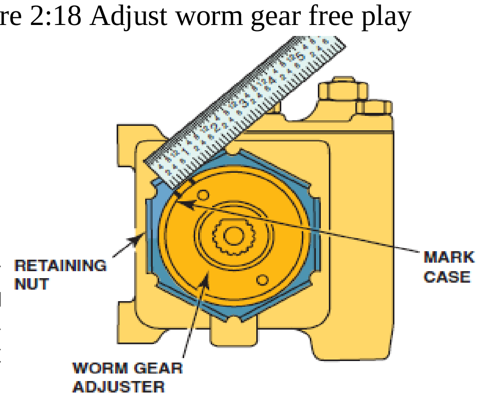


Figure 2:18 Adjust worm gear free play

When measuring and adjusting the worm bearing preload, a technician measures preload and adjusts



endplay. The endplay is correct when the preload measurement is correct.

Gear mesh preload is a measurement of how closely the teeth of the ball-nut gear and sector gear, or the worm gear and roller, fit together. Gear mesh preload is related to another measurement, called sector lash or gear lash.

Figure 2:19 Rotate the worm gear nut counterclockwise 1/2 inch, align the marks

Gear mesh preload is a measurement of how much turning force must be applied to the input shaft to overcome the resistance of the sector gear and move it. Gear mesh preload is usually measured in a 90-degree turn across the center of the input shaft movement.

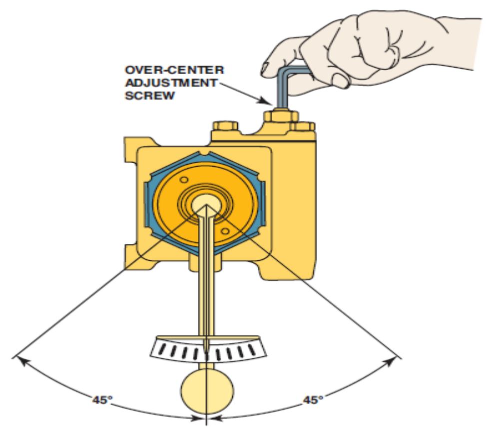


Figure 2:20: Performing an over center adjustment

General Motors calls this adjustment the over center adjustment. Gear mesh preload (over center adjustment) determines how sensitive the steering gear is to small steering wheel movements during straight-ahead driving. Insufficient preload contributes to steering wander.

Sector shaft endplay is a measurement of how much room the sector shaft has to slide axially. If provision is made to measure sector shaft endplay, the measurement is taken in fractions of inches or millimeters. Some steering gears provide an external adjusting method, but it is more common for sector shaft endplay to be adjusted by internal shims, if it is adjustable.

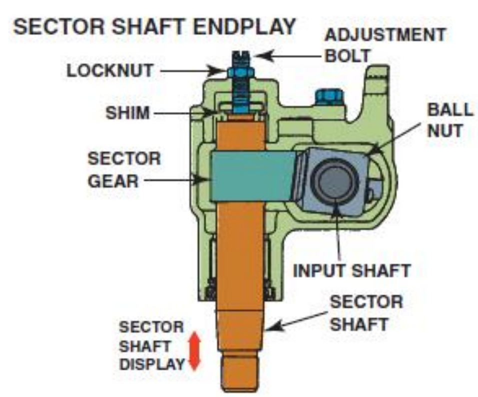


Figure 2:21 Sector shaft endplay

- **Rack-And-Pinion Steering Gears Adjustment**

Some rack-and-pinion steering gears can be adjusted. Pinion torque is a measurement of how much turning force is needed at the input shaft for the pinion to overcome the resistance of the rack and move it. The measurement gives an indication of how closely meshed the pinion teeth and the rack teeth are. Like gear mesh preload in a standard steering gear, pinion torque indicates steering system responsiveness. The adjustment method is to thread the rack support cover farther into the steering gear housing to reduce gear lash, or thread it out to increase gear lash.

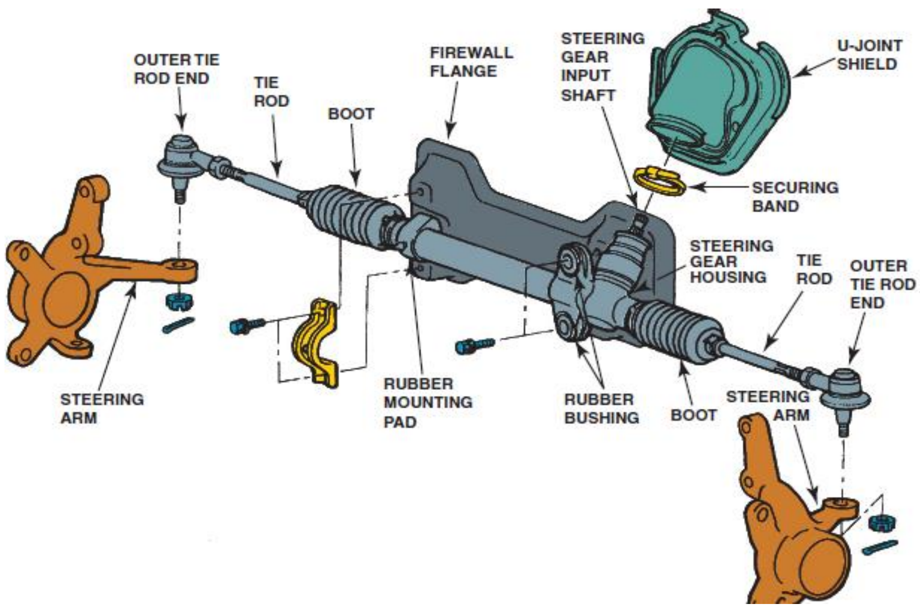


Figure 2:22 Manual rack-and-pinion steering gear mounts

Manufacturers specify an acceptable range of pinion torque in inch pounds or Newton-meters. Because the middle teeth on the rack wear before the teeth at either end, pinion torque should be checked across the whole stroke of the rack.

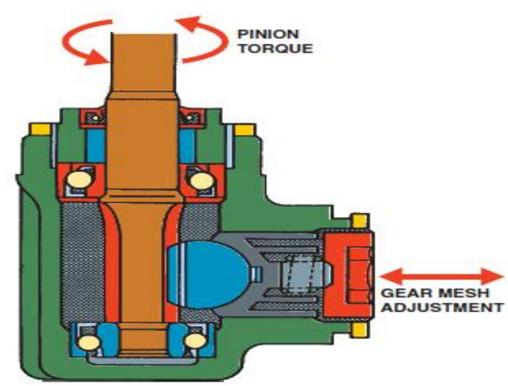
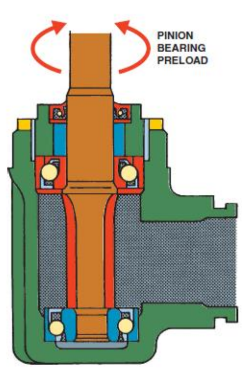


Figure 2:23 Tightening the rack support against the rack increases the pinion torque.



- **Bearing Preload Procedure**

Pinion bearing preload in a rack-and-pinion steering gear is the same concept as worm bearing preload in a standard steering gear. That is, it is a measurement of how much force is required to turn the steering gear input shaft against the force, or preload, that the bearings apply to the pinion gear and shaft.

Figure 2:24 Pinion bearing preload

2.4 Power steering system Service

2.4.1 Belt Tension Adjustment

The power steering belt should be checked for glazing (hard, shiny inner surface), cracking, fraying and proper alignment. The tension should be checked with a belt tension gauge and compared to specifications. Many serpentine belts use an automatic belt tensioner and do not require adjustment. V-belts and applications that do require adjustment may use either a screw-type adjustment or prying to set the proper tension.

On applications with a screw-type adjustment, make sure you have loosened all the required pivot and bracket fasteners to avoid stripping or bending the adjuster mechanism. If the tension is set by prying, loosen the fasteners, pry to the proper tension, and then tighten the slide bracket bolt. Use care when prying; do not pry against the reservoir or the side of the pump. Look for a 3/8ths or 1/2 inch square hole on the housing or a bracket. This hole is designed for a pull handle to be inserted for safe and easier prying.

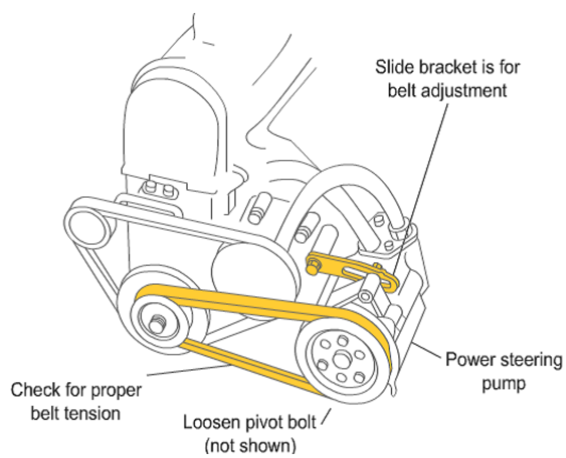


Figure 2:25 Belt Tension Adjustment

2.4.2 Steering fluid changing procedure

The power-steering fluid can be checked either hot or cold. Fluid level will vary with temperature, however, and a more accurate check is done when the engine is warm. The reservoir cap has a dipstick typically marked HOT and COLD on opposite sides of the dipstick.

Make sure to check the level on the right side of the dipstick. If necessary, add fluid to correct the level. Some manufacturers recommend a specific fluid for use in a power-steering system. However, most recommend a specific type of ATF. Always check the service information before installing fluid to the system.

Figure 2:26 Check the fluid level with the dipstick attached to the cap.

2.4.3 Hydraulic Tests

If a visual inspection of the vehicle suggests that the power steering system is at fault, check the hydraulic supply circuit first. Power steering gear performance is dependent on an adequate supply of oil pressure and oil flow through the circuit.

When diagnosing power steering problems, oil pressure and oil flow must meet the OEM specifications. Pressure and flow specifications vary considerably, so follow the vehicle manufacturer recommendations.

High system oil temperatures reduce the efficiency of the power steering pump and the steering gear. High temperatures are caused by restriction to flow or inadequate system oil capacity to allow for heat dissipation during normal operation. A supply pump that constantly operates at maximum pressure relief will also generate more heat than can be dissipated.

Various types of pressure gauges and flow meters are available and can be used to diagnose power steering problems. You can purchase a specialty power steering analyzer or use more crude, shop-made test components built into a manifold gauge set. The advantage of specialized power steering analysis equipment is speed and accuracy.

A pressure gauge that reads at least 3,000 psi and a flow meter with a capacity up to 10 gpm. should be used to check pressures and oil flow. A shutoff valve downstream from the pressure gauge makes it possible to isolate the steering pump from the steering gear and by closing the valve, maximum pump relief pressure can be read. A simple thermometer in the reservoir will indicate system oil temperatures.

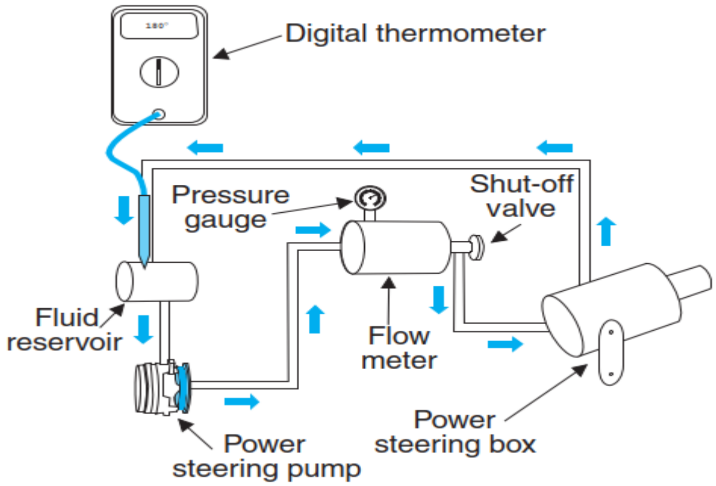


Figure 2:27 Equipment for testing hydraulic supply

The following procedure is general in nature, so make sure you consult the vehicle OEM service literature before actually performing it.

