INTRODUCTION

The steering column consists of many components. The steering shaft transmits rotary motion from the steering wheel to the steering gear, while the column jacket that encases it attaches to the vehicle body and offers a stationary mounting point for a number of switches and mechanisms. Figure 1.

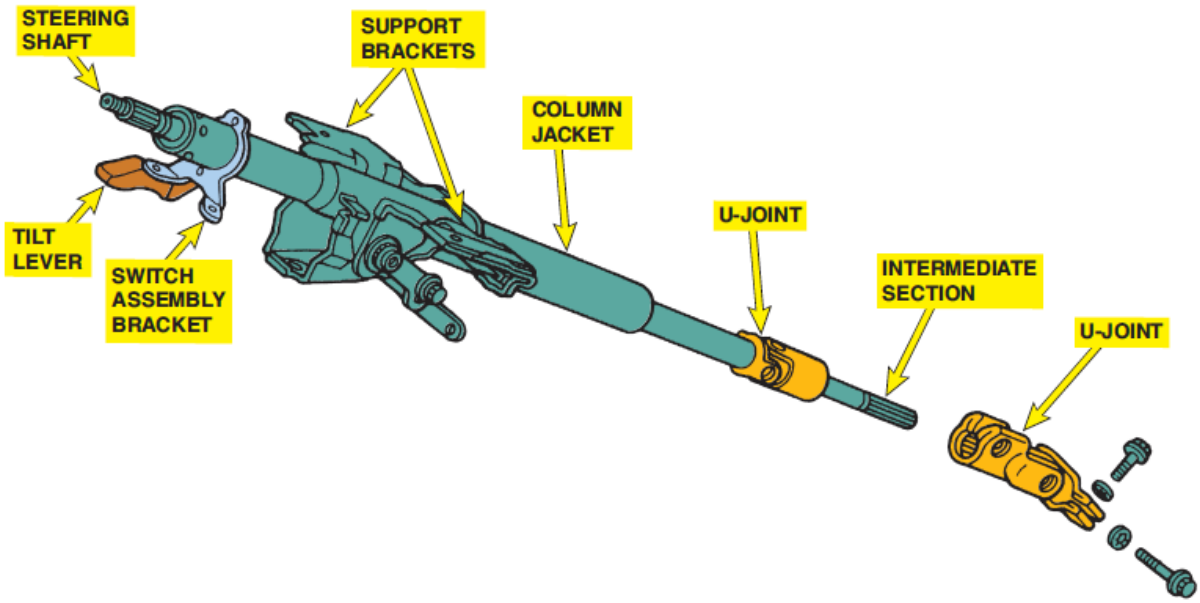

Figure 1. Typical steering column.

A multifunction switch operates the turn signals, the windshield wiper and washer switch, and the dimmer switch. To keep the wiring from the jacket-mounted switches out of sight, the part of the steering column that extends into the passenger compartment is shrouded by the column cover. Figure 2.

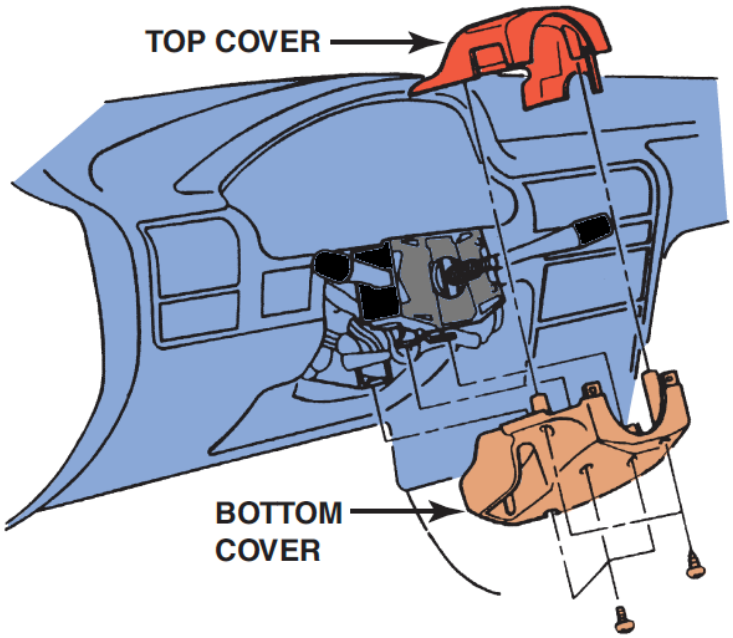

Figure 2. Steering column covers and multi-function switch.

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Federal law requires that all vehicles sold in the United States have steering columns and shafts that collapse during a head-on collision. One method is to use a two-piece column. One section of the column has a smaller diameter so that it fits inside the other and rides on a roller bearing. Another design uses a breakaway device that separates the steering column from the body of the vehicle in the event of a front-end collision. Figure 3.

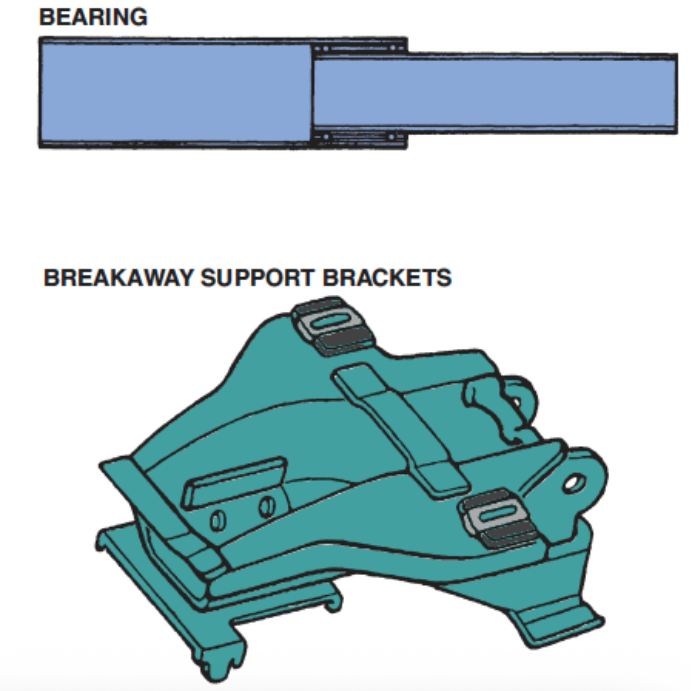

Figure 3. Collapsable and breakaway protective devices.

The steering column on many current vehicles use and electric power assist system, with the power steering motor and sensors built into the steering column. Figure 4.

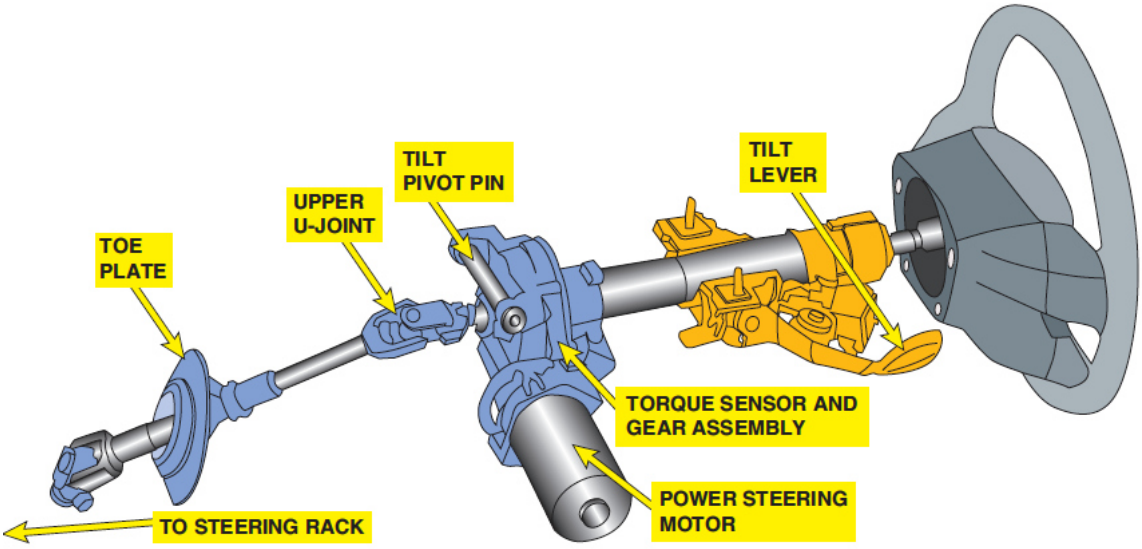

Figure 4. Electric power steering.

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A recirculating ball steering gear is the most commonly used conventional steering gear. Figures 5 and 6.

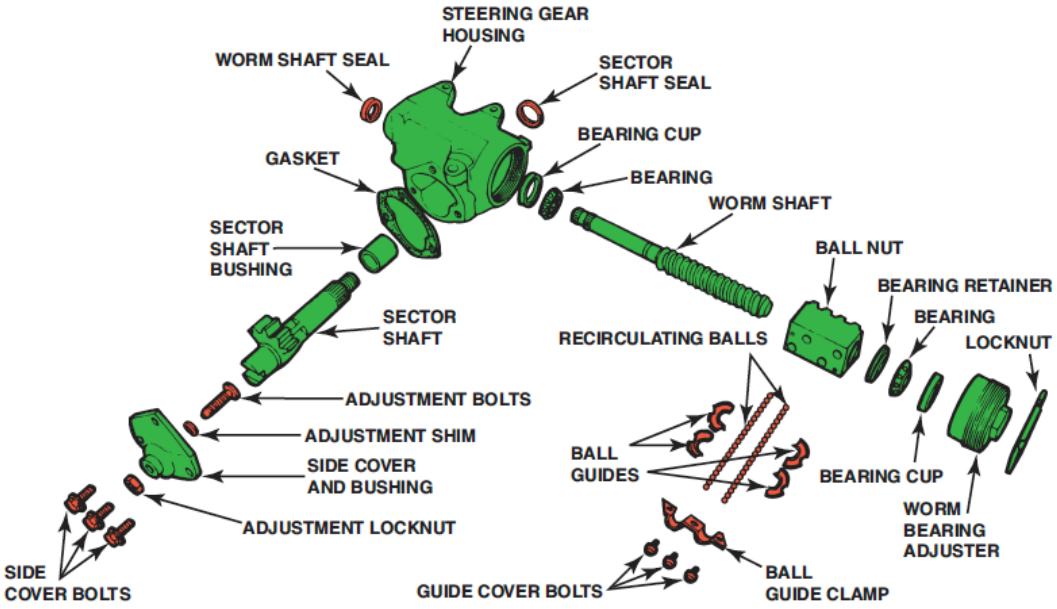

Figure 5. Steering gear components.

