

2007 STEERING SYSTEMS

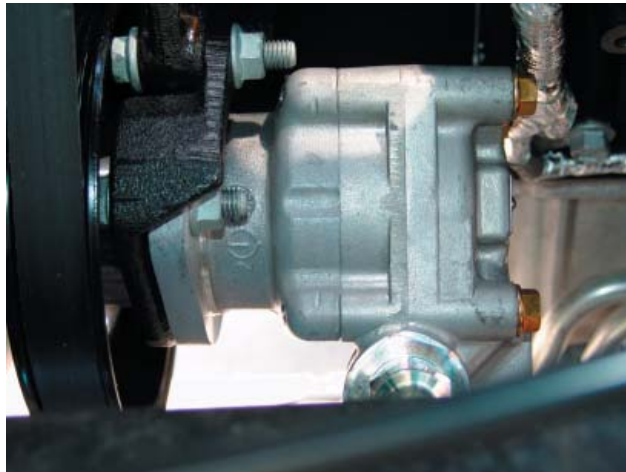


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GENERAL INFORMATION

OBJECTIVES OF THIS SECTION

This section is intended to provide information regarding the power steering gear system included on the W Series Workhorse chassis.

Guidance for proper and safe disassembly, inspection, maintenance, repair and assembly are provided.

Be sure to fully understand all instructions and procedures before beginning to service components.

Observe all Caution and Warning safety alerts that precede instructions or procedures. These alerts help to avoid damage to components, serious personal injury, or both.

Follow all established maintenance and service, installation, and diagnostics guidelines.

Use special tools when required to help avoid serious personal injury and damage to components.

SAFETY ALERTS AND SUPPLEMENTAL INFORMATION

WARNING !

A “WARNING” inserts an alert to instructions or procedures that must be followed to avoid death, serious injury or severe damage to major components. They will appear ahead of the action to which they apply.

READ AND OBSERVE ALL WARNINGS!

CAUTION

A “CAUTION” inserts an alert to instructions or procedures that should be followed to avoid injury or damage to components. They will appear ahead of the action to which they apply.

READ AND OBSERVE ALL CAUTIONS!

NOTE:

A “NOTE” provides information or suggestion that will help to correctly service a component or system. A “NOTE” is intended to be read wherever it is inserted. Notes may appear before or after the action to which they apply.

Comment, Clarification, Definition, Example, Explanation

... are useful explanations which may be read to increase understanding of procedures, functions or conditions. They may or may not be read depending upon the circumstances. They will appear after the action to which they apply.

WCC Product and Service Information Access

Visit the Workhorse website at www.workhorse.com to access and order product and service information.

Special Tool / Equipment Reference Information

The following is contact information to aid in acquiring specialized tools and equipment required to service and repair the W Series chassis.

Cummins: Contact a local authorized dealer or distributor.

Caterpillar: Contact a local authorized dealer or distributor.

Allison: Order service literature from SGI Inc., Attn: Allison Literature Fulfillment Desk, 8350 Allison Avenue, Indianapolis, Indiana 46268, or call (888) 666-5799. Visit their website at: www.allisontransmission.com.

ArvinMeritor: Call (888) 725-9355 or visit their website at: www.arvinmeritor.com.

Bendix: Visit their website at: www.bendix.com.

Dana: Call (269) 567-1000, or visit their website at: www.dana.com.

Eaton Truck Components: Visit their website at: truck.eaton.com

ZF Steering Components: Visit their website at: www.zf.com/na/.

SPX Kent-Moore: 28635 Mound Road, Warren, Michigan 48092. Call (800) 345-2233, or visit their website at: www.spxkentmoore.com.

Tiger Tools: Call (800) 661-4661, or visit website at: www.tigertool.com.

Owatonna Tools: Contact OTC Tool and Equipment Division, 655

Eisenhower Drive, Owatonna, Minnesota 55060.