1. Make necessary gauge/meter connections.
2. Start the engine and check the system oil level, ensuring that oil flow is in the proper direction through the flow meter.
3. Place the thermometer in the reservoir.
4. Run the engine at the correct idle speed and steer from lock to lock several times to allow the system to warm up (60–70°C).
5. With the engine running at a specified idle speed, slowly turn the shutoff valve until closed and read the pressure at which the pressure relief valve opens. (Open the shutoff valve as quickly as possible to avoid heat buildup or possible damage to the steering pump.) This pressure reading should equal the maximum pump pressure specified by the chassis OEM. Check your specifications.
6. With the engine running at a specified idle speed, the vehicle stationary on the shop floor, and with a normal load on the front axle, steer the wheels from a full right to a full left turn and observe the flow meter. The flow should not fall below the minimum gpm flow specification.
7. Increase engine speed to approximately 1,500 rpm and note the flow rate with the steering wheel stationary. Check this reading against the maximum flow rate specifications. Excessive oil flow can cause high operating temperatures and sluggish or heavy steering response.
8. If the supply pump is performing to specification, install a 1/2-inch (12.5 mm) spacer between the axle stops on one side and turn the steering wheel to full lock in the direction necessary to

pinch the spacer block. Record the maximum pressure reading. The maximum pressure reading should be within 100 psi of that recorded in step 5 for pump relief pressure when the shutoff valve was closed.

3 Remove the spacer and repeat the test in the opposite direction. Record the pressure. If the pressure does not meet the recorded maximum pressure reading, the steering gear is worn internally and should be repaired or replaced.

9. Normal system back-pressure should be 50 to 75 psi (345 to 482 kPa.) with the engine idling and the steering wheel stationary. Back-pressure is checked with the system at a nor-mal operating temperature.
10. Steering system oil temperature is best checked after 2 hours of normal operation. The ideal operating temperature should range between 140°F and 160°F (60°C and 70°C). Normal operation in this range will al-low for intermittently higher temperatures that will be encountered during periods of heavy steering usage.
11. Visually check for the presence of air mixed with the oil in the steering system. The oil should be clear. Any signs of frothing indicate air entry, and steering performance will be affected. Carefully check for leakage on the suction side of the steering pump. Drain and refill the system and bleed for air.

2.4.4 Flushing the System

The reason for flushing the system should be obvious. Hydraulic fluid is easily contaminated by moisture and dirt. Flushing removes the old fluid with its contaminants and new fluid is added to the system. It is also wise to flush the system after you have replaced or repaired a part in the system. Before beginning to flush the system, you should disable the engine's ignition. Then disconnect the power steering return hose and plug the reservoir. Attach an extension hose between the power-steering return hose and an empty container. Raise the vehicle's front wheels off the ground. Fill the reservoir with the correct type of fluid.

Fluid is clear, fill the reservoir to its full mark and lower the vehicle. Disconnect the extension hose from the power steering return hose and reconnect the return hose to the reservoir. Check the fluid level again and add fluid as necessary. Now enable the ignition system. Start the engine and turn the steering wheel from stop to stop. If the power-steering system is noisy and bubbles are forming in the fluid, the system must be purged of air.

2.4.5 Flow and Pressure Test

We will test flow and pressure test in hydraulic assist steering gear system

1. Use a high-pressure washer or steam cleaner to thoroughly clean the area around the steering gear.

Figure 2:28 high-pressure washer or steam cleaner

2. Park the vehicle in a stall and ensure that the front wheels are tracking in the straight-ahead position. Fit a shop exhaust pipe to the truck exhaust stack.

Figure 2:29 Fit a shop exhaust pipe to the truck exhaust stack

3. Place a drain pan under the steering gear to catch power steering fluid spilled during this procedure.

Figure 2:30 Place a drain pan under the steering gear

4. Separate the high-pressure supply hose from the steering gear. Be aware that the fluid in this line may have some residual high pressure. Some fluid will drain from the system, so the drain pan should be placed directly under the steering gear.

Figure 2:31 fluid will drain from the system

5. Connect the power steering analyzer in series with the high pressure supply hose and the nipple on the inlet side of the steering gear. Now the system will function as normal except that the hydraulic fluid will be routed through the power steering analyzer.

Figure 2:33 connect the power steering analyzer in series

6. Start the engine. Run it at idle speed and record the pressure and flow readings on the power steering analyzer. Check to specifications.

Figure 0-2 Flow and Pressure Test photo sequence

Figure 2:34 connect the power steering analyzer in series

7. Next close down the flow valve until the pressure increases to the test value specified in the OEM service literature. This may be between 500 and over 1,000 psi, depending on the system. Record the flowing pm at this pressure value. If the flow is lower than specified, the power steering pump may be defective and require replacement.

Figure 2:35 close down the flow valve

8. Test the pump relief valve and flow control pressures by closing down the flow valve until the flow gauge reads zero. Record the peak pressure reading on the gauge. Perform this two or three times but for no longer than 5 seconds separated by a 30 second interval. Check the gauge pressure.

Figure 2:36 Test the pump relief valve and flow control pressures

9. Compare all test results to OEM specifications and perform repairs as required. Ensure that after the power steering analyzer is removed, the engine is run, and the steering turned from lock to lock and back to center before attempting to remove the truck. This will ensure that no air remains in the high-pressure circuit.

Figure 2:36 Test the pump relief valve and flow control pressures

2.4.6 Grease Fitting

Grease fittings are permanently installed by either a (taper) thread or straight push-fit ('hammer in') arrangement, leaving a nipple connection that a grease gun attaches to. The pressure supplied by the grease gun forces a small captive bearing ball in the fitting to move back against the force of its retaining spring. The arrangement is thus essentially a valve that opens under pressure to allow lubricant to pass through a channel and be forced into the voids of the bearing.

When the pressure ceases, the ball returns to its closed position. The ball excludes dirt and functions as a check valve to prevent grease escaping back out of the fitting. The ball is almost flush with the surface of the fitting so that it can be wiped clean to reduce the amount of debris carried with the grease into the bearing.

The common convex shape of the fitting allows the simple concave tip of the grease gun to seal against the fitting easily from many angles, yet with a sufficiently tight seal to force the pressured grease to move the ball and enter the fitting, rather than simply oozing past this temporary annular (ring-shaped) seal. For higher pressure greasing, the grease gun end latches onto the nipple and sealing is affected as a butt joint.

Figure 2:37 Grease fittings

2.5 Wheel Alignment

In its most basic form, a wheel alignment consists of adjusting the angles of the wheels so that they are perpendicular to the ground and parallel to each other. The purpose of these adjustments is maximum tire life and a vehicle that tracks straight and true when driving along a straight and level road.

We will cover various levels of detail with the deepest levels containing information that even a wheel alignment technician will find informative.

Wheel Alignment is often confused with Wheel Balancing. The two really have nothing to do with each other except for the fact that they affect ride and handling. If a wheel is out of balance, it will cause a vibration at highway speeds that can be felt in the steering wheel and/or the seat. If the alignment is out, it can cause excessive tire wear and steering or tracking problems If you know anything about wheel alignment, you've probably heard the terms.

2.5.1 Camber

Camber is the angle of the wheel, measured in degrees, when viewed from the front of the vehicle. If the top of the wheel is leaning out from the center of the car, then the camber is positive, if it's leaning in, then the camber is negative. If the camber is out of adjustment, it will cause tire wear on one side of the tire's tread. If the camber is too far negative, for instance, then the tire will wear on the inside of the tread.

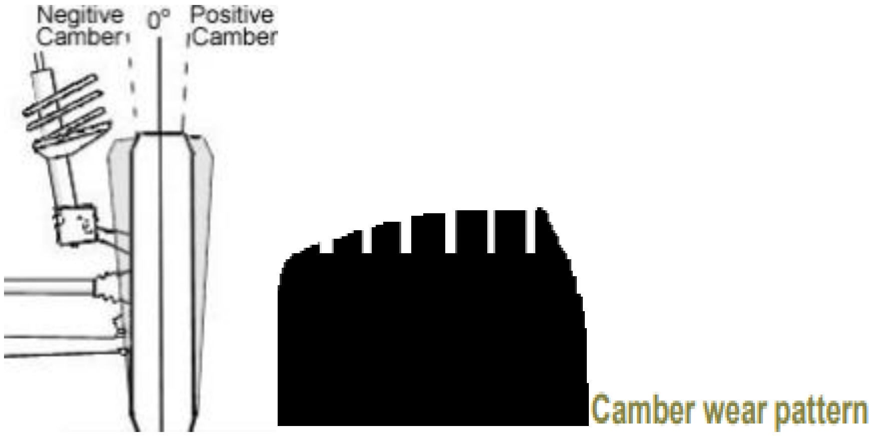


Figure 2:38 camber and their wear pattern

If the camber is different from side to side it can cause a pulling problem. The vehicle will pull to the side with the more positive camber. On many front-wheel-drive vehicles, camber is not adjustable. If the camber is out on these cars, it indicates that something is worn or bent, possibly from an accident and must be repaired or replaced.

2.5.2 Caster and Toe-in

When you turn the steering wheel, the front wheels respond by turning on a pivot attached to the suspension system. Caster is the angle of this steering pivot, measured in degrees, when viewed from the side of the vehicle. If the top of the pivot is leaning toward the rear of the car, then the caster is positive, if it is leaning toward the front, it is negative. If the caster is out of adjustment, it can cause problems in straight line tracking. If the caster is different from side to side, the vehicle will pull to the side with the less positive caster.

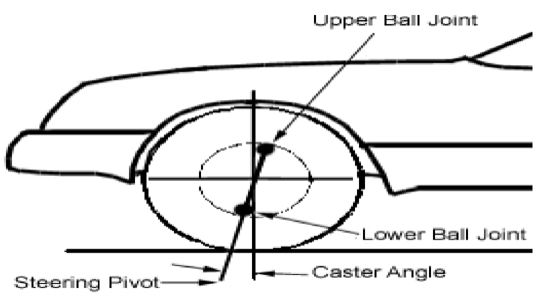


Figure 2:39 Caster

2.5.3 Caster and Toe-in

If the caster is equal but too negative, the steering will be light and the vehicle will wander and be difficult to keep in a straight line. If the caster is equal but too positive, the steering will be heavy and the steering wheel may kick when you hit a bump. Caster has little affect on tire wear.

The best way to visualize caster is to picture a shopping cart caster. The pivot of this type of caster, while not at an angle, intersects the ground ahead of the wheel contact patch. When the wheel is behind the pivot at the point where it contacts the ground, it is in positive caster. Picture yourself trying to push the cart and keep the wheel ahead of the pivot. The wheel will continually try to turn from straight ahead. That is what happens when a car has the caster set too far negative. Like camber, on many front wheel-drive vehicles, caster is not adjustable. If the caster is out on these cars, it indicates that something is worn or bent, possibly from an accident, and must be repaired or replaced.

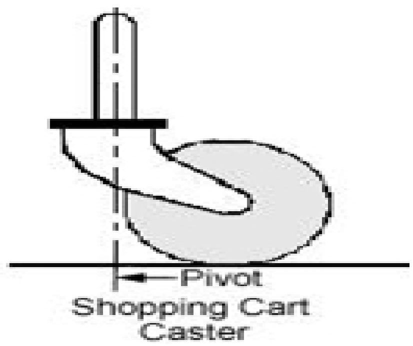


Figure 2:40 shopping cart Caster

2.5.4 Caster and Toe-in

The toe measurement is the difference in the distance between the front of the tires and the back of the tires. It is measured in fractions of an inch in the US and is usually set close to zero which means that the wheels are parallel with each other. Toe-in means that the fronts of the tires are closer to each other than the rears. Toe-out is just the opposite. An incorrect toe- in will cause rapid tire wear to both tires equally. This type of tire wear is called a saw-tooth wear pattern as shown in this illustration.

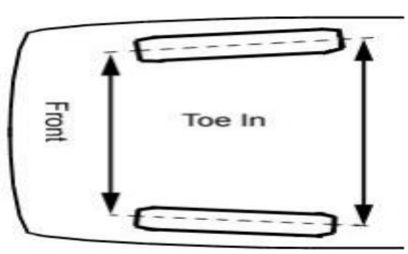


Figure 2:41 Toe-in

If the sharp edges of the tread sections are pointing to the center of the car, then there is too much toe-in. If they are pointed to the outside of the car then there is too much toe-out. Toe is always adjustable on the front wheels and on some cars, is also adjustable for the rear wheels.

2.5.5 Steering Axis Inclination (SAI)

SAI is the measurement in degrees of the steering pivot line when viewed from the front of the vehicle. This angle, when added to the camber to form the included angle (see below) causes the vehicle to lift slightly when you turn the wheel away from a straight ahead position. This action uses the weight of the vehicle to cause the steering wheel to return to the center when you let go of it after making a turn. Because of this, if the SAI is different from side to side, it will cause a pull at very slow speeds. Most alignment machines have a way to measure SAI; however it is not separately adjustable. The most likely cause for SAI being out is bent parts which must be replaced to correct the condition. SAI is also referred to as KPI (King Pin Inclination) on trucks and old cars with king pins instead of ball joints.