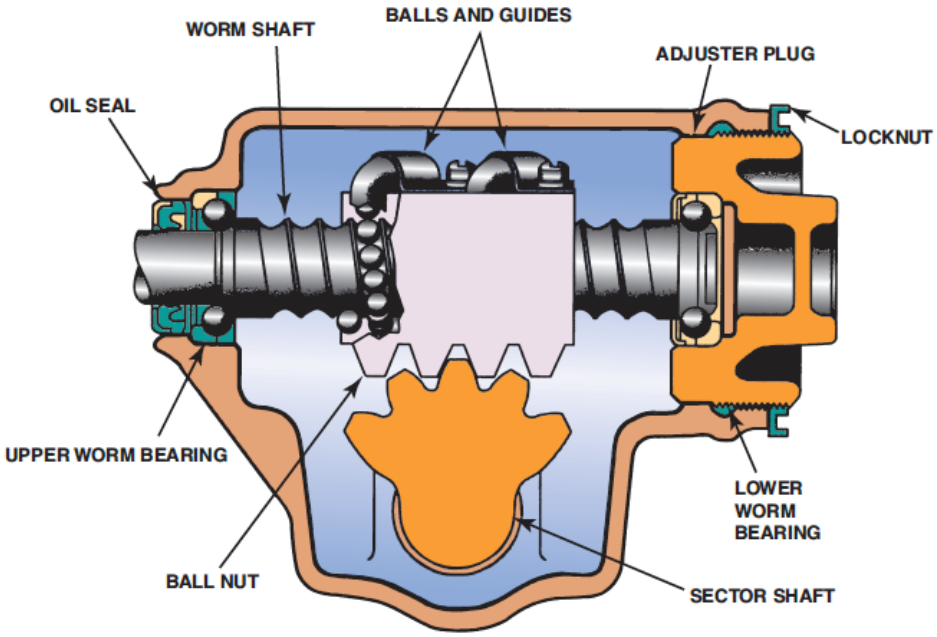

Figure 6. Steering gear cross-section.

The rack-and-pinion steering gear is widely used because it is light in weight and takes less space than a conventional steering gear. The pinion gear teeth mesh with the teeth on the rack so that when the pinion gear turns, it pushes the rack from side to side. The rack connects directly to the tie rods in the steering linkage to move the linkage back and forth in a straight line. Figure 7.

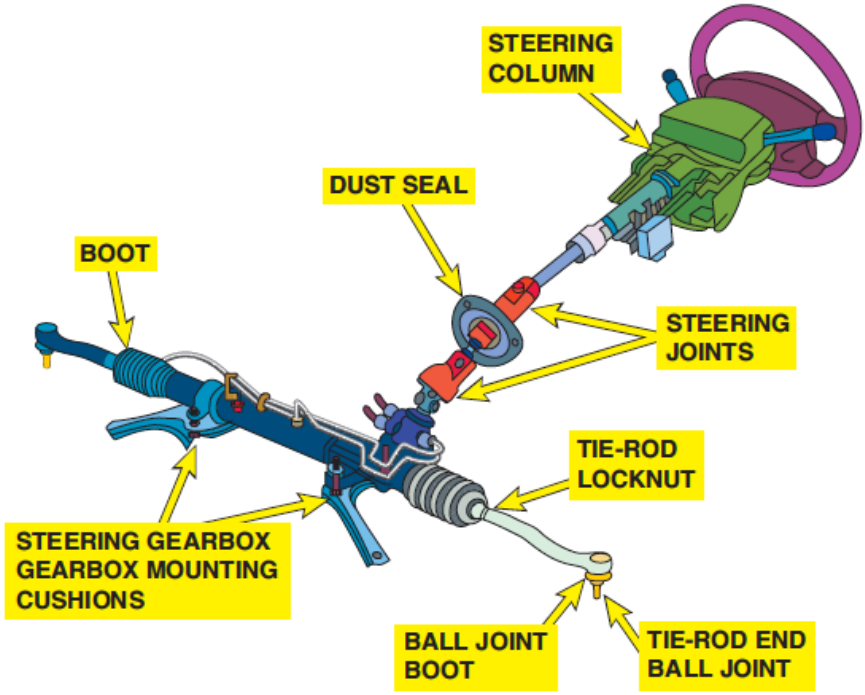

Figure 7. Rack-and-pinion steering.

ASE TEST TOPICS

► Steering Columns

1. Diagnose steering column noises and steering effort concerns (including manual and electronic tilt and telescoping mechanisms); determine needed action.

Some possible faults with the steering column are:

- Loose or Wandering Steering. This can indicate worn steering column bearings. Also caused by a partially collapsed column housing.
- Steering Wheel Vibration. Vibrations can stem from worn or mis-aligned universal joints, or other issues with the steering column's internal components.
- Loose Steering Wheel. This can result from worn steering column bearings. Also caused by partially collapsed column housing.
- Clicking or Clunking. These noises when turning can indicate worn universal joints, bearings, or bushings within the steering column.
- Grinding. A grinding noise when turning may be worn bearings or other issues within the steering column.
- Steering Column Adjustment Issues. The steering column tilt/telescope may not adjust properly, or the adjustment mechanism may fail.

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2. Inspect and replace steering column, steering shaft U-joint(s), flexible coupling(s), collapsible columns, intermediate shafts, and steering wheels (including steering wheels and columns equipped with airbags and/or other steering wheel/column mounted controls, sensors, and components).

Steering wheel removal.

Disable the driver's side airbag (supplemental inflatable restraint SIR) before removing the steering wheel.

- Disconnect the negative battery cable or remove the airbag fuse (has a yellow cover).
- Disconnect the yellow electrical connector located at the base of the steering column to disable the driver’s-side airbag.

Remove the center section of the steering wheel by removing the retaining screws, including the inflator module on vehicles equipped with an airbag. Figure 8.

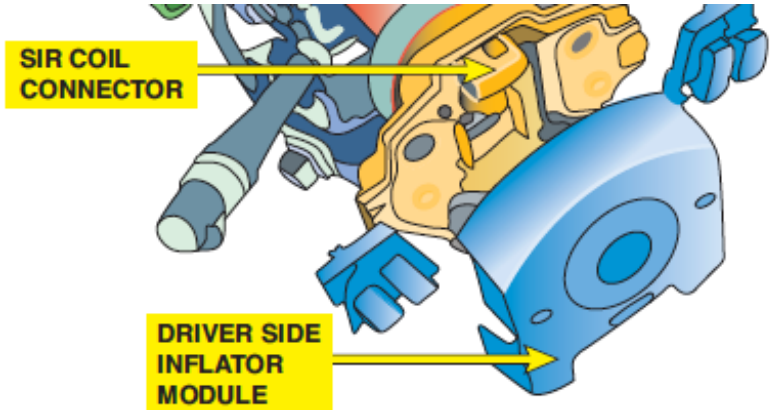

Figure 8. Remove the airbag fasteners and disconnect the SIR coil connector.

After removal of the airbag inflator module, remove the steering wheel retaining nut. Note the locating marks on the steering wheel and steering shaft. These marks indicate the proper position of the steering wheel for centerline steering. Figure 9.

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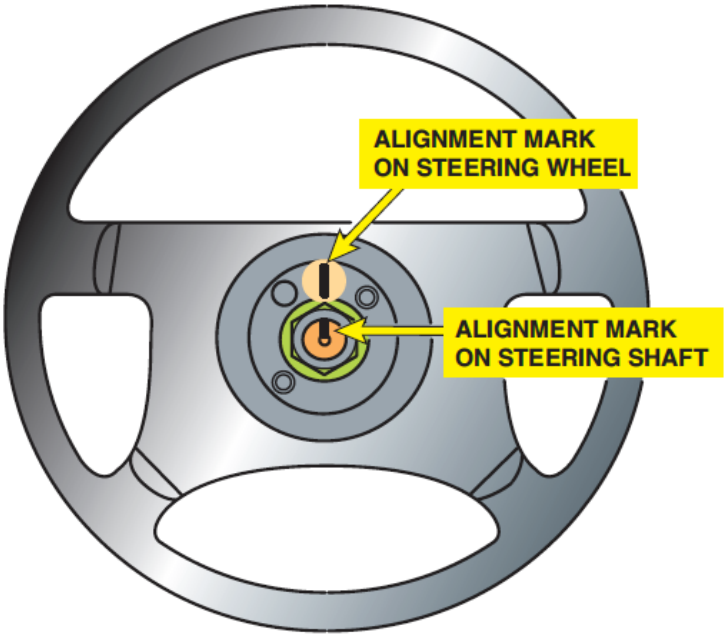

Figure 9. Alignment marks.

Most steering wheels are attached to the steering shaft with a spline and a taper. After removing the steering wheel nut, use a steering wheel puller to remove the steering wheel from the steering shaft. Figure 10.

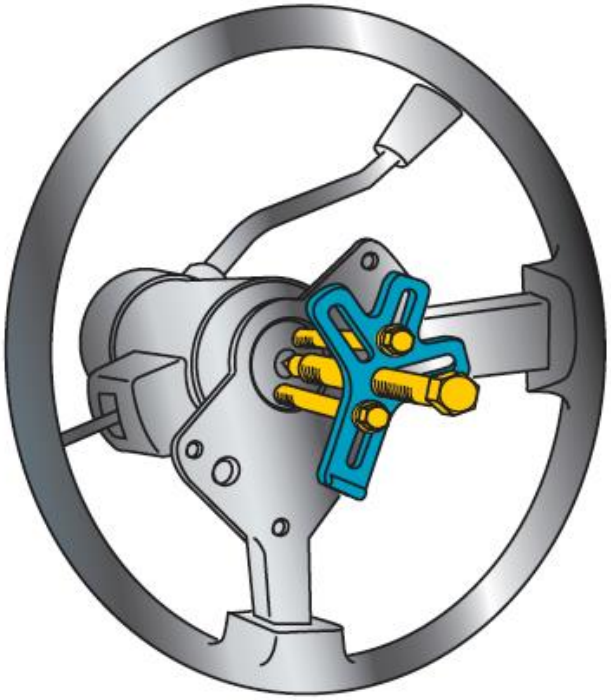

Figure 10. Steering wheel puller.

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Upper column and tilt mechanism.

The upper steering shaft, tilt mechanism, and bearings can be disassembled after removing the two pivot pins. Figure 11.

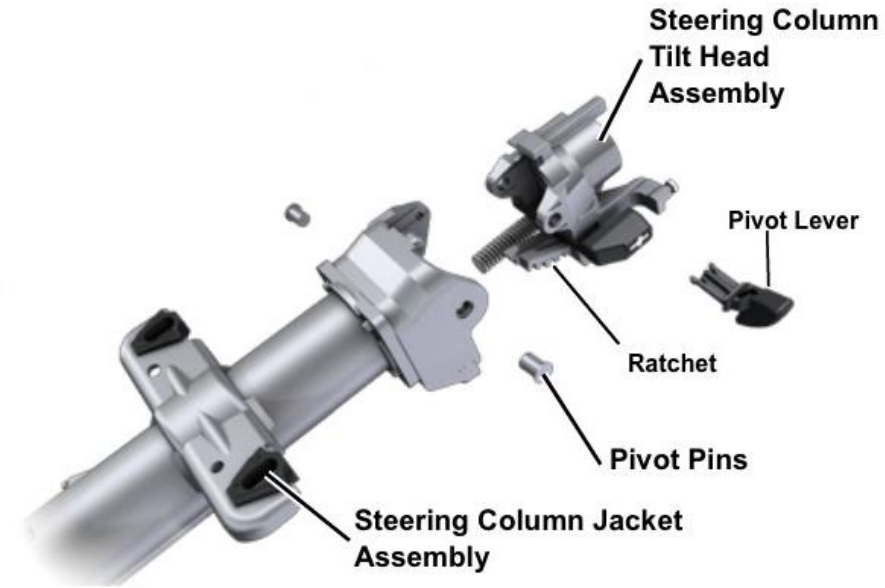

Figure 11. Upper steering column and tilt mechanism.

Additional components that may need inspection or replacement are the column U-joints and/or flexible couplings. Figures 12 and 13.

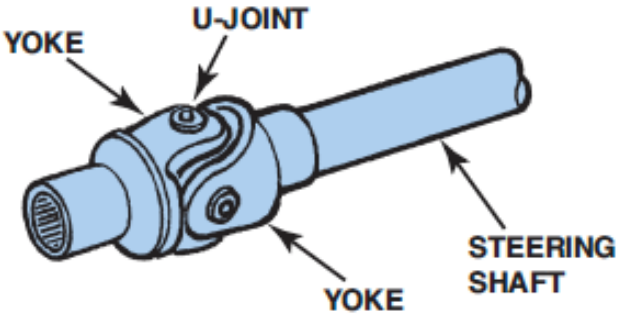

Figure 12. Steering column U-joints can become seized or worn.