Great Lakes Tool Specialties: 8530 M-89, Richland, Michigan

49083. Call (800) 877-9618 or (616) 629-9628.

Snap-On Tools: Contact the local Snap-On dealer or visit their website at: www.snapon.com

INTRODUCTION

WARNING !

To prevent serious eye injury, always wear safe eye protection when performing vehicle maintenance or service.

SYSTEM CONFIGURATION

The descriptions and procedures contained in this maintenance manual are applicable to all Workhorse W Series chassis. The power steering gear in this manual features the following components.

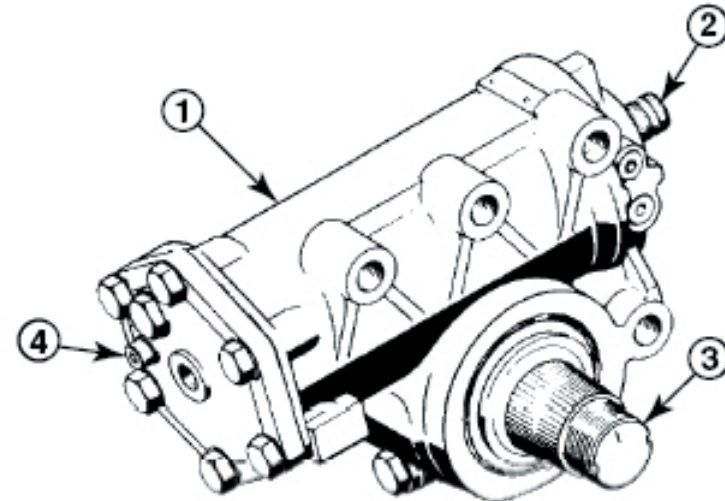


Figure 1 — Typical ZF Power Steering Gear

- 1 Steering Gear Housing
- 2 Input Shaft
- 3 Sector Shaft
- 4 Hydraulic Steering Limiter (If Equipped)

STEERING COLUMN AND HOUSING

The steering column and housing includes components between the steering wheel and the steering gear. The steering column is covered in this section as well.

POWER STEERING GEAR

The steering gear includes the ZF steering gear and internal components as mounted to the driver's side of the chassis frame.

Design Of The Power Steering Gear

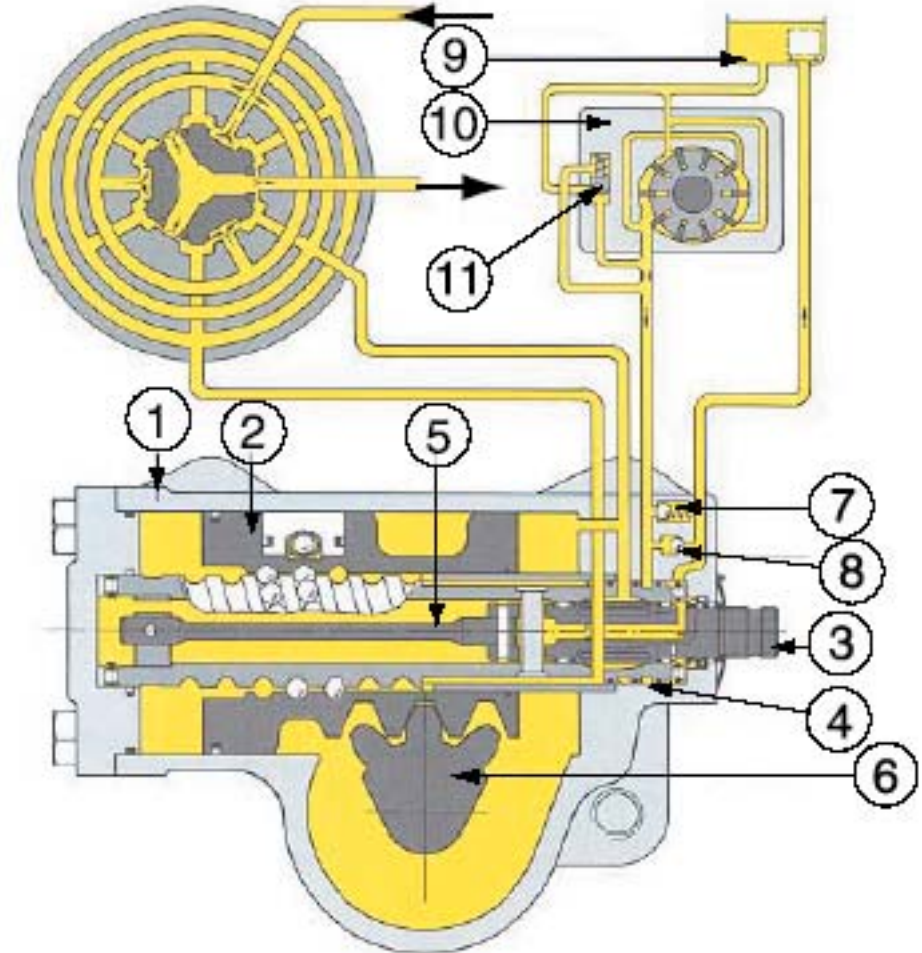
The housing of the ZF power steering gear contains the pressure relief valve, the power cylinder and a complete manual steering gear.