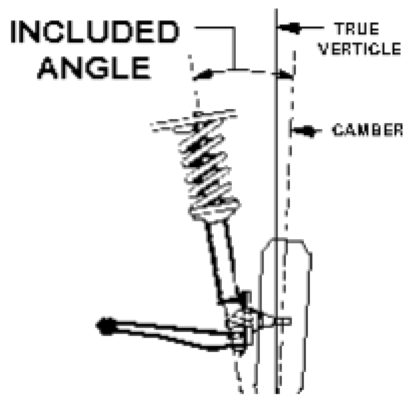


Figure 2:42 Steering Axis Inclination (SAI)

2.5.6 Riding Height

Riding height is measured, usually in inches, from the rocker panel to the ground. Good wheel alignment charts provide specs, but the main thing is that the measurements should be within one inch from side to side and front to rear. Riding height is not adjustable except on vehicles with torsion bar type springs. The best way to fix this problem is to replace the springs (Note: springs should only be replaced in matched pairs). Changes in riding height will affect camber and toe so if springs are replaced or torsion bars are adjusted, then the wheel alignment must be checked to avoid the possibility of tire wear. It is important to note that the only symptom of weak coil springs is a sag in the riding height. If the riding height is good, then the springs are good.

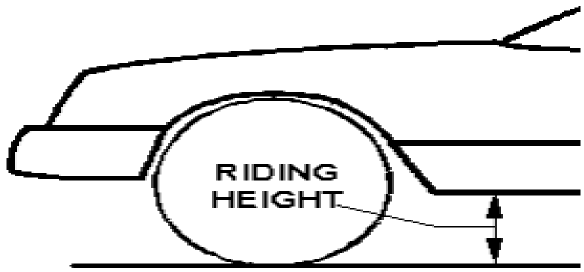


Figure 2:43 Riding Height

2.5.7 Set Back

Set back is when one front wheel is set further back than the other wheel. With alignment equipment that measures toe by using only the front instruments, any setback will cause an uncentered steering wheel. Any good 4-wheel aligner will reference the rear wheels when setting toe in order to eliminate this problem. Some good alignment equipment will measure set back and give you a reading in inches or millimeters. A set back of less than 1/4 inch is considered normal tolerance by some manufacturers. More than that and there is a good chance that something is bent.

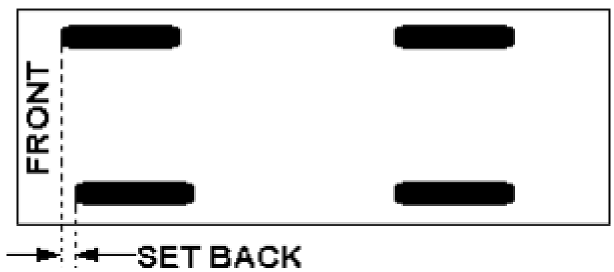


Figure 2:44 Set Back

2.5.8 Thrust Angle

Thrust angle is the direction that the rear wheels are pointing in relation to the center line of the vehicle. If the thrust angle is not zero, then the vehicle will "dog track" and the steering wheel will not be centered. The best solution is to first adjust the rear toe to the center line and then adjust the front toe. This is normally done during a 4-wheel alignment as long as the rear toe is adjustable. If the rear is not adjustable, then the front toe must be set to compensate for the thrust angle, allowing the steering to be centered.

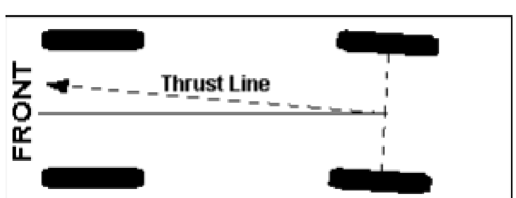


Figure 2:45 Thrust Angle

2.5.9 Steering Center

Steering center is simply the fact that the steering wheel is centered when the vehicle is traveling down a straight and level road. A crooked steering wheel is usually the most common complaint that a customer has after a wheel alignment is performed. Assuming that the steering wheel stays in the same position when you let go of the wheel (in other words, the car is not pulling), then steering center is controlled by the front and rear toe settings. When setting steering center, the rear toe should be set first bringing the Thrust Angle as close to the vehicle centerline as possible. Then the steering wheel is locked in a straight ahead position while the front toe is set. Before locking the steering wheel, the engine should be started and the wheel should be turned right and left a couple of times to take any stress off the power steering valve. After setting the toe, the engine should be started again to be sure that the steering valve wasn't loaded again due to the tie rod adjustments. Of course, you should always road test the vehicle after every alignment as a quality control check.

Another problem with steering center has to do with the type of roads that are driven on. Most roads are crowned to allow for water drainage, and unless you drive in England, Japan or another country where they drive on the wrong (sorry) left side of the road, you usually drive on the right side of the crown. This may cause the vehicle to drift to the right so that the steering wheel will appear to be off-center to the left on a straight road. The best way to compensate for this is as follows:

- If there is a difference in caster, it should be that the left wheel is more negative than the right wheel, but not more than 1/2 degree. Check the specs for any specific recommendations on side-to-side differences.
- If there is a difference in camber, then the left wheel should be more positive than the right wheel. Check the specs to see what the allowable difference is.

2.5.10 Toe Out on Turns

When you steer a car through a turn, the outside front wheel has to navigate a wider arc then the inside wheel. For this reason, the inside front wheel must steer at a sharper angle than the outside wheel. Toe-out on turns is measured by the turning angle gauges (turn plates) that are a part of every wheel alignment machine. The readings are either directly on the turn plate or they are measured electronically and displayed on the screen. Wheel alignment specifications will usually provide the measurements for toe-out on turns. They will give an angle for the inside wheel and the outside wheel such as 20 for the inside wheel and 18 for the outside wheel. Make sure that the readings are at zero on each side when the wheels are straight ahead, then turn the steering wheel so that the inside wheel is at the inside spec. then check the outside wheel.

The toe-out angles are accomplished by the angle of the steering arm. This arm allows the inside wheel to turn sharper than the outside wheel. The steering arm is either part of the steering knuckle or part of the ball joint and is not adjustable. If there is a problem with the toe-out, it is due to a bent steering arm that must be replaced.

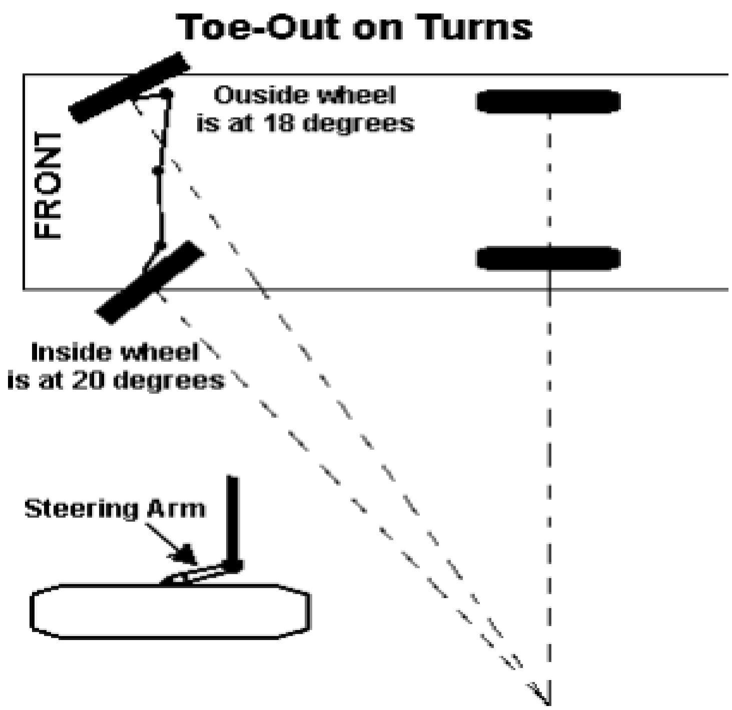


Figure 2:46 Toe Out on Turns

Self-check

Instruction 1: Select the best answer

Part-I: Multiple Choice

1. In a rack and pinion steering system, what protects the rack from contamination?
   a. The inner tie-rod socket b. The outer tie-rod socket
   c. Grommets d. The bellows boot
2. The main job of the idler arm is to ___.
   a. support the left side of the center link b. support the right side of the center link
   c. support the Pitman arm d. keep both ends of the steering system level
3. Which of the following is true of electric power steering systems?
   a. The power assist motor can be integrated with the rack gear.
   b. The assist motor may be located in the steering column.
   c. The assist motor may drive the pinon gear. d. All of the above.
4. Rack and pinion steering ___.
   a. is lighter in weight and has fewer components than parallelogram steering
   b. does not provide as much feel for the road as parallelogram steering
   c. does not use tie-rods in the same fashion as parallelogram steering
   d. all of the above
5. If an electrical defect occurs in the electronic power-steering (EPS) system, ___.
   a. the system continues to operate normally, but the EPS warning light is illuminated
   b. the system continues to operate with a slightly reduced power-steering assist
   c. manual steering remains but there will not be any power assist
   d. the EPS control unit locks the armature in the steering gear to prevent armature and screw shaft damage.

Part-II Give Short Answer for The Following Questions

1. Describe how a rack and pinion steering, a parallelogram steering, and a worm and roller system operate.
2. A power-steering hose transmits fluid under pressure from the ___ to the ___ ___ ___.
3. Describe the operation of a power assisted recirculating ball gearbox.
4. Define the term gearbox ratio.
5. What are the benefits of four-wheel steering systems?

Unit Three: Inspection and Repair of Suspension Systems

This unit is developed to provide you the necessary information regarding the following content coverage and topics:

- Inspection Suspension Systems
- Servicing Suspension Systems

This unit will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Performing Suspension Systems Inspection
- Performing Suspension Systems Servicing

3.1 Suspension Systems Inspection

The purpose of an inspection is to determine the cause for the vehicle owner's complaint and to determine what steps will be needed to cure the complaint. It is a god practice to note any other parts that show signs of failing in the near future so the customer ca be aware of them. The suspension should operate for many miles and a year or so until the next time it is inspected; the average motorist does not check suspension components very frequently (Figure LO1.1a).

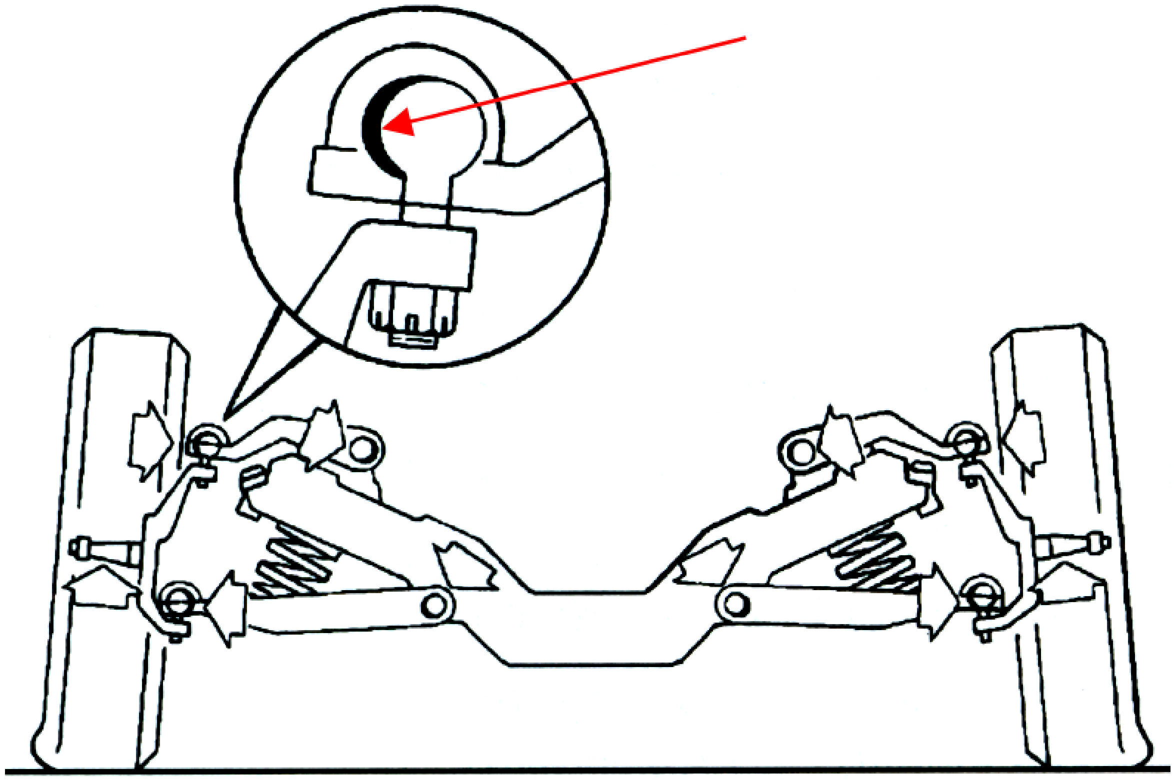


Figure 3: 1 Suspension system Inspection Point

As the suspension parts wear, they allow the alignment of the front tires to chance and permit uncontrolled, sloppy tire movement.