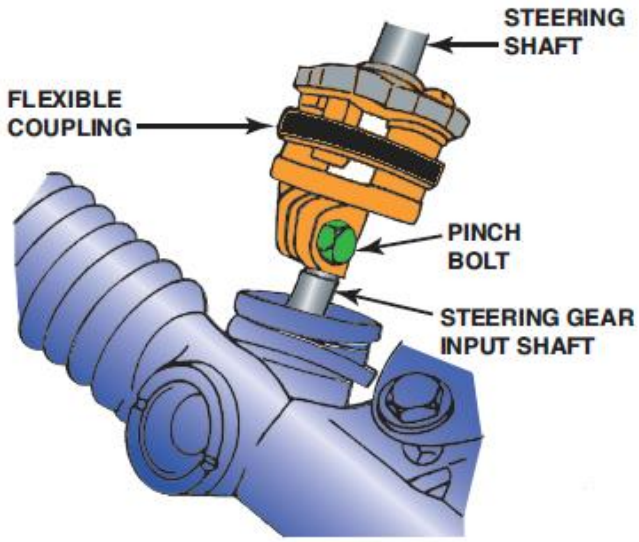

Figure 13. Flexible couplings may be torn or loose at the bolt holes.

3. Disable, enable, and properly handle airbag system components during vehicle service following manufacturers' procedures.

Check service information for the exact disabling procedure, which usually includes the following steps:

STEP 1 Disconnect the negative battery cable. Once the battery is disconnected, wait as long as recommended by the manufacturer before continuing. When in doubt, wait at least 10 minutes to make sure the reserve capacitor is completely discharged.

STEP 2 Remove the airbag fuse (some vehicles)

STEP 3 Disconnect the yellow electrical connector located at the base of the steering column to disable the driver's-side airbag.

STEP 4 Disconnect the yellow electrical connector for the passenger side airbag.

Use care when handling the inflator module section when it is being removed from the steering wheel. Always hold the inflator away from your body. Store the module pad side up in a safe place where it cannot be disturbed or damaged while the vehicle is being serviced.

4. Diagnose, inspect, adjust, repair or replace components (including motors, sensors, switches, actuators, harnesses, and control units) of steering column-mounted, electronically controlled, hydraulically and/or electrically assisted steering systems; initialize systems as required.

Many of today's vehicles use electric power steering (EPS) systems, which is also called electric power-assisted steering (EPAS). Electric power steering takes the place of hydraulic components that were previously used by using an electric motor to provide power assist effort.

Column mounted electric power steering has the sensors and assist motor located inside the vehicle. This is the most commonly used type and involves using a manual rack-and-pinion steering gear assembly with a motor assist in the steering column. Figure 14.

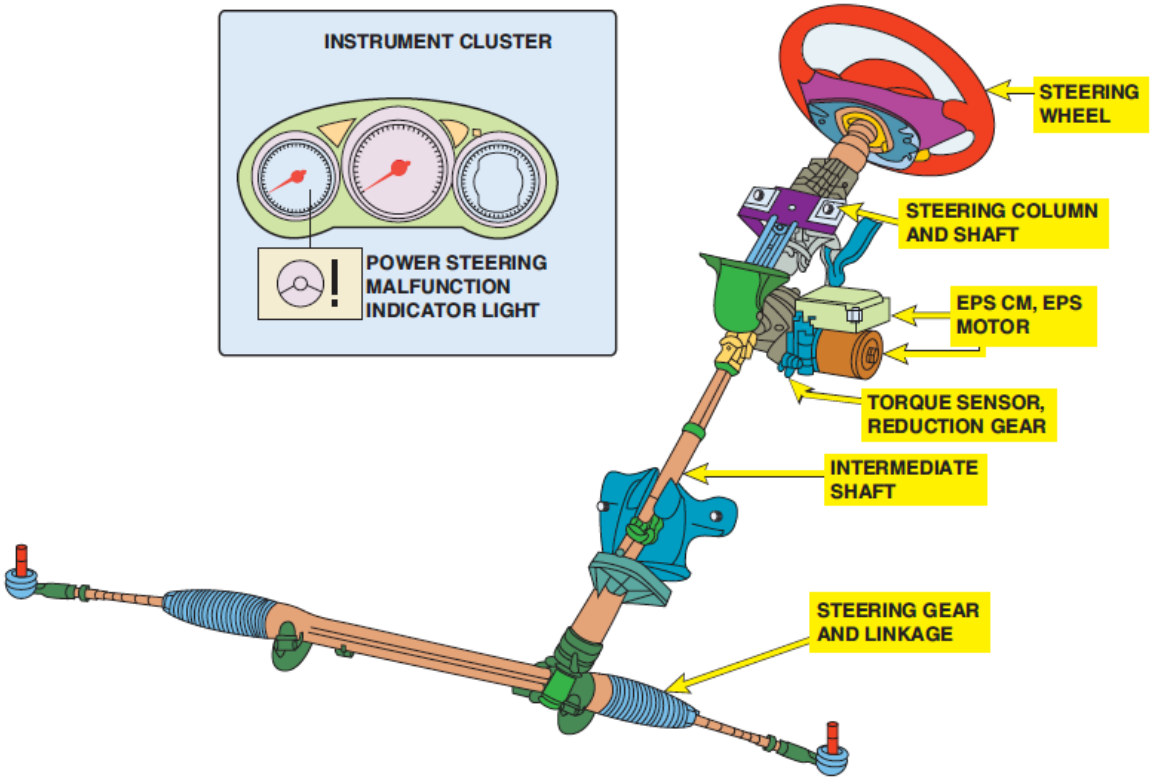

Figure 14. A typical column-mounted electric power steering (EPS) system showing the location of the major components involved including the dash warning light symbol.

The EPS system includes the following components and input signals from sensors and output signals to actuator components:

- Power steering control module (PSCM)
- Battery voltage
- Steering shaft torque sensor
- Steering wheel position sensor
- Power steering motor
- Driver information center (DIC)
- Serial data communications circuits to perform the system functions

The steering shaft torque sensor includes two different sensors in one housing. The sensors are used to detect the direction the steering wheel is being rotated. The PSCM uses the steering position sensor (SPS) to determine the steering system on-center position. Figure 15.

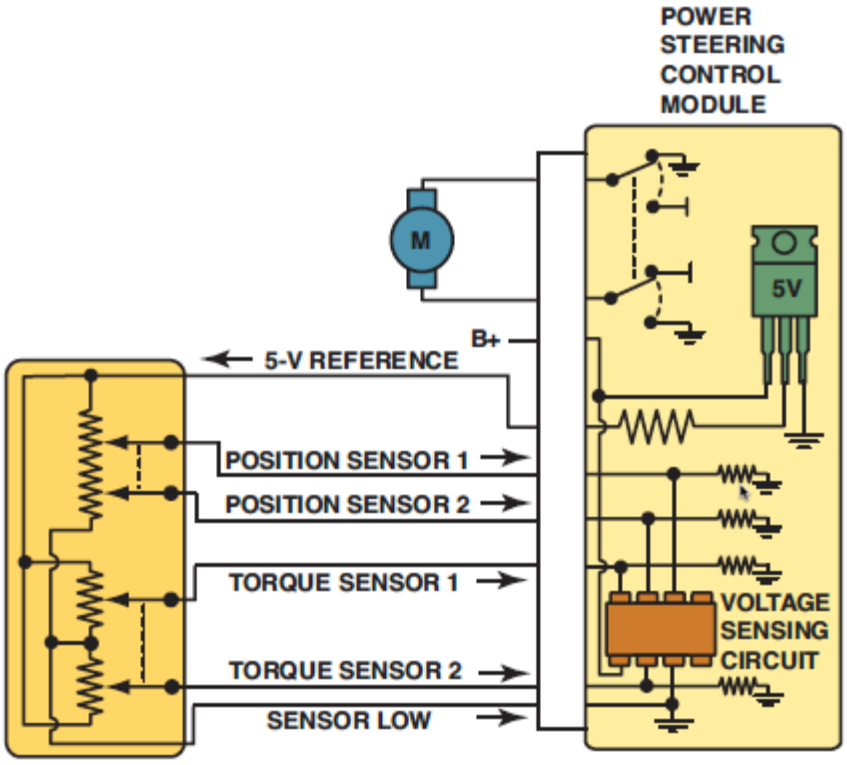

Figure 15. Schematic showing the electric power steering motor and the torque/position sensor.

The PSCM has the ability to detect malfunctions within the power steering system. Any malfunction detected will cause the driver information center to display the power steering warning message and/or the service vehicle soon indicator.

The PSCM must also be set up with the correct steering tunings, which are different in relation to the vehicle's power train configuration, model type, and tire and wheel size. A factory or aftermarket factory-level scan tool is needed to retrieve data and to perform relearn procedures if the unit is replaced.

Most electric power steering diagnostic trouble codes will be "C" codes for chassis-related faults or "U" codes for data communication faults. Figure 16.

DIAGNOSTIC TROUBLE CODE (DTC)	DESCRIPTION OF FAULT
C1511; C1512; C1513; C1514	Torque sensor fault detected
C1521	Short in motor circuit
U0073	EPS control module lost communications

Figure 16. Typical electric power steering fault codes.

► **Steering Units**

5. Diagnose steering gear (non-rack and pinion type) noises, binding, vibration, freeplay, steering effort, steering pull (lead), and leakage concerns; determine needed action.

Steering gear (non-rack and pinion type) noises, binding, and vibrations are usually due to problems in the steering column or steering linkage. Steering pull (lead) is usually a tire or alignment problem. Freeplay, steering effort, and leakage concerns may be due to problems in the steering gear box.

As parts wear, clearances inside the housing and between parts increase, causing looseness and excessive play. This causes delayed reaction to the steering input, and too much steering wheel freeplay. Sources of possible fluid leakage are the seals and gasket. Figure 17.

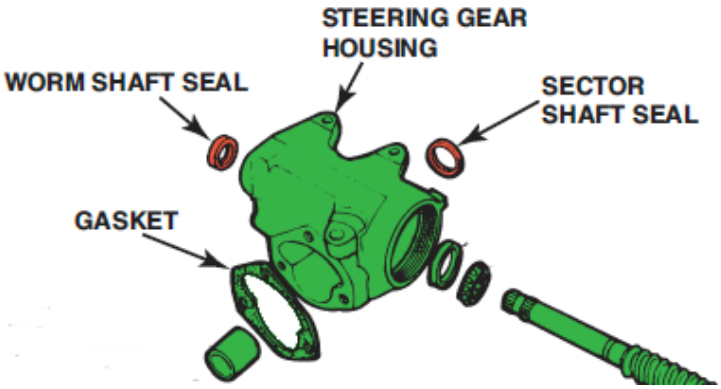

Figure 17. Possible sources of fluid leakage.

6. Diagnose rack and pinion steering gear noises, binding, vibration, freeplay, steering effort, steering pull (lead), and leakage concerns; determine needed action.