The steering fluid flow and the pressure needed by the steering gear is supplied by an belt-driven pump. To achieve this, the steering fluid is drawn from the steering fluid tank, through the pump and fed back to the steering fluid tank via the pump and the steering gear.

The steering gear housing (1) (Refer to Fig. 2) and the piston (2) have the function of a cylinder. The piston transforms the rotation of the steering input shaft (3) and the worm (4) into an axial motion which it transmits to the sector shaft (6).

By means of a ball chain, the piston (2) and the steering worm gear (3) are in positive engagement. As the worm rotates, the balls at one end of the chain are taken up by a recirculation tube and fed back to the other end so that an endless ball chain is formed.

The teeth of the piston (2) cause the sector shaft (6) to rotate when the piston is made to move by the operator turning the steering wheel.



- | | |
|------------------------------|-------------------------|
| 1 Steering Gear Housing | 7 Pressure Relief Valve |
| 2 Piston | 8 Replenishment Valve |
| 3 Steering Input Shaft | 9 Steering Fluid Tank |
| 4 Steering Worm/Valve Sleeve | 10 Power Steering Pump |
| 5 Torsion Shaft | 11 Flow Limiting Valve |
| 6 Sector Shaft | |

Figure 2 — Typical ZF Power Steering gear Design

The control valve consists of the valve rotor (3) which is carried in a needle bearing in the worm and is provided with six control grooves on the circumference, and of the valve sleeve (4), also with six control grooves, on the worm (4).

A torsion bar (5) pinned to the valve rotor (3) and the worm (4) keeps the control valve in mid-position as long as no effort is exerted on the steering wheel.

A pressure relief valve (7) limiting the maximum pressure within the steering system may be integrated in the steering gear housing.

In addition, a replenishment valve (8) taking in steering fluid from the return line when a steering motion takes place without hydraulic assistance is fitted to the housing or the control valve.

In comparison with constant ratio steering gears, variable ratio steering gears are more direct on-center than outside the mid-position area, which has a favourable effect on the steering performance as minor steering corrections only, if any, are required.

At the same time, in the static parking range a higher hydraulic torque is available at the sector shaft as the steering ratio is greater at larger steering wheel turning angles.

In the event of a failure of the hydraulic assistance the steering efforts at the steering wheel rim are lower in this range than they would be for a constant ratio steering gear.