Safety Tip: A suspension, steering, or brake failure can place the car and its passengers in a highly dangerous situation. While making an inspection, this fact is in the forefront of the front-technician's mind. Any item that might fail in the near future and cause an accident is noted and brought to the car owner's attention.

Sometimes an inspection will determine that a simple adjustment or realignment is all that is needed to correct the situation; often a worn bushing or ball joint will show up. Worn parts must be replaced before an alignment can be done. It does no good to do a wheel alignment if the suspension parts are sloppy. In most cases on an older car, when realignment is necessary, that need is probably caused by worn parts or sagged springs. Remember tat the rear wheels also have a suspension system and that their parts also wear out. Rear suspension bushings and pivots are checked in the same manner as those at the front.

As an inspection is being performed, it is a good practice to follow a set procedure to ensure that portions of the suspension and steering systems are not skipped or forgotten. When checking a modern car, another good practice is to note the instrument panel lights as you start the engine. They will indicate if the car has ABS or an airbag and if these systems are operating properly.

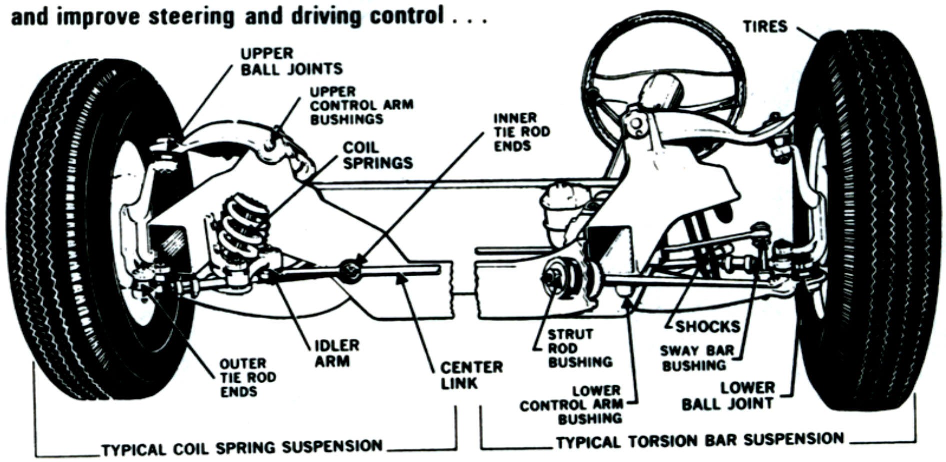
A suspension and steering system inspection should include checks of the:

1. Steering wheel for excessive steering looseness or binding.
2. Tires for correct inflation.
3. Tires for wear pattern to give an indication of incorrect alignment, balance, or worn parts, and also for physical defects that might cause failure.
4. Vehicle for correct height and attitude.
5. Vehicle for optional springs, shock absorbers, or overload devices that might change the ride quality or alignment.
6. Tire spinning (by hand) for tire runout and wheel bearing condition.
7. Tire and wheel shake (top and bottom) for wheel bearing looseness.
8. Tire and wheel shake (side to side) for steering component looseness.
9. Ball joints for excessive looseness, boot condition, and binding.
10. Control arm bushings and end links for wear or deterioration.
11. Strut rod bushings for wear deterioration.
12. Stabilizer bar bushings and end links for wear or deterioration.
13. Springs for loose or broken parts.
14. Shock absorbers or strut for leakage, loose or broken mounts or broken parts.
15. Tie rods for looseness or torn boots.

Many technicians follow an inspection checklist (Fig LO1-1b). The checklist helps ensure that none of the checks is missed or forgotten, and it allows a more professional discussion with the car owner. An inspection of the springs and the shock absorbers often begins with a customer complaint of noise, tire wear low vehicle (one end, one side or all over, excessive vehicle leaning on turns, or front end dive under braking. Any of these complaints might indicate weak or broken springs or shock absorbers.

MOOG

Moog problem solving parts help hold alignment, increase tire life, and improve steering and driving control . . .



YOUR CAR DESERVES A

WHEEL TO WHEEL SECURITY CHECK

Owner ____________ Date ____________ Phone ____________

Make ____________ Model ____________ Year ____________

Mileage ____________ License Number ____________ Engine Size ____________

PARTS DESCRIPTION	OK	COMMENTS	PARTS	LABOR
SPRINGS				
CONTROL ARM BUSHINGS				
POWER STEERING				
LOWER BALL JOINT				
UPPER BALL JOINT				
WHEEL BRGS.				
BALANCE				
TIRES				
TIE ROD ENDS				
IDLER ARM				
PITMAN ARM				
CENTER LINK				
SWAY BAR BUSHINGS				
STRUT ROD BUSHINGS				
SHOCK ABSORBERS				
ALIGNMENT				
REMOVED PARTS REQUESTED	YES / NO	SUB TOTAL		

CAR HEIGHT			
	Left	Right	Specs.
FRONT			
REAR			
BALL JOINT READINGS			
Load Carrier	Left	Right	Specs.
AXIAL			
RADIAL			
ALIGNMENT			
	Left	Right	Specs.
CAMBER			
CASTER			
TOE			

REMARKS:

TOTAL ____________

Inspector
FORM 2000C • Litho in U S A

Figure 3: 2 many technicians follow a checklist like this to ensure that they do not skip any checks and also to give the car owner a record of what was found during the inspection

3.2 Servicing suspension system

3.2.1 Check Ball Joints

Ball joint boots are checked visually ; the area behind the boot and ball joint where you cannot see can be checked by running your finger around the boot and feeling for problems Look or feel for grease outside of the boot, which indicates breaks or tears. If the boot is torn, the ball joint will probably fail, if it has not already, and should be replaced (Fig. 5). While checking the boot, squeeze it to ensure that there is grease inside of the boot. An empty boot indicates a need for lubrication.

Lubrication requirements for a ball joint vary among manufacturers. The lubrication intervals for modern joints are rather long; one manufacturer, for example, requires lubrication every 3 years or 30,000 miles (48000 Km). Long interval such as this makes it easy for the average motorist to forget about lubricating ball joints completely. Low friction ball joints are permanently sealed and require no further lubrication.

Checking a Wear Indicator Ball Joint for Excess Clearance

To check a wear indicator ball joint for excessive clearance, you should:

1. Park the car on a level surface. Depending on the suspension type and where the spring is located, a ball joint is either (A) a load-carrying or (B) a friction-loaded type that allows access to the lower control arms and ball joints. The ramps of an alignment rack are ideal. The weight of the car should remain on the tires.
2. Wipe off any grease or dirt on the checking surface or the lower face of the ball joint.
3. On some styles, slide a plain flat screwdriver or other flat, metal object about ¼-1/2 in. 6-12 mm) wide across the bottom surface of the

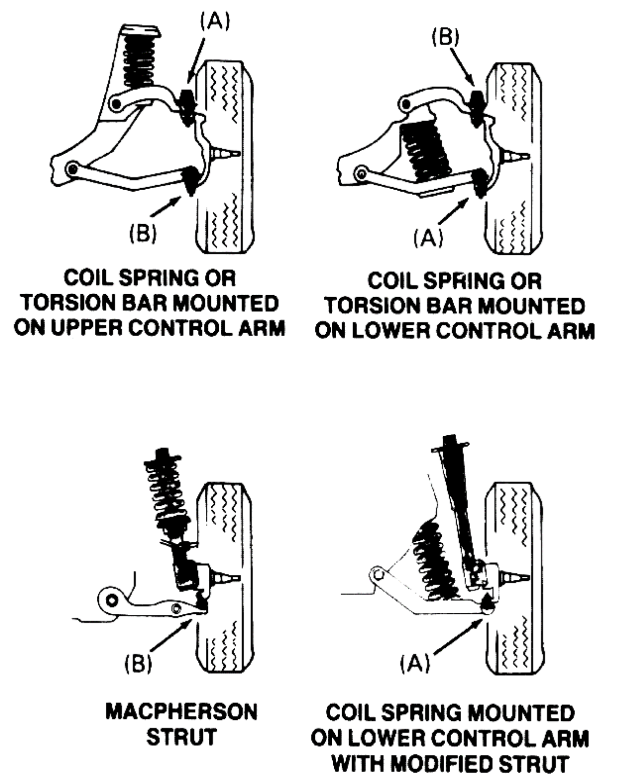


Figure 3:3 Depending on the suspension type and where the spring is located, a ball joint is either (A) a load-carrying or (B) a friction-loaded type.

ball joint; it should bump into the checking surface. If the checking surface has moved up into the ball joint, the ball joint is excessively loose and should be replaced.

On some styles, grip the grease fitting with your fingers and try to rotate it; if the grease fitting can be rotated, the ball joint is excessively loose and should be replaced.

Figure 3: 4 A cut or torn ball joint boot will let the grease escape and allow dirt and water to enter the joint; if the joint is not already worn out, it will soon fail

4. Checking a Load-Carrying Ball Joint on a Lower Control Arm for Excessive Clearance

When the vehicle load passes from the spring and through the lower control arm to the steering knuckle, the lower ball joint is the load-carrying ball joint.

This is true in cases where either a torsion bar, coil spring or air spring is attached to the lower control arm. This load squeezes a compression loaded ball joint tightly between the control arm and the steering knuckle or tries to pull a tension loaded joint apart.

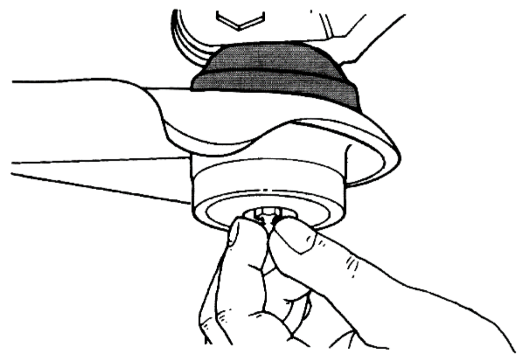


Figure 3: 5 If the grease fitting can be easily rotated on some ball joints, the joint is worn out and should be replaced.

The ball joint must be unloaded to measure the amount of clearance in the ball joint. This is usually accomplished by lifting the car by the lower control arm so the spring s compressed. If the car was lifted by the frame, the spring would push the lower control arm downward until the rebound/extension bump stop contacted the upper control arm. In this position the spring pressure holds both ball joints tightly. The ball joints appear to have zero clearance.

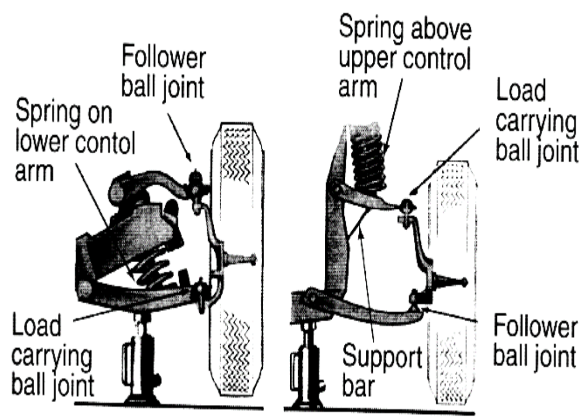


Figure 3: 6 when checking the clearance of a load carrying ball joint, the load of the vehicle must be removed from the ball joint using a jack placed in the correct location depending on whether the load-carrying joint is the lower or upper one.

3.2.2 Check Control Arm Bushings

Worn suspension bushing allows the control arm to move inward and outward or forward and backward as well as up and down. This results in an alignment change of the tires which in turn, will cause tire wear and handling difficulties. This looseness often causes suspension noises, usually “clunks” when driving over rough roads or when the brakes are applied. Faulty rubber control arm bushings can usually be seen during a visual inspection. In locations where the bushings are difficult to see, faulty bushings are identified by excessive control arm motion through either an in-and-out or a sideways direction.