Some rack and pinion steering gear concerns are:

- Binding, freeplay, steering effort.
  - Misadjusted rack support bushing (too tight, too loose)
  - Rack mount rubber bushings worn out/missing/oil soaked
- Vibration.
  - Wheel balance
  - Rack rubber mounts worn out/missing
- Leakage, especially power racks Figure 18.
  - Internal seals leaking
  - Rack worn or scored (internal)

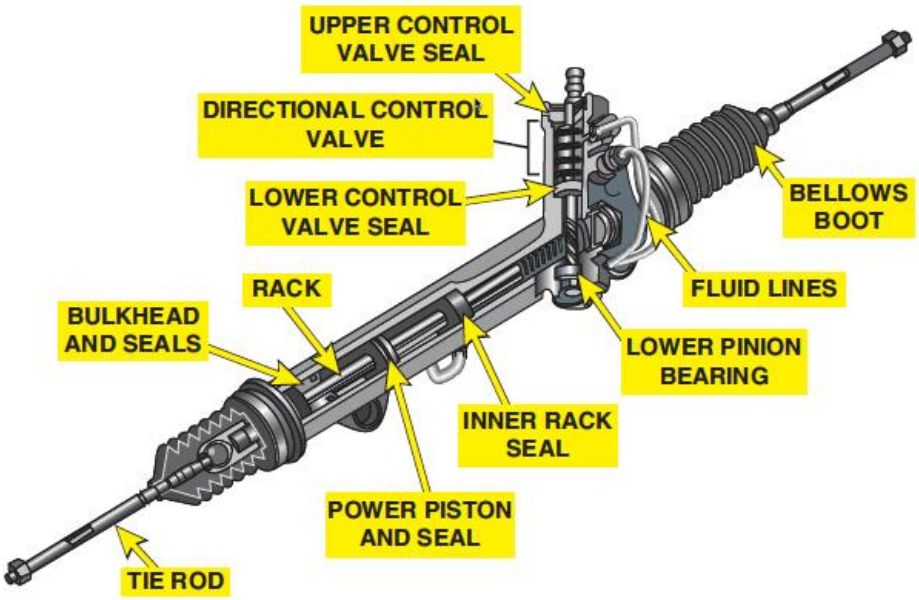

Figure 18. Fluid leaks of the internal seals will cause fluid leaking from the rack boots.

7. Inspect power steering fluid level and condition; determine fluid type and adjust fluid level in accordance with vehicle manufacturers' recommendations.

The correct power steering (PS) fluid is critical to the operation and service life of the power steering system. The exact power steering fluid can be found in the following places:

- On the cap of the power steering reservoir
- In the owner's manual
- In service information

A check of the power steering fluid should include inspecting not only the level but the condition and color of the fluid, which could indicate a possible problem with other components in the steering system. Figure 19.

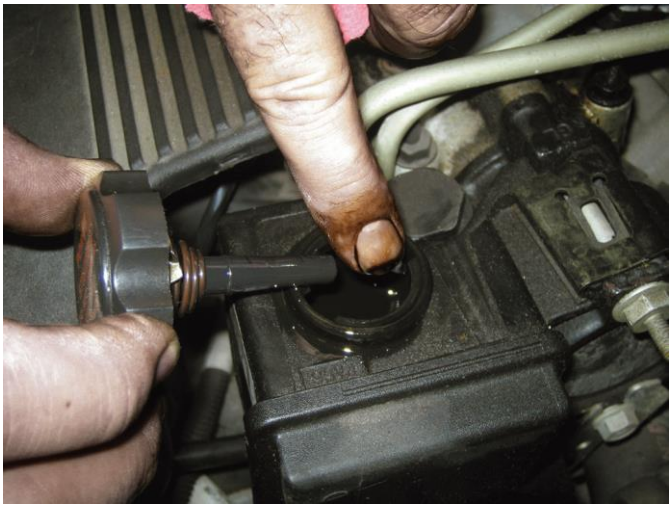

Figure 19. The fluid should be clear of contaminants.

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8. Inspect, adjust, align, and replace power steering pump belt(s), tensioners, and pulleys.

It is generally recommended that all belts be inspected regularly and replaced as needed. Replace any serpentine belt that has more than three cracks in any one rib that appears in a 3 inch span. Fig. 20.

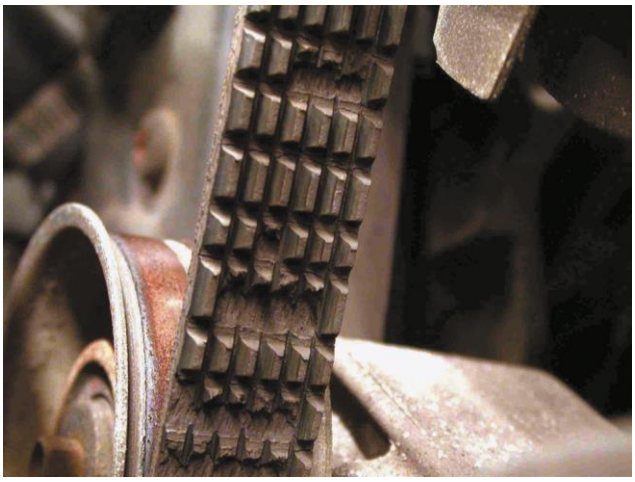

Figure 20. A defective belt.

A loose, worn, or defective power steering pump drive belt. This can cause jerky steering and belt noise, especially when turning. A bent or misaligned drive pulley can cause a grinding noise.

If the belt needs replacement, first make note of the belt routing. There may be a diagram under the hood. Use a tool to release the tensioner and then remove the belt. Install the new belt and check it for the proper tension. Using a new tensioner is recommended. Fig. 21.

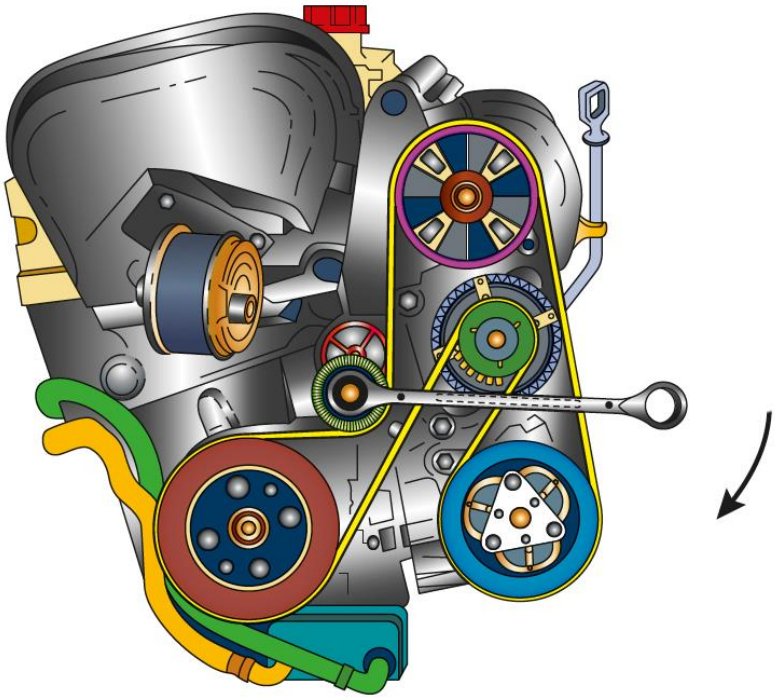

Figure 21. To release the tensioner, push the wrench in the direction shown.

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9. Diagnose power steering pump noises, vibration, and fluid leakage; determine needed action.

Low or contaminated power steering fluid is usually caused by a slight leak at the high-pressure hose or defective inner rack seals on a power rack-and-pinion power steering system. This can cause a loud whine and a lack of normal power steering assist.

Broken or loose power steering pump mounting brackets can cause jerky steering. Tighten all the hardware to ensure the belt will remain tight and not slip, which would cause noise or a power-assist problem.

10. Remove and replace power steering pump; inspect pump mounting and attaching brackets; remove and replace power steering pump pulley; transfer related components.

Most power steering pump service requires the removal of the pump from the engine mounting and/or removal of the drive pulley. The pulley must be removed and installed with a pulley removal and installation tool. Figure 22.

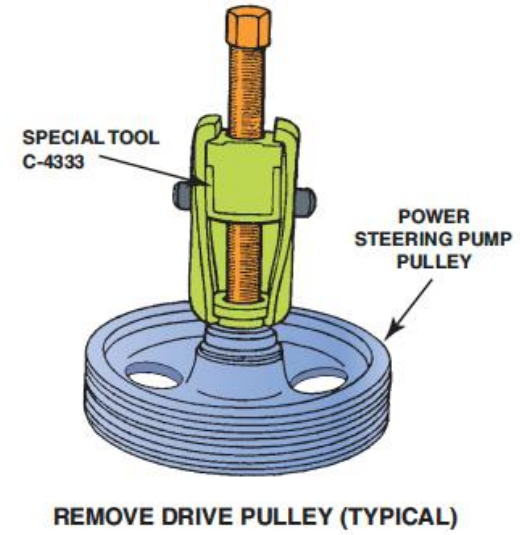

Figure 22. Tools required to remove and reinstall the pump pulley.

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11. Perform power steering system pressure and flow tests; determine needed action.

Many vehicle manufacturers recommend using a power steering analyzer that measures both pressure and volume. Figure 23.

Use of a power steering pressure tester involves the following steps:

STEP 1 Disconnect the pressure hose at the pump.

STEP 2 Connect the hoses of the tester to the pump and the disconnected pressure line. Figure 24.

STEP 3 Open the valve on the tester.

STEP 4 Start the engine. Allow the power steering system to reach operating temperatures.

STEP 5 The pressure gauge should register 80 to 125 PSI (550 to 860 kPa). If the pressure is greater than 150 PSI (1,400 kPa), check for restrictions in the system.

STEP 6 Follow the tester instructions to check maximum pressure. Peak pressure should be higher than 1,000 PSI (6,900 kPa).

STEP 7 If the pump is working as designed, turn the steering wheel to both stops. If the pressure at both stops is not the same as the maximum pressure, the steering gear (or rack and pinion) is leaking internally and should be repaired or replaced.

Figure 23. A power steering analyzer that measures both pressure and volume. The shut-off valve is used to test the maximum pressure of the pump.

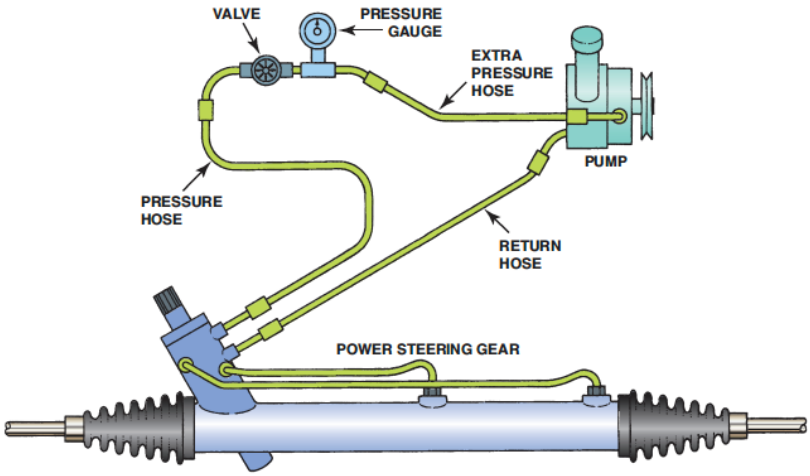

Figure 24. Power steering analyzer connections.

12. Inspect and replace power steering hoses, fittings, O-rings, coolers, and filters.

Both high-pressure supply and low pressure return hoses should be inspected as part of any thorough vehicle inspection. While the low-pressure return hose generally feels softer than the high-pressure return hose, neither should feel spongy. A soft, spongy hose should always be replaced. Figure 25.