Operation Of The Power Steering Gear

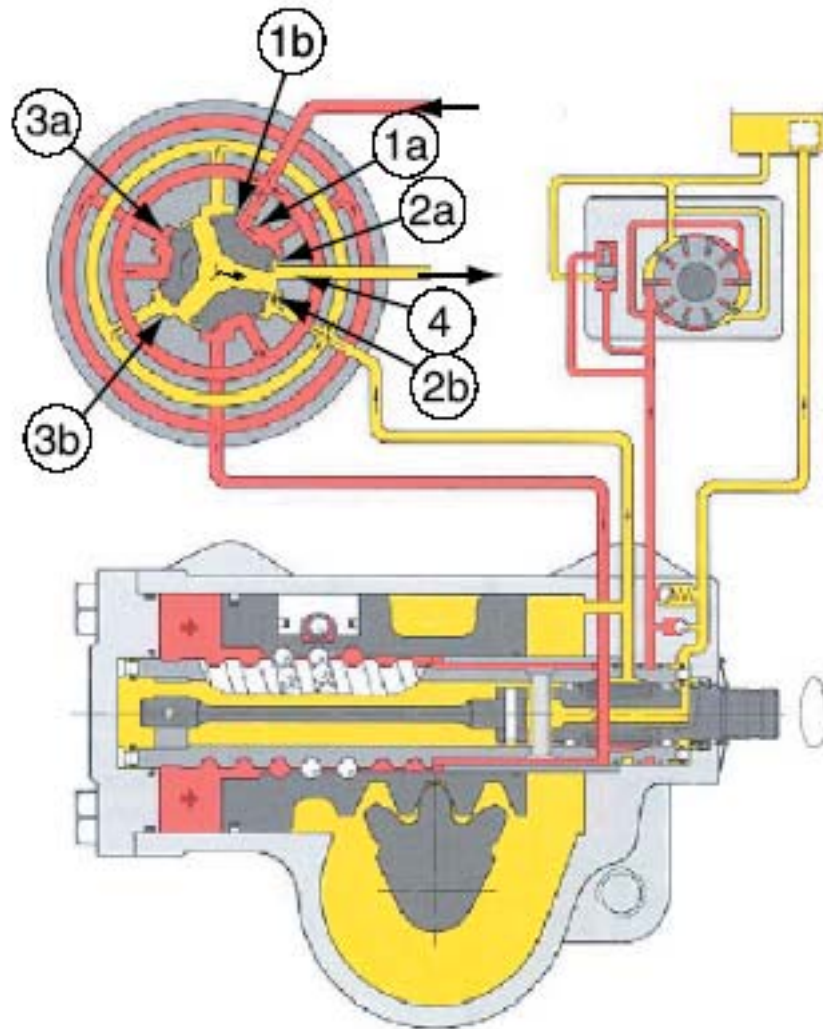
The three functional drawings Fig. 2 to Fig. 4 give a simplified representation of the valve and of the steering fluid flow. Also, these figures give a cross-sectional view of the valve to schematically represent the connections from the control valve to the cylinder chambers as well as the mode of functioning of the valve.

When torque is transmitted from the steering input shaft to the worm (or vice-versa), the torsion bar (5) is subjected to a deformation in its center, causing a twisting to occur between the valve rotor (3) and the valve sleeve (4) and thus to move the control grooves of the valve rotor away from the mid-position as compared to the position of the valve sleeve control grooves.

When the steering wheel is released, the action of the torsion bar makes the valve return to the neutral (mid) position. Through a channel in the housing, the steering fluid flows into the annular groove of the valve sleeve and is fed to the curved control grooves of the inner valve rotor through three symmetrically arranged radial bores.

The position of the control grooves in the valve rotor and the valve sleeve is such that, in the mid-position of the valve, the steering fluid can flow through the inlet slots (1) to the axial grooves (3) of the valve sleeve, which are also curved. From there, the steering fluid can freely flow through radial bores to one, each, chamber of the power cylinder.

As long as the steering valve is in the mid-position, the steering fluid can flow to both of the power cylinder chambers and, also, flow off through the three return grooves (4) in the valve rotor (3a and 3b in Fig. 3) and, from there, back to the steering fluid tank.



- | | |
|---------------|-----------------|
| 1 Inlet Slot | 3 Axial Groove |
| 2 Return Slot | 4 Return Groove |

Fig. 3 — Steering Motion to the Right

Steering Assist — Right

When the steering wheel is turned to the right, the steering input shaft / piston will rotate to the right (Fig. 3). A pressure will now build up in the left-hand cylinder chamber which is a function of the steering effort required.