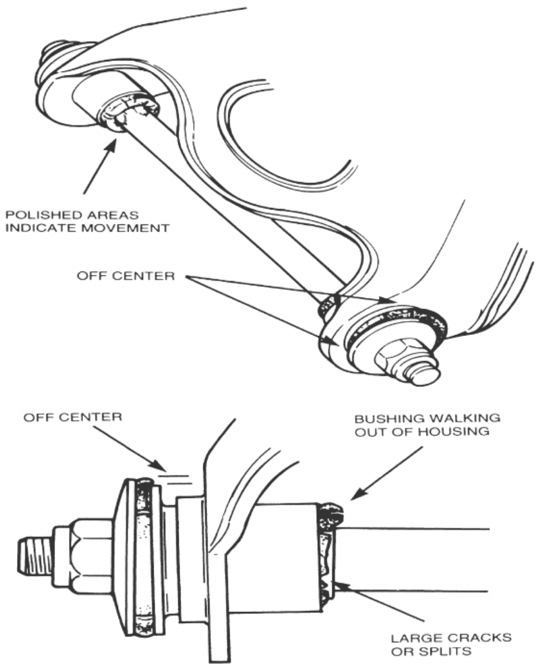


Figure 3: 7 These faults indicate control arm bushings that need replacement.

To check rubber control arm bushings, you should:

1. If possible, check the upper control arm bushings from under the hood. Use a light so you can get a good look at the rubber parts of the bushing. Ignore small, light cracks as long as the rubber is still solid and resilient. Look for heavy cracks, rubber material breaking out, or rubber distortion, which allows the control arm to change position. The pivot bolt should be centered in the bushing. Bushings that are distorted, breaking up, or getting ready to break up should be replaced.
2. Raise and support the car on a hoist or jack stands.
3. Visually check the bushings on the lower control arm, looking for the same sort of problems Also, check the sides of the control arm and the frame metal next to it for signs of metal contact, which indicate bushing failure.

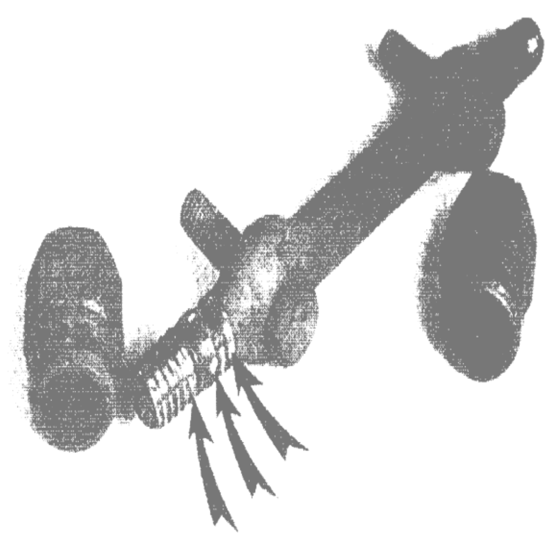


Figure 3:8 A badly worn metal control arm bushing and shaft. Note the worn, shiny areas on the control arm shaft

4. Swing the tire rapidly back and forth while forcing it to bump at the steering stops; also, force the tire in and out. While doing this, watch the control arm for any motions that would indicate bushing failure.
5. On single lower control arms, try prying the inner end of the control arm sideways using a pry bar or large screwdriver. A slight motion is acceptable; larger motions indicate weak bushings.

To check metal control arm bushings, you should:

1. Bounce the suspension while listening for squeaks or other bushing related abnormal noises. If possible, place our finger lightly on the bushing while bouncing the front end; a noisy bushing will often have a rough, harsh feel. Noisy bushings can sometimes be cured by greasing them, but if they have squeaked for very long, they are probably worn and should be replaced
2. Raise and support the car on a hoist or a jack stands.
3. Swing the tire back and forth rapidly, so the turning stops strikes rather hard, and watch the control arm bushings. A very slight amount of side motion is acceptable, but a definite motion or jumping of the control arm on the shaft indicates faulty bushing.

3.2.3 Check Strut Rod Bushings

Strut rod bushings are rubber bushings that are compressed tightly against each side of an opening in the frame bracket. If they become weak, the outer end of the lower control arm will have an excessive amount of travel in a forward and backward direction.

Strut rod bushing failure is often indicated by a "thump" or "clunk" as the brakes are applied. These bushings are checked visually.

To check strut rod bushings, you should:

1. Raise and support the car on a hoist or jack stands.
2. Grip the bushing end of the strut rod and shake it up and down; any free play indicates a faulty bushing.

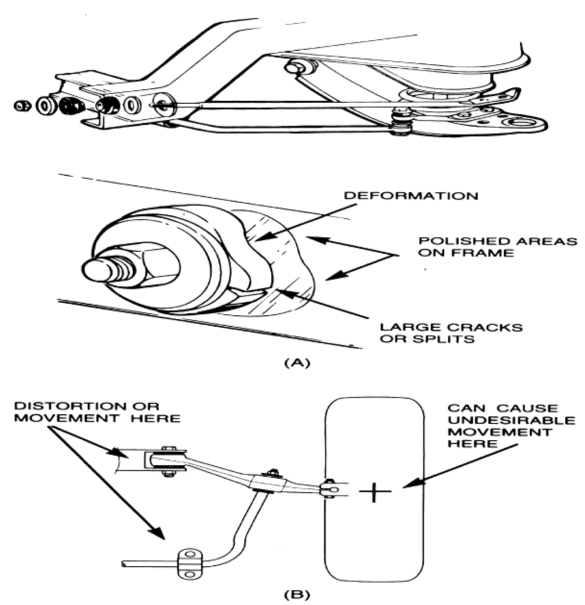


Figure 3: 9 Faulty strut rod bushing (A) allows the outer end of the lower control arm to move forward or rearward (B).

Inspect the bushing for hard cracks, rubber breaking, and severe distortion of the rubber; also check for signs of contact between the metal backup washer and the bushing bracket. Any of these indicate a faulty bushing.

3.2.4 Leaf Spring Servicing

Leaf spring suspensions tend to be low maintenance over the lifetime of the vehicle. The U-bolts should be tightened on a PM Service along with lubricating pin bushings and visually inspecting the spring clearance. On new trucks and trailers, it is good practice to re-torque U-bolt nuts after the first month or 1,000 miles of operation.

Thereafter, tightening of U-bolts should be built into a PM schedule C type service occurring typically between 35,000 and 50,000 line haul miles, or every 6 months, depending on the application. If the vehicle is operated in an environment with a lot of corrosion re-torqueing cannot be accurately per-formed. In this case, tap the U-bolt with a hammer and look for any signs of movement. This should give you a good indication if it has lost its tension.

If spring pins fail to take grease, the first thing you should do is jack up the frame removing the weight from the spring and try again. If this does not work, try using a hand grease gun with the weight off the spring. A hand grease gun develops more pressure than an air-actuated grease gun. If this fails, you can try heat using a rosebud (make sure the bracket/shackle is not made out of aluminum alloy). But when you spend extra time properly lubing a spring pin, remind yourself that without grease, the pin/bushing will fail if not lubricated. It is only a question of when the failure will occur.

Inspect spring ends to ensure that they have not shifted and come into contact with the sides of equalizer or hanger brackets. Inspect spring hangers for cracks. Spring end contact indicates that the spring assemblies are not seated on the axle housing or there is a need for suspension alignment. Check U-bolt seats, U-bolts, and spring assembled for integrity.

a) Leaf Spring Replacement

The exact replacement procedures will differ somewhat for each type of leaf spring assembly, but the basics remain similar. The following is a general outline of spring pack replacement.

b) Remove the Spring Pack

1. Chock the tires, place a floor jack under the truck frame, and raise the truck sufficiently to relieve the weight from the spring to be removed. Then place safety stands under the frame.
2. Remove shock absorbers where used.
3. Remove U-bolts, spring bumper, and retainer or U-bolt seat.
4. Remove the lubricators or zerk fittings (not used on springs equipped with rubber bushings).
5. Remove the nuts from the spring shackle pins or bracket pins.

6.Slide the spring off the bracket pin and shackle pin and remove from chassis.

c) Install a Spring Pack

Although the actual installation procedures will vary with each spring type, the pivot end of the spring is usually fastened to the frame bracket first. The shackle or slipper end then can be fastened by aligning it to the other frame bracket. When installing the U-bolts or spring clips to secure the axles, do not final torque until the springs have been placed under normal load. This requires lowering the chassis weight onto the spring.

d) Maintenance

U-bolts that loosen in service place undue strain on the spring center bolt. OEMs state that center bolts should be re-torqued at specified intervals but this is seldom done. If you are torqueing center bolts on a spring not clamped by U-bolts, remember that they are under considerable tension should the center bolt fail.

Loose spring clips or U-bolts can result in axle misalignment, which adversely affects tire wear. When torqueing U-bolt nuts, follow the recommended tightening sequence after lubricating the U-bolt threads with a little lubricant. The lubricant helps ensure the specified clamping pressure of the spring pack.

To correctly torque U-bolt nuts, first tighten all the nuts until they are snug. Next, tighten the nuts until approximately one-third of the recommended torque is achieved. Repeat tightening of the nuts, using the same sequence and gradually increasing the torque through a second, third, and fourth stage, until the recommended final torque is attained.

3.2.5 Shock Absorber Servicing

A. Replacing a shock absorber

The task of replacing a shock absorber is straight-forward and one that a new technician should be able to accomplish as follows:

1. Remove the nuts from the top and bottom bolts/studs from the eyes of the shock absorber.
2. Remove the shock absorber from the vehicle.
3. Insert new rubber bushing into the eyes of the new shock absorber.
4. Install the top bolt/stud through the top mounting bracket on the frame rail.
5. Place a flat washer over the bolt and thread the bolt into the upper rubber bushings of the new shock absorber.
6. Place a second flat washer over the bolt and then turn the nut finger tight.

7. Extend the lower part of the shock absorber until the mounting holes line up in the lower brackets and shock absorber eye.
8. Install the bottom bolt/stud through the lower mounting bracket on the axle.
9. Place a flat washer over the bolt and thread the bolt into the lower rubber bushing of the new shock absorber.
10. Place a second flat washer over the bolt and turn the nut finger tight.
11. Check to make sure that the rubber bushings are seated properly and tighten the nuts to the specified torque.

3.2.6 Equalizing Beams Servicing

Power wash the suspension and inspect the components for cracks or damage. Inspect rubber bushings for damage or deterioration and plan to replace them if they show any indications of fatigue.

A. Equalizing Beam Bushings

Special service tools facilitate replacement of equalizing beam bushings. It is recommended that you use them if available. The bushings can be removed with standard shop tools but it can be a tough job. If a portable press is available, this can be used in conjunction with steel pipe sections with diameters equivalent to the bushing sleeves as drivers for both removal and installation.

B. Equalizing Beam Overhaul

Make a thorough inspection before you start disassembling the suspension to ensure that you have replacement parts in place before undertaking the work.

The following procedure describes a general approach to reconditioning an equalizing beam suspension.

C. Preparation for Overhaul

1. Block the wheels on both axles of the truck.
2. Remove the drive axle shafts from both rear axles.
3. Remove the four saddle caps that lock the center bushing of the equalizer beams to the saddle assemblies.
4. Disconnect the torque rods from the axle housing by loosening the locknuts and driving the shaft from the bushing and axle housing bracket.
5. Using an overhead hoist (A-frame works best), raise the truck frame sufficiently so that the lower part of the saddle clears the top of the axle housings. Support the frame securely. Block the axles to prevent them from pivoting on the wheels.

6. Roll axles, with the beams attached, out from under the truck.

D. Overhaul Procedure

The replacement procedure outlined here primarily references bolt-type beam ends.

1. Disconnect the equalizer beam from the axle housing
2. Separate the equalizer beams from the cross tube.
3. After both equalizer beams have been separated from the axles, separate the beams from the cross tube by pulling them apart by hand.
4. Remove the saddle assemblies, springs, or cushions. Reference the leaf spring-type equalizer beam.