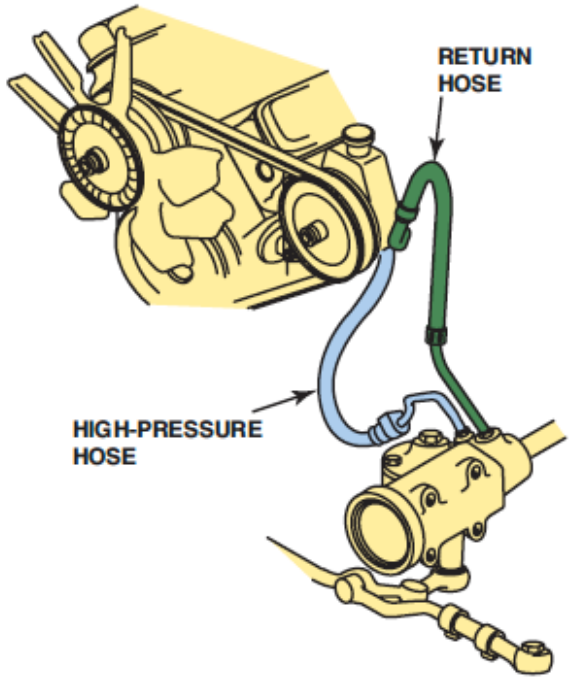

Figure 25. Power steering hoses.

When replacing any power steering hose, make certain that it is routed the same as the original and does not interfere with any accessory drive belt, pulley, or other movable component such as the intermediate steering shaft.

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13. Inspect steering gear (non-rack and pinion type) seals and gaskets; remove and replace steering gear.

The steering gear seals and gasket are locations to inspect for leaks. Replacing any of these usually involves removing the steering gear from the vehicle. Figure 26.

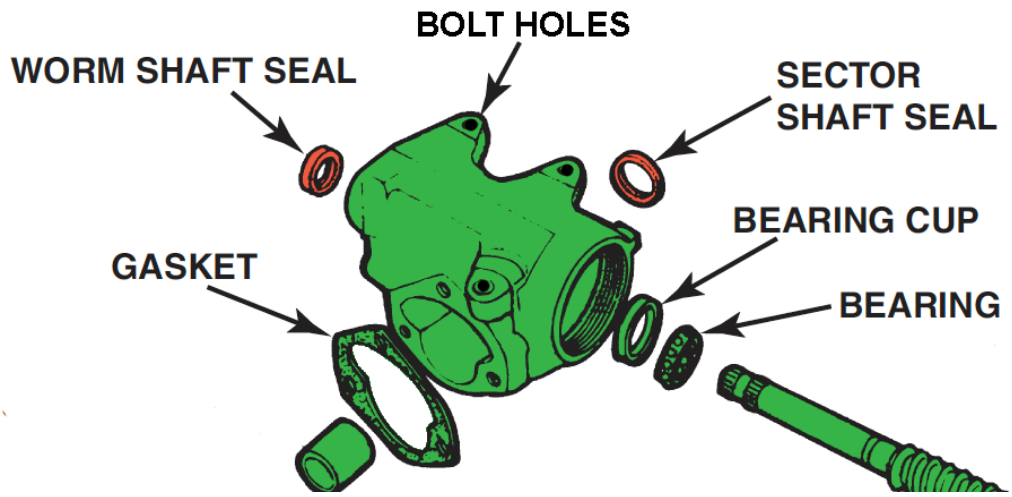

Figure 26. Steering gear seals, gasket, and mounting bolt threaded holes.

Steering gear removal

- Drain the power steering fluid.
- Locate the steering shaft connection to the gear.
- Remove the pinch bolt or clamp securing the shaft.
- Use a puller or pry bar to separate the shaft from the gear.
- Use appropriate wrenches (line wrenches, stubby wrenches, or crowfoot) to disconnect the power steering lines.
- Disconnect the steering linkage from the pitman arm.
- Unbolt the steering gear from the vehicle's frame.
- Carefully maneuver the gear out of the vehicle, taking note of any spacers or brackets.

Reverse this order to reinstall the steering gear. Fill the fluid reservoir and bleed the power steering system.

14. Remove and replace rack and pinion steering gear; inspect mounting surfaces; inspect and replace mounting bushings and brackets.

A rack and pinion steering gear may be mounted to the engine bulkhead (firewall) or attached to the engine cradle, either in front of the engine or between the engine and bulkhead. Figure 27.

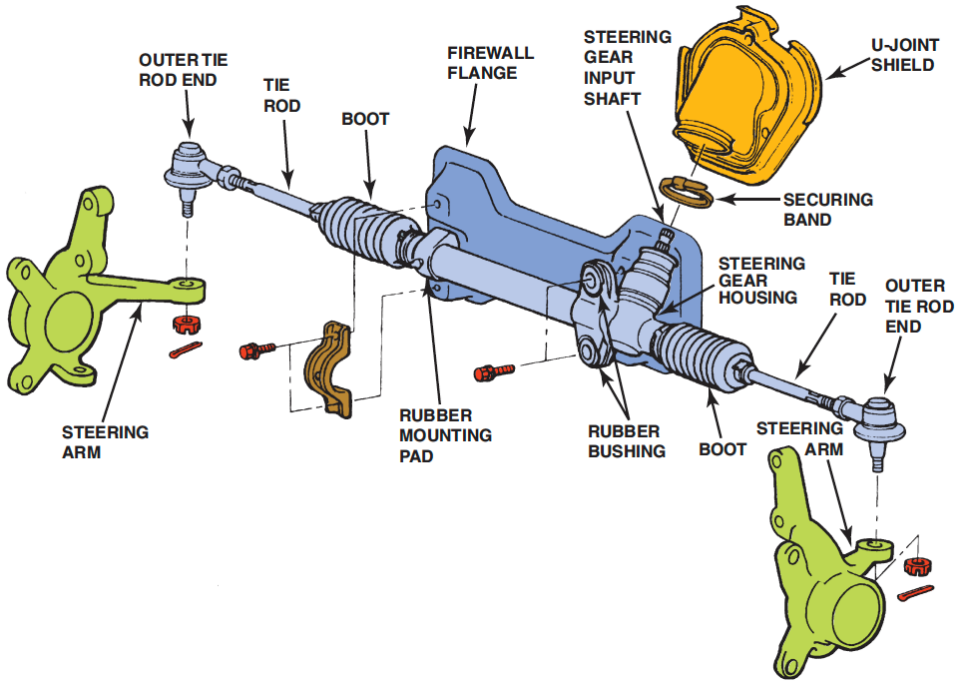

Figure 27. Bulkhead-mounted rack and pinion steering gear.

Rack and pinion steering gear removal uses these general steps:

- Remove the pinch bolt or clamp securing the shaft.
- Use a puller or pry bar to separate the shaft from the steering rack.
- Use appropriate wrenches (line wrenches, stubby wrenches, or crowfoot) to disconnect the power steering lines. Figure 28.
- Disconnect the tie rod ends from the steering arms.

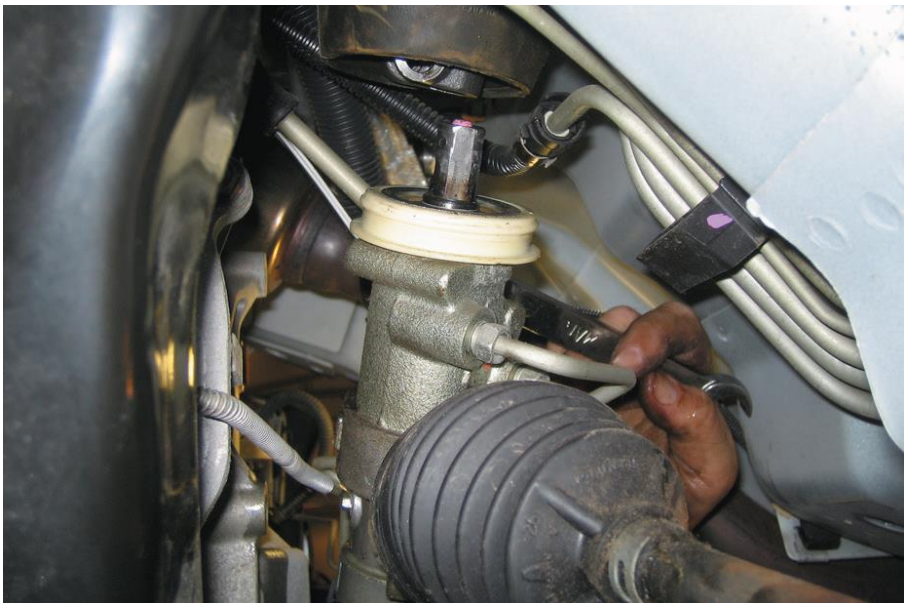

Figure 28. After disconnecting the steering shaft from the rack input shaft, disconnect the power steering lines.

- Lower the engine cradle using tall jacks (some vehicles) so the rack mounting bolts can be removed. Figures 29 and 30.

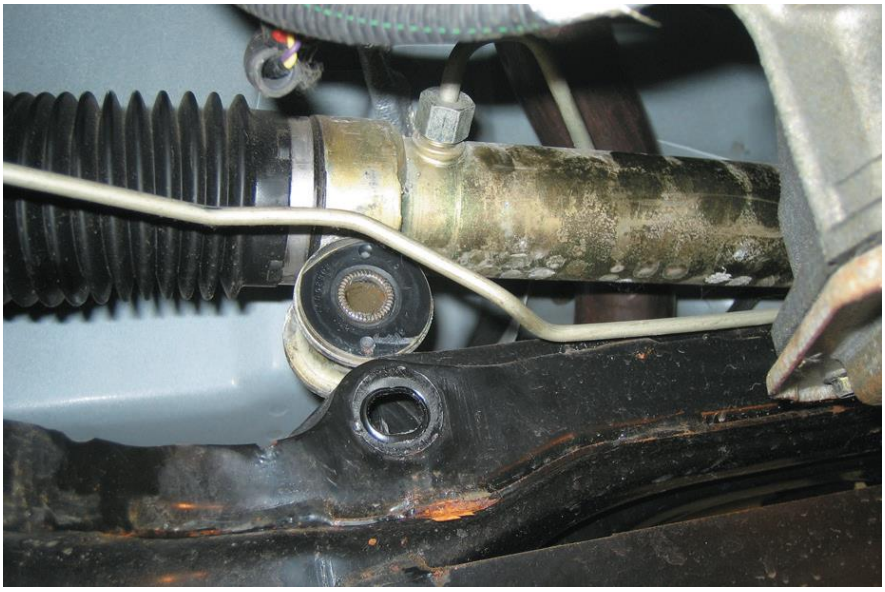

Figure 29. Lower the engine cradle and remove the rack mounting bolts.

Figure 30. Removing the rack and pinion from the vehicle.

Reverse this order to reinstall the rack and pinion steering gear. Fill the fluid reservoir and bleed the power steering system.

15. Adjust steering gear (non-rack and pinion type) worm bearing preload and sector lash.

Depending on the type of steering gear, the worm shaft may be adjusted to have a slight amount of endplay or a slight amount of preload. Worm endplay is a linear measurement, made in fractions of

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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. A preload of 6 to 15 inch-pounds is the most common. Figure 31.

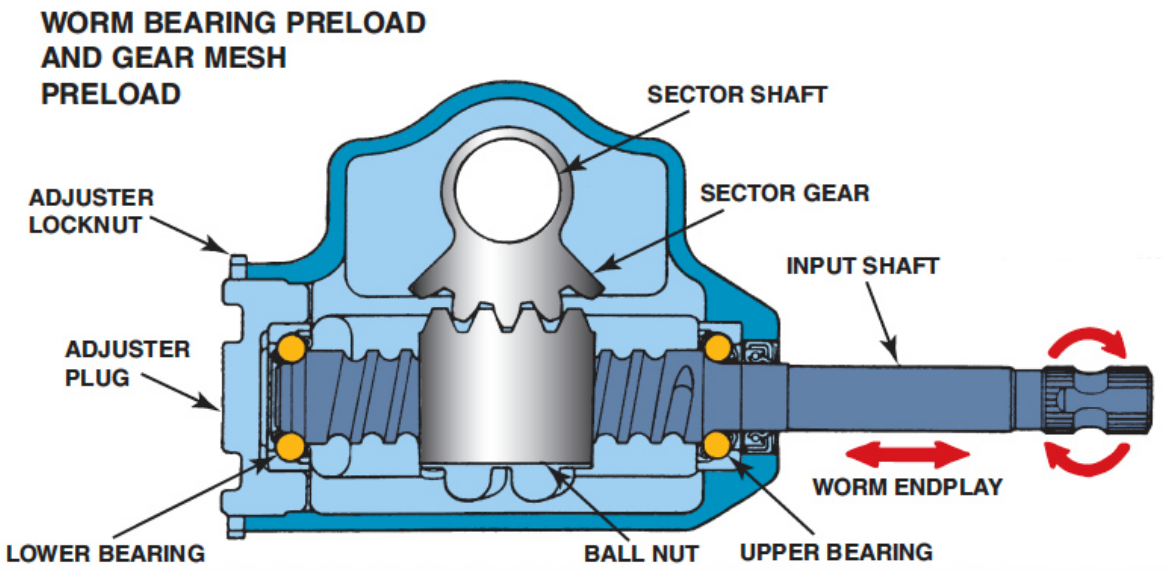

Figure 31. Worn shaft end play or preload is adjusted at the adjuster plug.

Gear mesh preload (overcenter adjustment) determines how sensitive the steering gear is to small steering wheel movements during straight-ahead driving. Insufficient preload contributes to steering wander.

Gear mesh preload is usually measured in a 90-degree turn across the center of the input shaft movement. After the worm bearing preload procedure has been completed, use the torque wrench to measure the rotating torque, which should be 6- to 15 inch-pounds. If the rotating torque is within the specified range, adjust the overcenter adjustment screw until you achieve 6- to 10 inch-pounds more rotating torque and then tighten the retaining nut. Figure 32.

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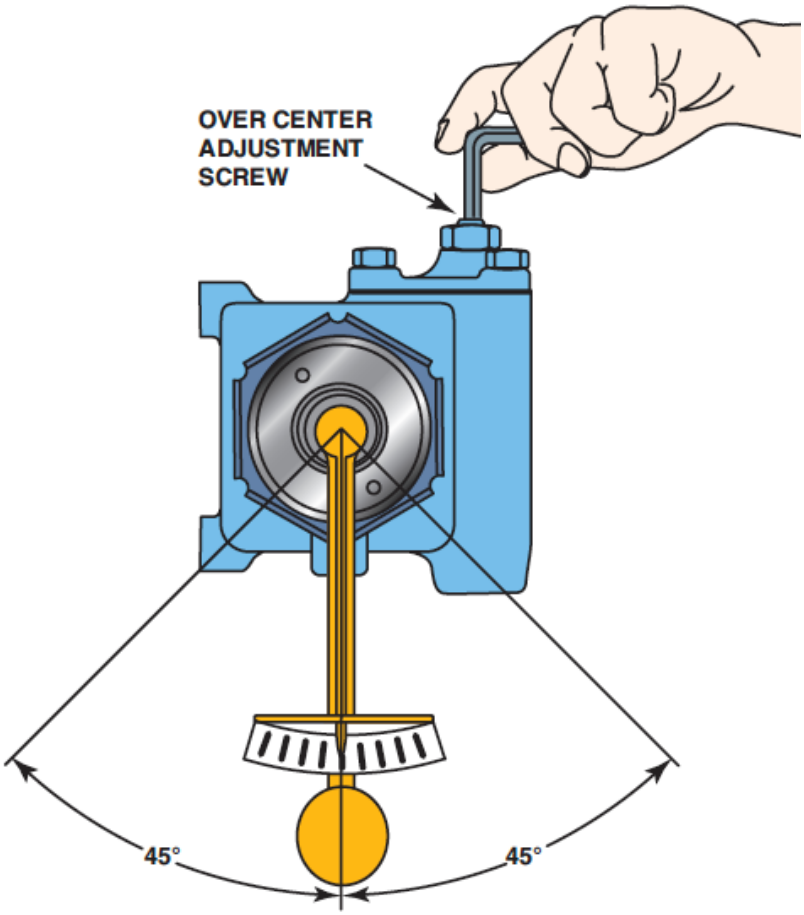

Figure 32. The overcenter adjustment is done while moving the torque wrench back and forth over the straight ahead position.

6. Adjust rack and pinion steering gear.

Pinion bearing preload in a rack-and-pinion steering gear is the same concept as worm bearing preload in a standard steering gear. To provide for the adjustment, there may be a threaded adjustment mechanism or selectively sized shims that install behind a shim cover. Figure 33.

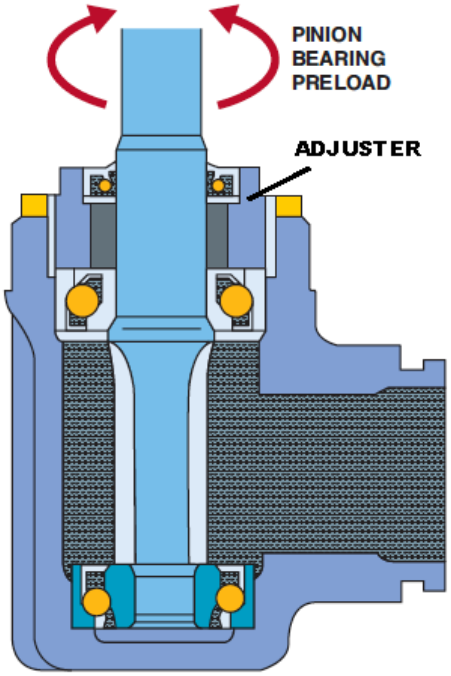

Figure 33. Pinion preload adjustment.

To adjust the rack-to-pinion gear preload, loosen the rack support retaining nut and tighten the adjuster nut until it bottoms. Then loosen 60 degrees (one “flat” of the six-sided retainer). Tighten retaining nut. Figure 34.

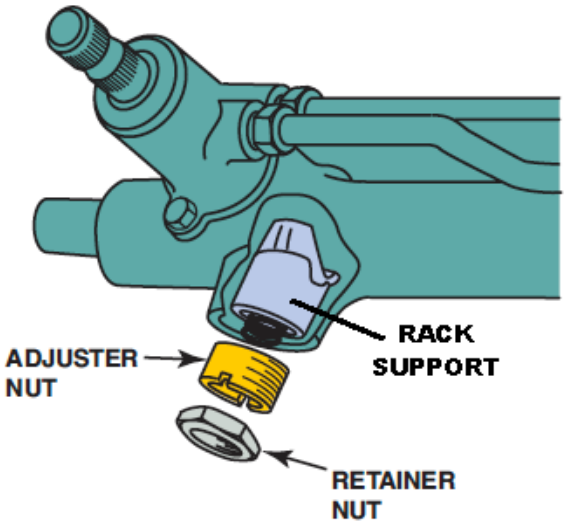

Figure 34. Rack-to-pinion mesh (preload) adjustment.

17. Inspect and replace rack and pinion steering gear bellows/boots.

To replace a rack and pinion boot, Figure 35:

- Disconnect the inner tie rod from the outer tie rod and remove the adjuster nut.
- Loosen or remove the boot clamps.
- Slide the boot off the inner tie rod and install the new boot and clamps. Make sure the air bleed tube is attached (if used) Figure 36.

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- Check and adjust the toe setting on the front wheels.

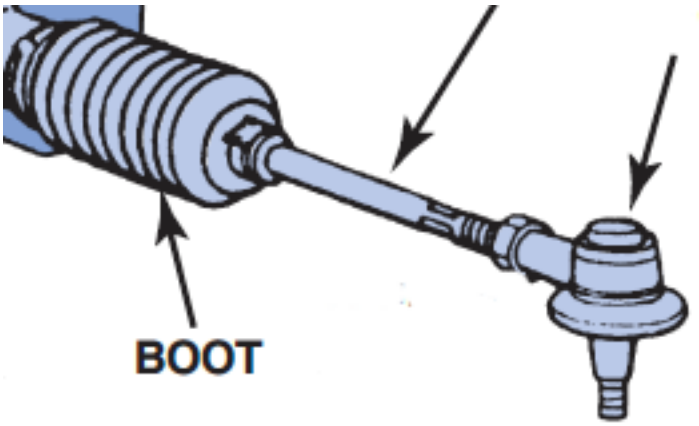

Figure 35. Disconnect the inner tie rod from the outer tie rod and remove the boot.

Figure 36. Air bleeder tube, usually on power assisted rack and pinion gears.

18. Flush, fill, and bleed power steering system.

Whenever there is any power steering service performed, such as replacement of a defective pump or steering gear or rack and pinion unit, the entire system should be flushed.

STEP 1 Raise the front wheels off the ground.

STEP 2 Remove the low-pressure return hose from the pump and plug the line fitting on the pump.

STEP 3 Place the low-pressure return hose into an empty container.

STEP 4 Fill the pump reservoir with fresh fluid and start the engine.

STEP 5 As the old and dirty power steering fluid is being pumped into the container, keep the reservoir full of clean fluid while the assistant turns the steering wheel full lock one way to full lock the other way

STEP 6 When the fluid runs clean, stop the engine and reattach the low-pressure return hose to the pump reservoir.

STEP 7 Restart the engine and fill the reservoir to the full mark. Turn the steering wheel back and forth, avoiding the stops one or two times to bleed any trapped air in the system.

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19. Diagnose, inspect, repair or replace components of variable-assist steering systems.

Variable-effort steering (VES) systems are designed to provide variable power-assisted steering. The amount of power assist increases at lower vehicle speeds to aid parking maneuvers and decreases at higher speeds for greater road feel. Most vehicles now do this via electric power-steering units.

Depending on the system, the components of variable effort power steering may include:

- Vehicle speed sensor
- Power steering control module (PSCM), PCM, or ABS control module
- Steering wheel speed sensor or position sensor
- Various type of solenoid actuators
- Magnetic actuator (Magnasteer®)

20. Diagnose, inspect, adjust, repair or replace components (including motors, sensors, switches, actuators, harnesses, and control units) of rack-mounted, electronically controlled, electrically assisted steering systems; initialize systems as required.

Many of today's vehicles use electric power steering (EPS) systems. Electric power steering takes the place of hydraulic components that were previously used by using an electric motor to provide power assist effort.

The rack-mounted system has the assist motor attached to the rack and is often called a rack-and-pinion electric power steering (R-EPS) system. One design has the assist motor surrounding the rack; this style is called a direct-drive electric power steering (D-EPS) system. Figure 37.

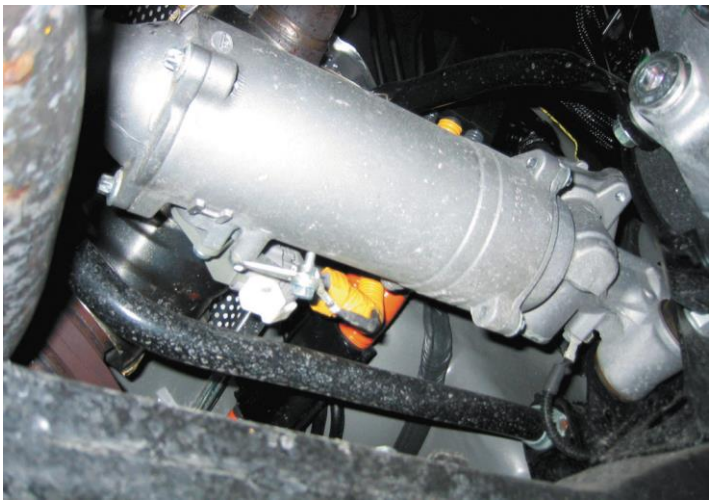

Figure 37. The electric motor surrounds the rack in this type.