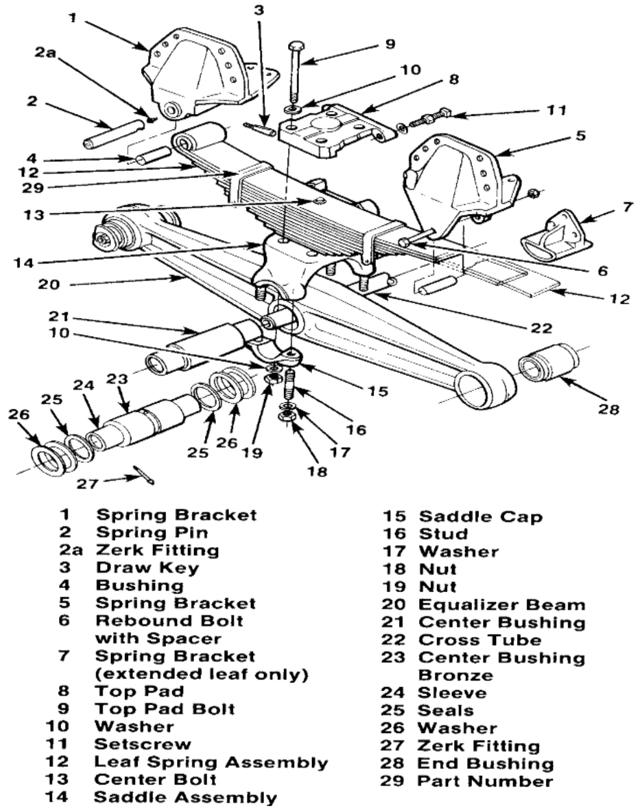


Figure 3: 10 Leaf Spring-Type, Equalizer Beam Suspension

a. Support the spring and saddle assembly on a floor jack and safety stand. Loosen the spring-aligning setscrew. Remove the spring top pad saddle bolts and nuts. Remove the top pad. Lower the floor jack and remove the saddle.

b. Remove the spring assembly by repositioning the floor jack under the spring. Loosen the locknut on the spring pin draw key

c. Back off the nut sufficiently to protect the draw key threads and then strike the nut with a soft hammer to loosen the draw key. Remove the draw key and drive the spring pin out of the spring and spring bracket. Lower the spring assembly from the frame and remove it from the jack.

3.2.7 Air Suspensions Servicing

Air suspension systems tend to require a little more attention in inspection and preventive maintenance schedules than mechanical suspensions. Some of the commonly required service procedures are outlined in this section, including repairs and height control valve adjustment.

A. Ride Height Control Servicing

a) Checking a Ride Height Control Valve

Ride height control valves (also known as leveling valves) are too often improperly diagnosed as defective and unnecessarily replaced. A simple diagnostic routine can determine whether the valve is defective or whether proper adjustment has not been performed.

b) Ride Height Adjustment

Some versions of height control valves have a centering pin and bosses. The pin is positioned in the bosses after setting the height.

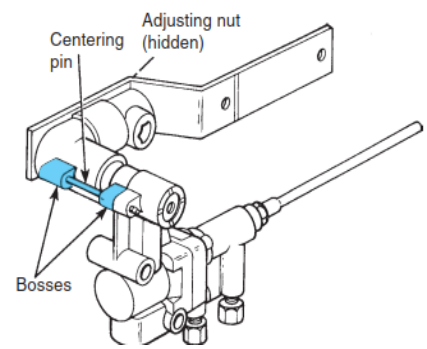


Figure 0:10 Ride Height control valve Adjustment

To adjust the height control valve, do the following:

1. Remove the plastic center pin from the bosses
2. Ensure that at least 100 psi (690 kPa) air pressure is indicated on the dash air pressure gauges of the truck.
3. Disconnect the vertical link from the height control valve lever.
4. The height adjustment is checked at the rearmost axle. Place a straightedge on the centerline of the top metal plate on the air springs, do not position the straightedge on the frame rails.
5. Measure the distance from the bottom edge of the straightedge to the top edge of the transverse cross-member. Reference the OEM service literature for the correct specification distance.
6. If the distance is less than specified, raise the valve control lever and hold it up until the distance is correct. Release the lever. Loosen the lever adjusting nut, which is located 17/8 inch (4.75 cm) from the lever pivot point, so that the steel portion of the lever moves but the plastic portion does not. Position the lever so that the link-to-lever bolt can be inserted through the lever and link.
7. If the distance is more than specified, lower the valve lever and hold it down until the distance is correct. Release the lever. Loosen the lever adjusting nut. Position the lever and link so that the lever bolt can be inserted through the lever and link.
8. Install the lever link bolt nut. Tighten the nut 115 to 130 inch-pounds (13 to 15 Nm).
9. Centre the plastic portion of the valve lever and insert the alignment pin through the boss on the valve body and plastic arm.
10. Tighten the lever adjusting nut to lock the steel and plastic portions of the lever together; then tighten to specification.

11. Remove the centring pin (if equipped) and discard.

c) Replacing a Height Control Valve

Make sure that you use the procedure outlined previously in this chapter to performance check the height control valve before replacing it. One OEM reports that 50 percent of height control valves submitted for warranty function to specification. The following procedure to replace a defective leveling valve:

1. Exhaust air pressure from the truck chassis air system. Then disconnect the air lines from the height control valve.
2. Remove the height control valve threaded extension link from the valve and axle by removing the fasteners.
3. Remove the mounting fasteners that connect the height control valve to the truck frame.
4. Disconnect the brass air fittings from the height control leveling valve and install them in the replacement valve.
5. Secure the new height control valve to the truck frame, torqueing the fasteners to specification. Reattach the airlines to the valve, making sure that each connects to the correct port.
6. Install the threaded extension rod to the height control valve using the appropriate fasteners.
7. Build up chassis system air pressure to cut out and then adjust the height control valve for ride height using the method described earlier.

B. Air Spring Replacement

The procedure for replacing air springs differs slightly depending on whether the bag is of the convoluted type or reversible bellows type. The description provided here references the more common reversible bellows-type air spring,

1. Chock the wheels and exhaust the air pressure from the air spring
2. Raise the truck frame to remove the load from the suspension. Support the frame with safety stands.

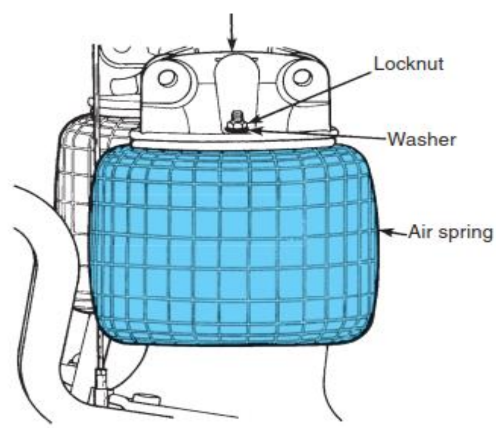


Figure 3: 11 Reversible Sleeve Air Spring Upper

3. Remove the locknuts and washers that connect the air spring to the air spring mounting bracket
4. Remove the airlines connected to the air spring.
5. Remove the brass air fittings from the air spring.
6. Remove the locknuts and washers that connect the air spring to the frame hanger and then those that attach the pedestal to the saddle. Remove the air spring from its upper and lower mountings.
7. Install the replacement air spring to the frame hanger by inserting the studs on the air spring into the appropriate holes on the hanger bracket.
8. Slide the air spring pedestal onto the spring mounting saddle. You can inflate the bag using shop air to extend the spring if required.
9. Install the locknuts and washers to secure the air spring to the bracket. If the pedestal is aluminum and uses bolt fasteners, lightly paste some Aluminastic™ compound or equivalent on the threads to prevent reaction. Tighten and torque the locknuts.
10. Install the washers and locknuts to secure the air spring to the frame hanger. Tighten and torque the locknuts
11. Install the brass air fitting to the air spring using a thread sealant.
12. Install the airlines to the brass fitting.
13. Supply air pressure to the air spring. Adjust the height of the truck or trailer to specification

Self-check

Part One: Say true or false for the given statement

1. In an S-L A suspension, the short upper arm is parallel to the longer, lower arm.
2. The upper and lower ball joints are the steering axis in an S-LA suspension
3. The roll center is at the center of the car on a line between the center of the tire's road contact and the instant center.
4. Placing the upper and lower control arms at angles (viewed from the side) creates a resistance to brake drive
5. On most S-L-A cars the load carrying ball joint is on the lower control arm

Part Two: Multiple Choice

1. What occurs when a wheel hits a dip or hole and moves downward?

   a. Jounce b. Free length c. Deflection d. Rebound

2. Technician A says that load-carrying ball joints should always have some play in them. Technician B says that follower ball joints should never have some play in them. Who is correct?

   a. Technician A only b. Technician B only c. Both A and B d. Neither A nor B

3. Technician A says that a weak suspension spring can cause a loss of traction during acceleration. Technician B says that a weak suspension spring can cause poor braking power. Who is correct?

   a. Technician A only b. Technician B only c. Both A and B d. Neither A nor B

4. When a car is steered, the steering knuckle rotates on the

   a. Steering axis b. Roll center c. Instant center d.any of these

5. The coil spring is mounted off-center on some struts to

   a. reduce vibrations
   b. increase spring leverage
   c. try to center the loads on the strut
   d. all of these

Part Three: Answer the following questions accordingly

1. Describe how a stabilizer bar works.
2. Explain the difference between sprung and un-sprung weight.
3. What are two reasons for using an air spring?
4. Explain the action of both compression (jounce) and rebound strokes.
5. Describe the action of the independent front wheel suspension system.

Operation Sheet 3.1

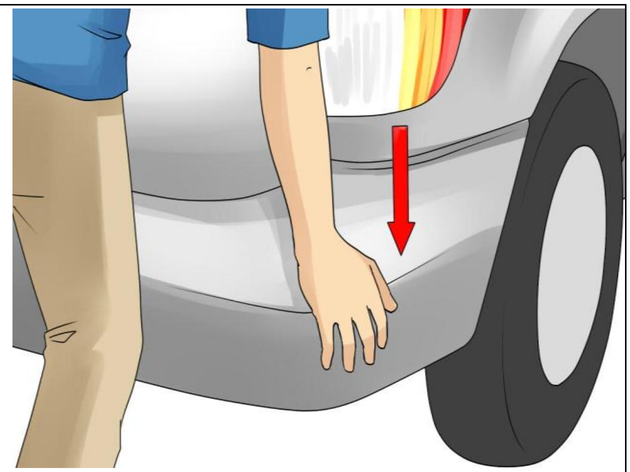
Operation Title: Perform Bounce Test

Purpose: The bounce test is a simple and quick test that should give an indication of the condition of the suspension system.

Equipment Tools and Materials:

- Vehicle equipped with suspension system

Procedure:

<table>
<tr>
<td>
1. Grip one end of the bumper and alternately pull upward and push downward several times until you get that corner of the car bouncing up and down as high as you can. While the car is bouncing up and down, listen for any unusual noises that might indicate worn or broken parts.
2. With the car at the upper end of a bounce, release the bumper and watch the remaining oscillations until they stop. Two or more oscillations indicate the possibility of worn shock absorbers or, less likely worn front-end bushings.
3. Repeat steps 1 & 2 at the other end of the bumper and compare the bouncing action of the two sides of the car. They should be the same; a difference indicates a weak shock absorber or worn suspension bushings.
</td>
<td>

A shock absorber bounce test is manually performed by bouncing each corner of the car; with the car bouncing as much as possible, it is released and the bouncing action is observed. If it bounces more than one and half oscillations, the shock absorber is probably weak.
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<tr>
<td colspan="2">
4. Repeat steps 1, 2 and 3 at the other end of the car. Do not compare the number of bounces of the front with the rear; they are often different. A car with no more than one or two bounce oscillations after releasing the bumper at each corner of the car and with smooth, quite operation probably has good springs and shock absorbers, if the height and ride quality are good. Unusual or excessive noises, differing number of bounce oscillations at each side of the car, or excessive bouncing indicates a need to follow up the bounce test with one of the remaining tests.
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Operation Sheet 3.2

Operation Title: Check Suspension Ride Height

Purpose:

A suspension ride height check is a simple and quick way to determine if the car is too low; weak, sagging springs let the suspension height drop.