Another design has the assist motor attached to the rack housing and drives a ball screw with a belt to move the rack. Figure 38.

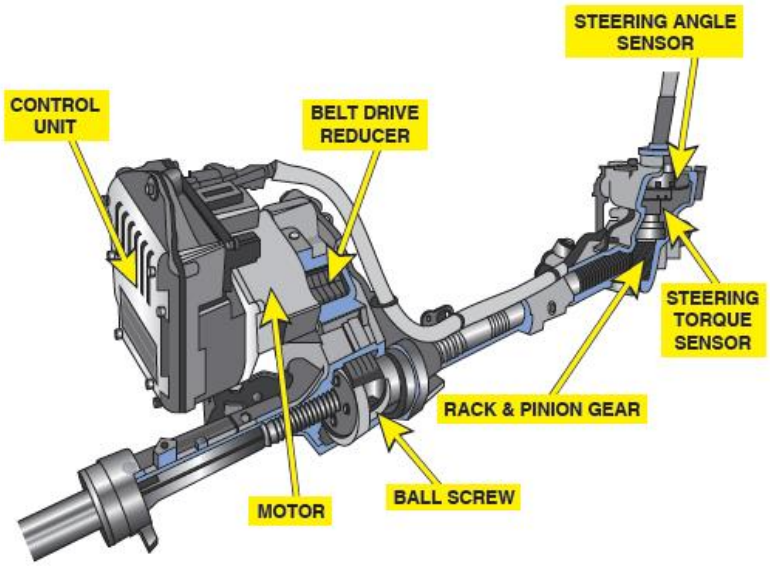

Figure 38. A belt driven electric power steering rack and pinion assembly.

The electric power steering (EPS) is controlled by the EPS electronic control unit (ECU), which calculates the amount of needed assist based on the input from the steering torque sensor. On a rack mounted electric steering system the torque sensor and the steering angle sensor are mounted inside the rack input shaft housing (refer to figure 38).

The ECU has the ability to detect malfunctions within the power steering system. Any malfunction detected will cause the driver information center to display the power steering warning message and/or a power steering malfunction indicator. Figure 39.

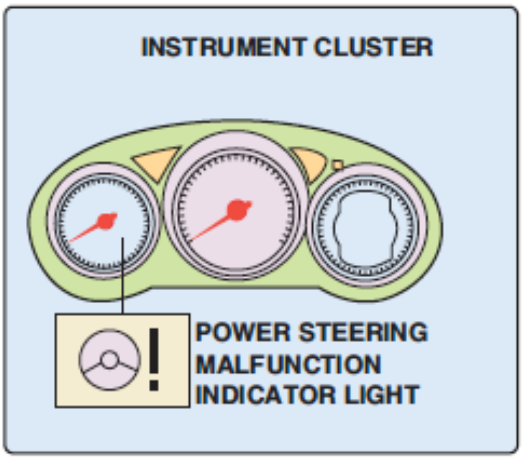

Figure 39. Electric steering fault indicator.

The ECU must also be set up with the correct steering tunings, which are different in relation to the vehicle's power train configuration, model type, and tire and wheel size. A factory or aftermarket factory-level scan tool is needed to retrieve data and to perform relearn procedures if the unit is replaced.

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► **Steering Linkage**

21. Inspect and adjust (where applicable) front and rear steering linkage geometry.

The steering linkage relays steering forces from the steering gear to the front wheels. Most conventional steering linkages use the parallelogram type design. This type of linkage uses four tie rods, two inner and two outer (left and right), a center link (between the tie rods), and an idler arm on the passenger side and a pitman arm attached to the steering gear output shaft (pitman shaft). Figure 40.

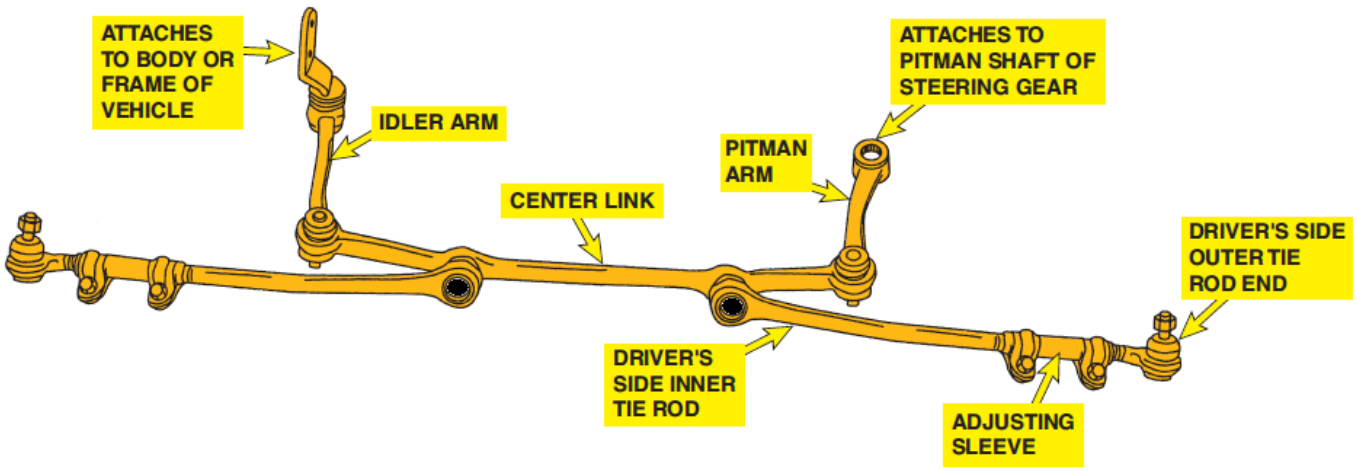

Figure 40. Typical conventional (non-rack and pinion) steering linkage.

The steering linkage should be inspected for loose or bent components which may change the designed geometry of the linkage. Figure 41.

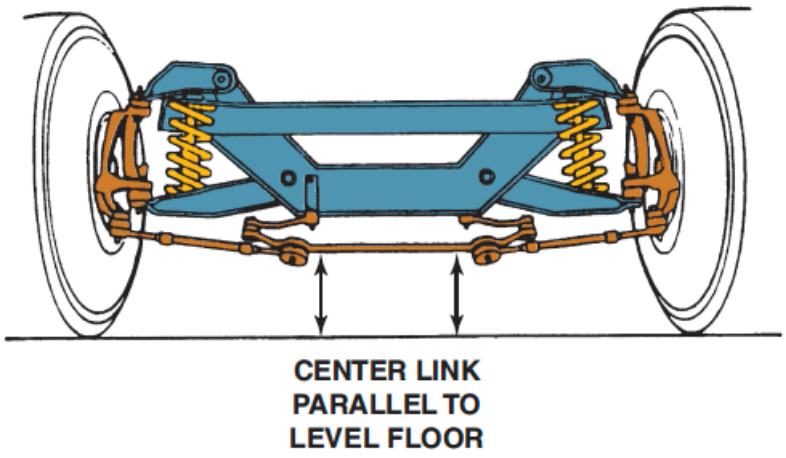

Figure 41. Check the center link. If not level, a bent or misadjusted idler arm could be the cause.

22. Inspect and replace pitman arm.

Pitman arms require a larger puller to remove the pitman arm from the splines of the pitman shaft. Replace the pitman arm using the hardware and fasteners supplied with the replacement part. Figures 42 and 43.

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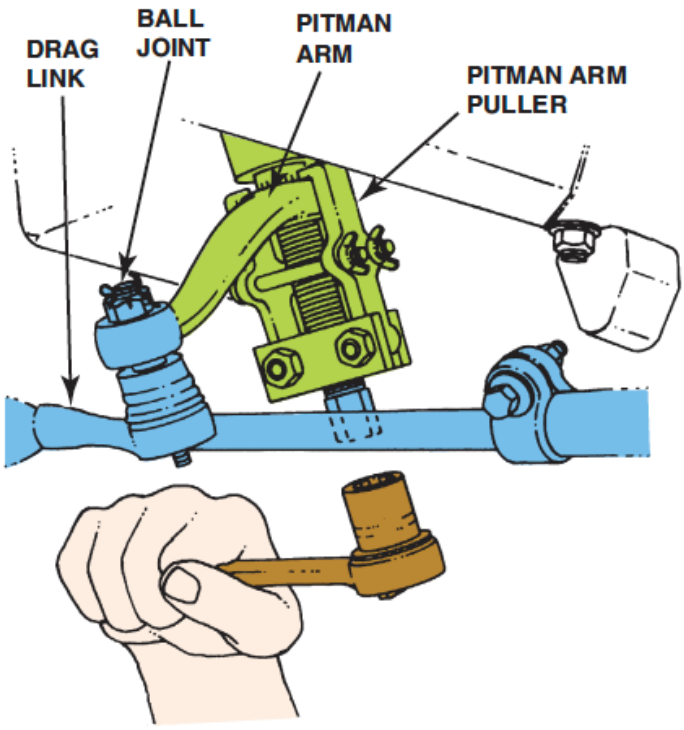

Figure 42. Removing the pitman arm from the steering gear sector shaft.

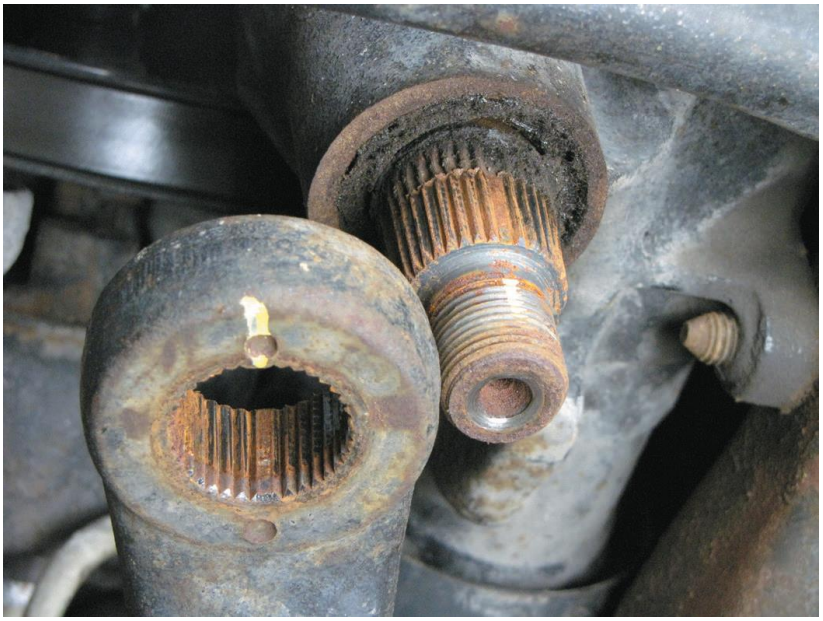

Figure 43. Align the wide index splines when installing the pitman arm.

23. Inspect and replace center link (relay rod/drag link/intermediate rod).

Some center links have ball joints while others have tapered socket holes to accept ball joints on the Some center links are equipped with ball-and-socket joints, which can wear. Other center links are manufactured with holes for ball-joint studs only. Figure 44.

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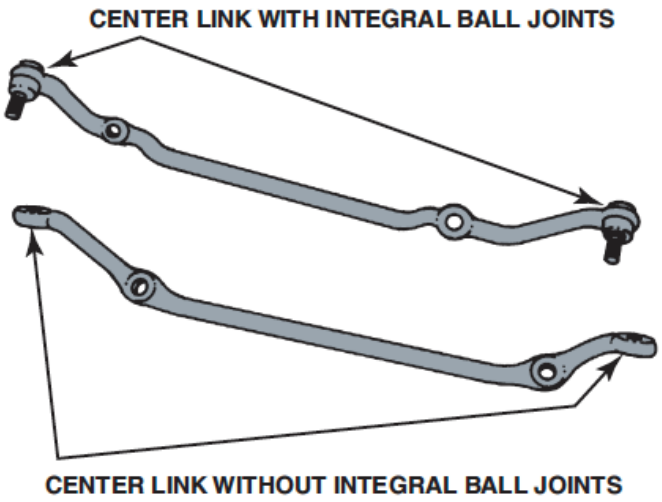

Figure 44. Two types of center link.

Generally, the center links that do not use joints are unlikely to need replacement unless a joint becomes loose and wears the tapered stud hole. Endplay in any tie rod or ball joint should be zero.

24. Inspect, adjust (where applicable), and replace idler arm and mountings.

Idler arm inspection is performed by using hand force of 25 pounds (110 N-m) up and down on the arm. If the total movement exceeds 1/4 inch (6 mm), the idler arm should be replaced. Figure 45.

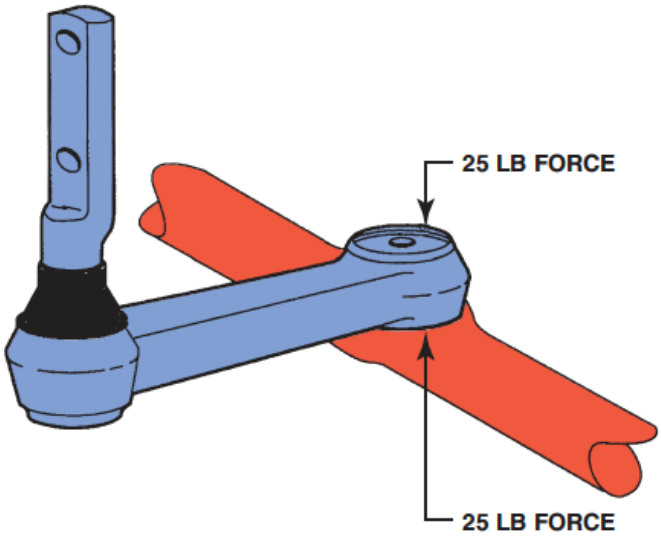

Figure 45. Checking idler arm play.

The idler arm is bolted to the vehicle frame on the passenger side. There may be a spacer or bracket, and some idler arms have elongated holes for adjustment. Figure 46.

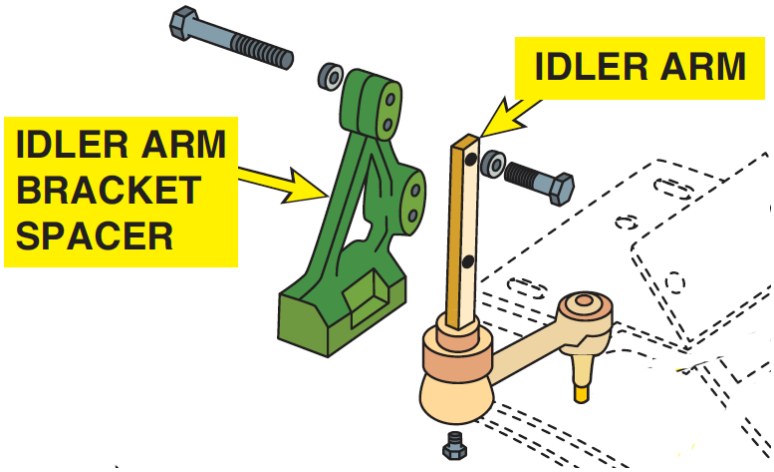

Figure 46. Idler arm and spacer.

25. Inspect, replace, and adjust tie rods, tie rod sleeves/adjusters, clamps, and tie rod ends.

Steering linkage should be tested by hand for any vertical or side-to-side looseness. Tie rod ends use ball-and-socket joints to allow for freedom of movement for suspension travel and to transmit steering forces to the front wheels. Free play in any tie rod should be zero. Figure 47.

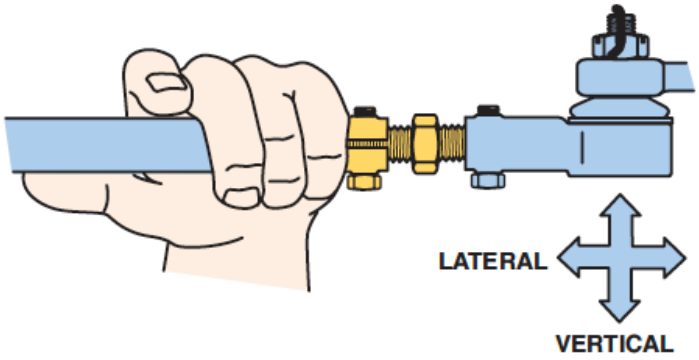

Figure 47. All joints should be checked by hand for any lateral or vertical play.

To replace a tie rod end, loosen the retainer nut and use a tie rod removal puller to break the tapered shaft loose. Remove the nut and unscrew the tie rod end from the adjusting sleeve. Figure 48.

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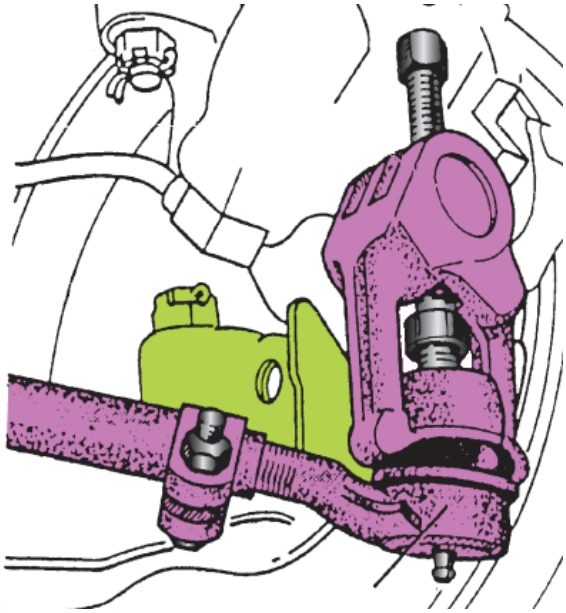

Figure 48. Tie rod end removal tool.

When replacing tie rod ends, use the adjusting sleeve to adjust the total length of the tie rod to the same position and length as the original. Measure the original length of the tie rods and assemble the replacement tie rod(s) to the same overall length. When the new tie rod is threaded to this dimension, the toe setting will be close to the original. Figures 49 and 50.

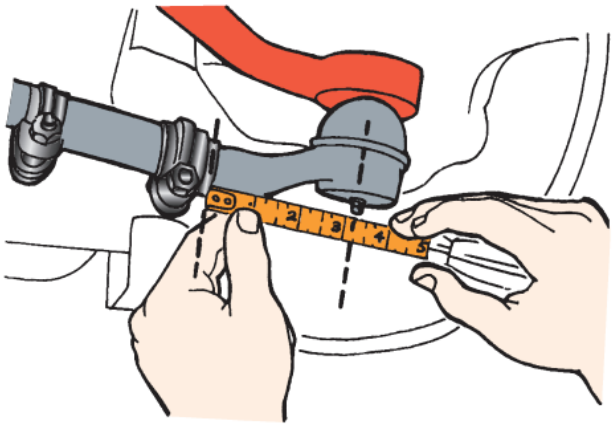

Figure 49. Measure from the adjusting sleeve to the center of the tie rod end.

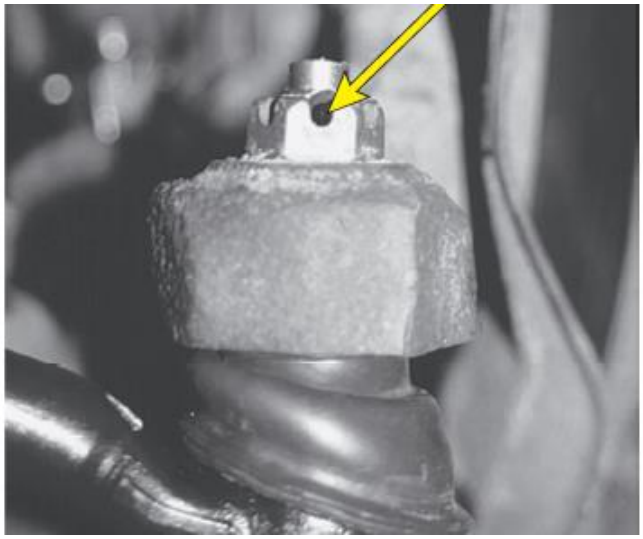

Figure 50. Align the hole in the tie rod end with the slot in the retaining nut. If the holes do not line up, always tighten the nut farther (never loosen) until the hole lines up.

Inner tie rod end assemblies used on rack-and-pinion steering units require special consideration and often special tools. Always follow the instructions that come with the replacement part(s). Figure 51.

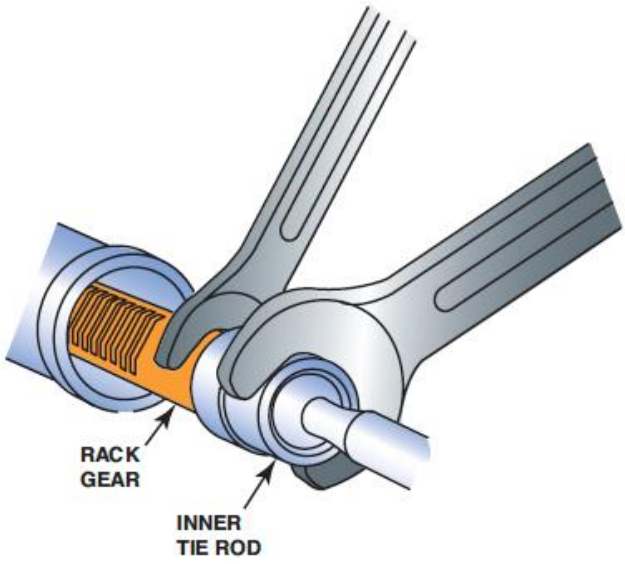

Figure 51. Removing an inner tie rod.

26. Inspect and replace steering linkage damper(s).

Many light trucks, vans, and some luxury cars use a steering dampener attached to the linkage. A steering dampener is similar to a shock absorber, and it absorbs and dampens sudden motions in the steering linkage. Figure 52.

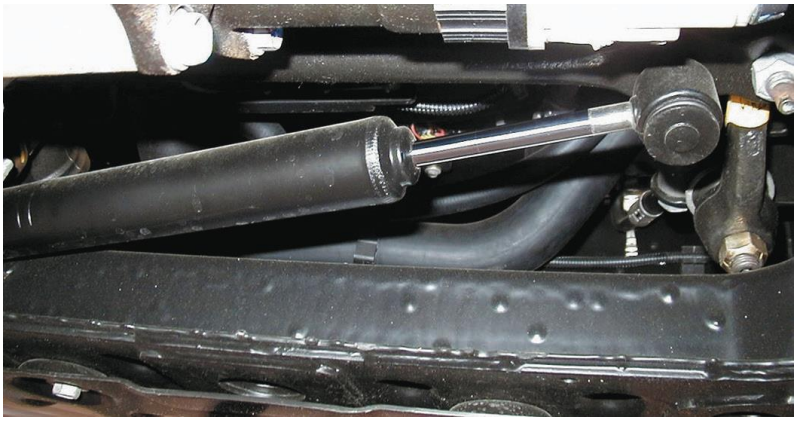

Figure 52. Inspect the steering damper for leakage and worn rubber mounts.