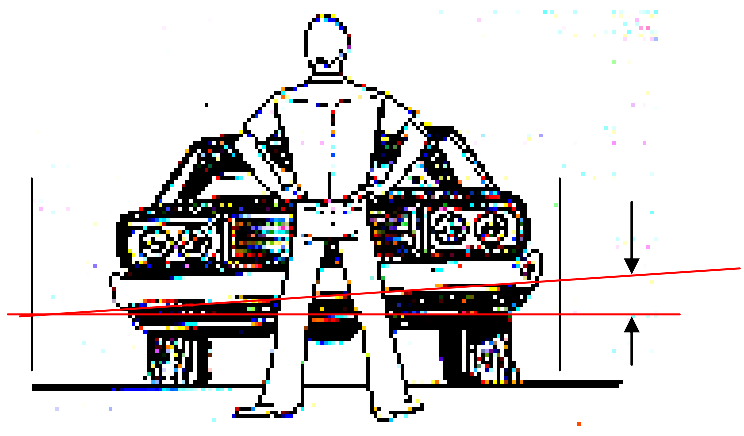
Equipment Tools and Materials:

- Vehicle equipped with suspension system

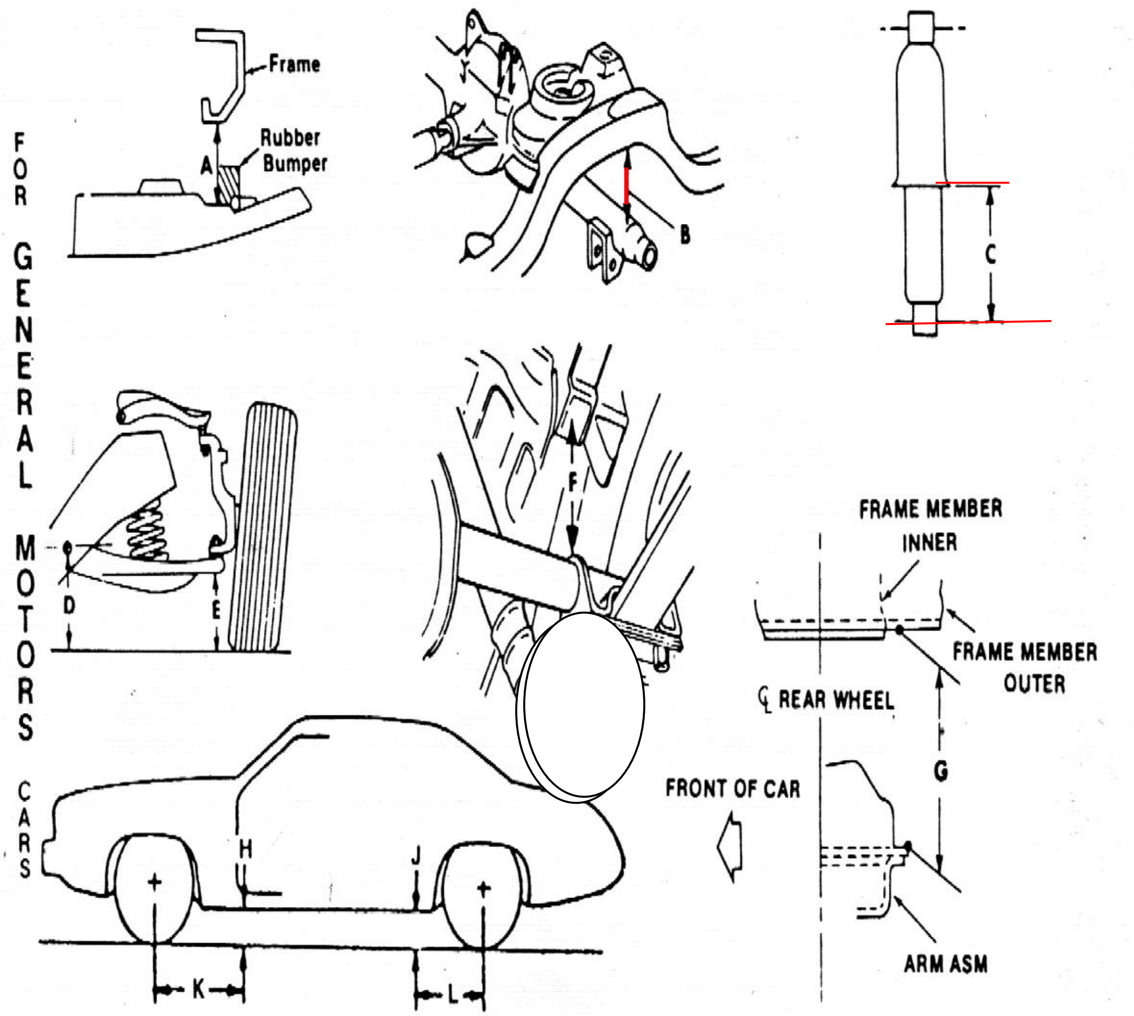
Procedure:

1. Park the car on a smooth level surface; the ramps of a wheel alignment rack are ideal because they are level and allow easy access to the suspension members.
2. Check for unusual amounts of weight that might be in the trunk or backseat of the car. Hey should be removed or allowances made for any added weight; ride height specifications are given for unloaded cars.
3. Check the tire pressure and correct it, if necessary. Note whether the tires are stock size; if not, allowances must be made in the checking dimensions.
4. Obtain the ride height specifications and the locations of the measuring points.
5. Measure the distances at each measuring point and compare them with the specifications. Sagged springs are indicated if the measured distances are shorter or lower than the specifications.
6. Compare the left and right measurements; they should be almost equal.

When one side of the car sags more than the other, it is necessary to determine whether the lean is caused by a weak front spring, a weak rear spring, or both; either will cause this problem.



This vehicle is probably leaning because of a weak right front or rear spring; Lifting the car in the exact center at the front or rear will usually show if it is the front or the rear spring that has sagged.



"A" Dim. — Vertical distance from top of front lower control arm In front of rubber strike-out bumper, to undersides of frame.

"B" Dim. — Vertical distance from top of rear axle housing to underside of frame side member.

"C" Dim. — Vertical distance from lower edge of front shock absorber dust shield to centerline of lower attachment stud.

"D" Dim. — Vertical distance from ground to centerline of front bushing bolt head.

"E" Dim. — Vertical distance from ground to underside of ball joint cover plate in board of and adjacent to lube fitting.

"F" Dim. — Vertical distance from top of rear axle housing to underside of bump stop bracket adjacent to rubber bumper.

"G" Dim. — Vertical distance from top of control arm flange, adjacent to shock absorber, to underside of frame outer side rail.

"H" Dim. — Ground to rocker panel at front.

"J" Dim. — Ground to rocker panel at rear.

"K" Dim. — Front wheel centerline to "H".

"L" Dim. — Rear wheel centerline to "J".

Operation Sheet 3.3

Operation Title: Replacing shock absorbers

Purpose: Every learner should know how to Replacing shock absorbers

Conditions for the operations:

- ✓ Safe working area
- ✓ Properly operated tools and equipment
- ✓ Appropriate working cloths fit with the body

Equipment Tools and Materials:

- ✓ Different types of wrench

Quality Criteria: Assured performing of all the activities according to the procedures

Precautions:

- ✓ Wearing proper clothes, eye glass, glove
- ✓ Make working area hazard free
- ✓ Read and interpret manual which guide you how to use tools and equipment

Procedure:

1. Jack up the front end of the car
2. place a jack stand under the suspension parts beneath each shock
3. Lower the jack on to the jack stands so that the shocks will not fully extended
4. Remove the attachment bolts
5. Remove the shocks
6. Compare the new shocks with the new ones to be sure. You have the correct replacements.
7. you must purge the new shocks to remove any air that might be trapped in the hydraulic fluid. To do this, fully extend the shock while holding it right-side-up. Then turn it up side down and push it together. Run through this step four or five times.
8. put the new shocks in place.
9. attach the mounting bolts, but do not tighten them completely
10. Jack the car up and remove the jack stands
11. Lower the car to the ground or floor, (This step permits the shocks to center themselves)
12. Tighten the attachment bolts to the manufacturer's specifications.

Operation Sheet 3.4

Operation Title: Replacing Macpherson Strut Front Suspension

Purpose: Every learner should know how to Replacing Macpherson Strut Front Suspension

Conditions for the operations:

- ✓ Safe working area
- ✓ Properly operated tools and equipment
- ✓ Appropriate working cloths fit with the body

Equipment Tools and Materials:

- ✓ Different types of wrench

Quality Criteria: Assured performing of all the activities according to the procedures

Precautions:

- ✓ Wearing proper clothes, eye glass, glove
- ✓ Make working area hazard free
- ✓ Read and interpret manual which guide you how to use tools and equipment

Procedure

1. Jack up the front end of the car and support if with jack stands
2. Remove the front wheel to expose the strut
3. Remove the bolt or bolts that connect the strut to the lower control arm
4. Disconnect the top of the strut from the car body by removing the mounting nuts. These nuts are located under the hold.
5. Remove the strut and replace the bottom of it in a vise with wooden blocks to protect it.
6. Attach a spring compressor to the spring and begin compressing it.
7. Tighten the compressor slowly and evenly on both sides until it releases tension from the top of the strut.
8. Remove the large retaining nut at the top of the strut.

   CAUTION. The retaining nut holds the spring in place, so you have to remove it very carefully, work from one side of the strut, not above it. The spring will be under heavy compression, and it could fly off the strut if the compressor failed.
9. Slowly loosen the spring compressor until the tension is completely release.
10. Remove the cartridge and replace it with the new unit. Reassemble the strut using the reverse procedure of disassembly.

Operation Sheet 3.5

Operation Title: Control Arm Assembly

Purpose: Every learner should know how to Replacing Macpherson Strut Front Suspension

Conditions for the operations:

- ✓ Safe working area
- ✓ Properly operated tools and equipment
- ✓ Appropriate working cloths fit with the body

Equipment Tools and Materials:

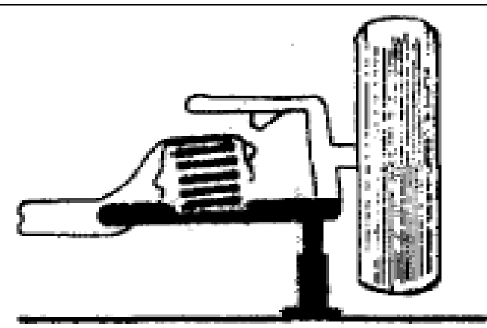
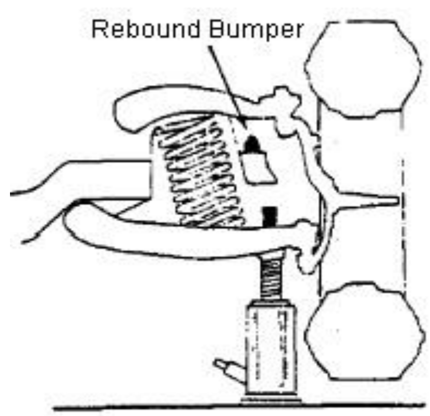
- ✓ Different types of wrench and Hydraulic jack

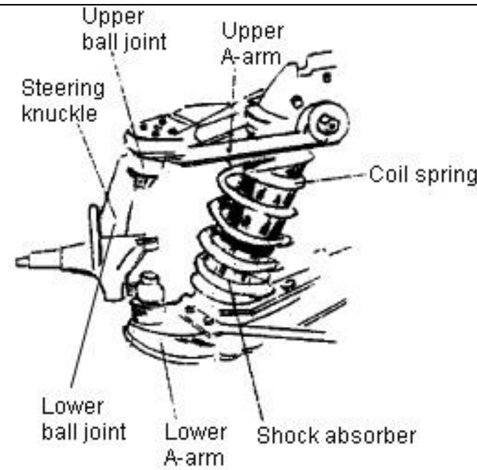
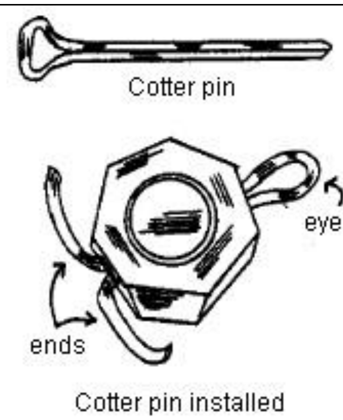
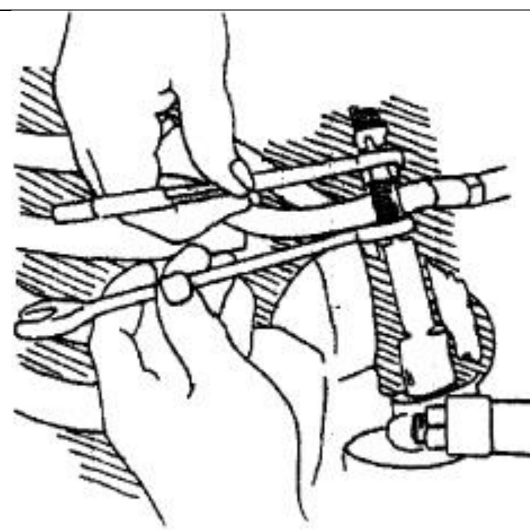
Quality Criteria: Assured performing of all the activities according to the procedures

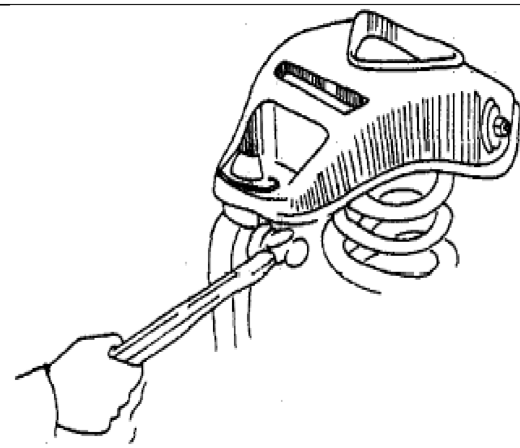
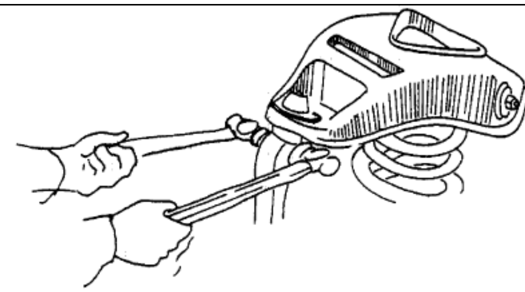
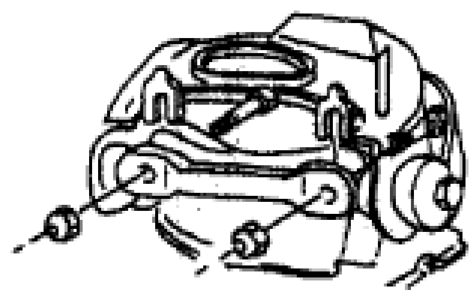
Precautions:

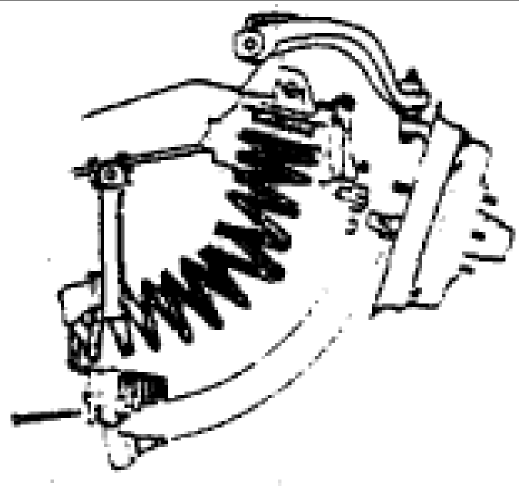
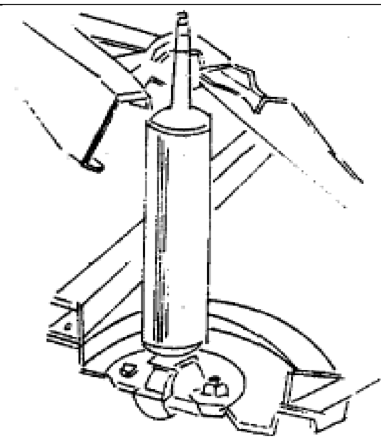
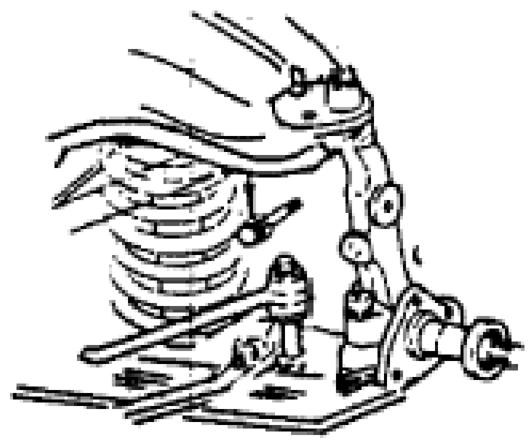
- ✓ Wearing proper clothes, eye glass, glove
- ✓ Make working area hazard free
- ✓ Read and interpret manual which guide you how to use tools and equipment

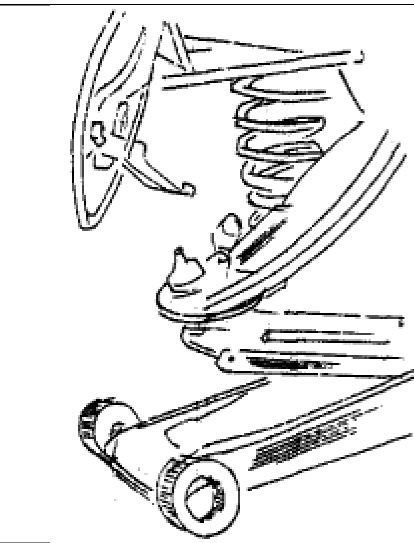
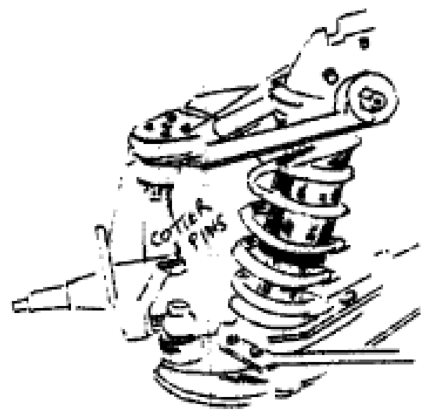
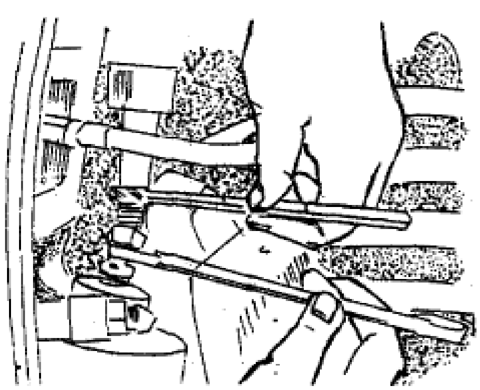
Procedure:

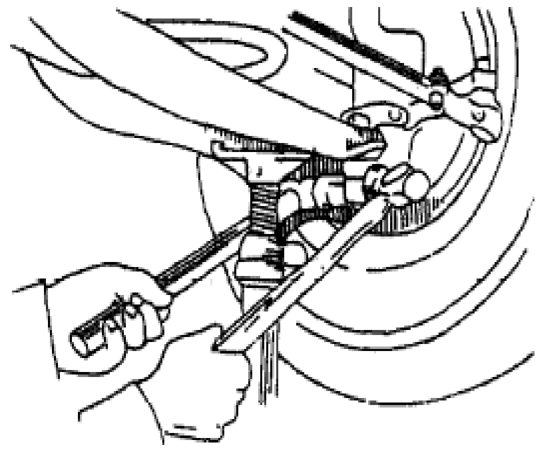
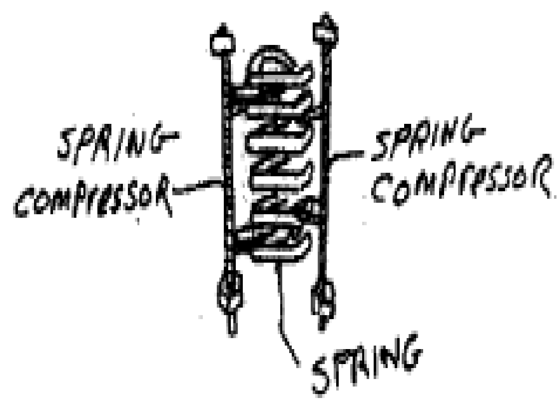
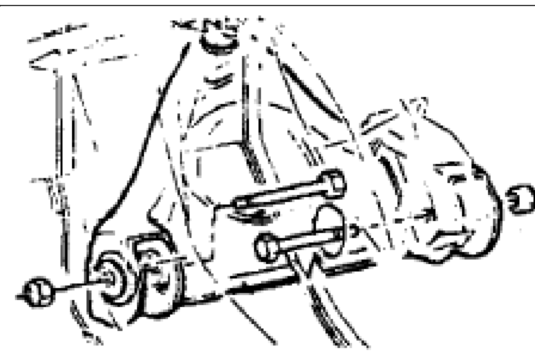
1. Remove an upper control arm assembly on a lower control arm mounted coil spring	
a. Raise the vehicle. • Place safety stands under the frame. • Place the jack under the lower control arm. Get it as close to the lower ball joint as possible. b. Remove the tire and wheel assembly. c. Remove the rebound bumper from the upper control arm. Do this by removing the hold-down bolt.	

d. Remove the cotter pin from the ball joint stud • Use the diagonal pliers to straighten the ends of the cotter pin. Pull the eye from the nut. e. Loosen the nut on the upper ball joint stud. Do not remove it.	
f. Break the ball joint loose between the tapered ball stud and the tapered hole in the steering knuckle. Use method number 1 (Figure 4). • Use a special removing tool to apply pressure to the ball joint stud. Place the tool over the lower ball joint stud.	 *Figure 4.*
• Use one wrench to hold the adjusting bolt on the tool. Use a second wrench to turn the tool for tightening and loosening. • Tighten the tool until it is under strong tension. • Note: Do not attempt to break the joint with tool force only. This will damage the tool.	

• Rap the stud area of the steering knuckle sharply with a hammer. Jar the joint loose	
g. Break the ball joint loose between the tapered ball stud and tapered hole in the steering knuckle. Using method number two • Place one hammer on one side of the spindle. Place it near the ball joint. • Rap the other side of the spindle with another hammer sharply. This frees the stud from the knuckle. h. Wire the brake and knuckle in place. This prevents brake hose damage. i. Remove the nut from the stud. j. Lift the upper arm from the knuckle. k. Remove the upper control arm shaft-to-bracket nuts and lock washers. Carefully noting the number, thickness and location of the adjusting shims (for correct replacement) l. Remove the control arm assembly. Pull it away from the vehicle.	 

a. Raise the vehicle and place under the frame. Note: The vehicle needs to be high enough off the floor to allow the lower control arm to swing down without striking the floor.	
b. Remove the tire, wheel and drum assembly. c. Remove the shock absorber Note: On some models only disconnect the lower end and push the rod all the way in.	
d. Disconnect the stabilizer at the control arm. • Remove the nut from the bar end. • Lift the bar away from the lower control arm.	

e. Disconnect the strut rod from the control arm, if so equipped. f. Disconnect the tie rod from the steering arm. g. Place a floor jack under the lower control arm. Locate it parallel with the arm	
h. Raise the lower control outer end enough to take the pressure off the lower ball joint i. Remove the cotter pin from the upper and lower ball joint stud bolts. Use diagonal pliers to straighten the ends of the cotter pin and pull the eye from the nut.	
j. Loosen the lower stud nut approximately two turns. k. Install the special ball stud bolt remover tool. • Place the tool over the top stud. • Adjust the bolt on the tool to fit snugly against the lower ball stud. • Tighten the tool with one wrench while holding the adjusting bolt with another wrench. • Tighten the tools until the studs are under tension.	  

l. Tap the steering spindle sharply with a hammer near the lower stud. This will loosen the stud from the spindle. Caution: Prevent the coil spring from slipping by installing a spring compressor. m. Remove the ball joint stud nut n. Lower the control arm slowly with the jack. Caution: The coil spring is very dangerous while under pressure. Use extreme care when working with it.	
o. Remove the jack from under the control arm. p. Remove the spring compressor.	
q. Remove the control arm pivot bushing bolts. Unscrew the nut and remove the bolt on both pivot bushings. r. Remove the lower control arm from the vehicle.	

LAP Test

Practical Demonstration

Name: ___________________________ Date: ____________

Time started: ____________________ Time finished: _______________

Instruction I: Perform the following tasks

Task 1: Servicing Leaf spring

Task 2: Servicing Air suspension

Task 3: Servicing Shock Absorber

Reference

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- Automatic Transmissions and Transaxles Seventh Edition James D. Halderman
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- Automobile Engineering G.B.S. NARANG
- Automobile engineering R.K Rajput
- Automotive mechanics 10th edition William H. Crouse
- Journals/Publication/Magazines

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