To achieve this, the control grooves of the valve rotor are rotated clockwise and the inlet slots (1a) are opened wider to admit the steering fluid, while the inlet slots (1b) are closed and obstruct the feeding of steering fluid to the axial grooves (3b) of the valve sleeve.

The steering fluid will now flow through the inlet slots (1a) to the axial grooves (3a) of the valve sleeve and, from there, will pass through the ball screw thread, through the space between the recirculating balls, and flow to the left-hand cylinder chamber. The closed inlet slots (1b) prevent the steering fluid from flowing off to the tank and, thus, cause a pressure to build up on the proper side of the assembly for a right-hand turn.

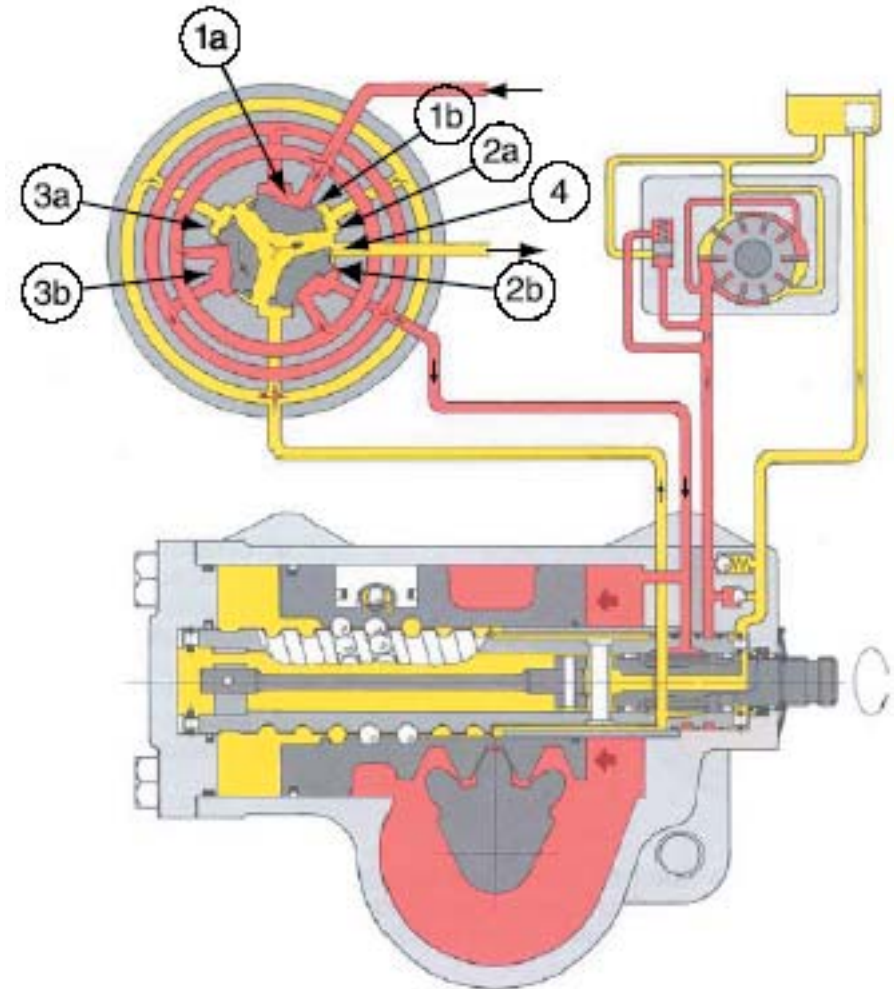
The steering fluid from the right-hand cylinder chamber is pushed out and to the steering fluid tank. Passing through the opened return slots (2b), it flows to the return grooves (4) of the valve rotor. From there, it flows through the central bore in the valve rotor and the worm and off to the steering fluid tank.

Steering Assist — Left

When the steering wheel is turned to the left, the piston is shifted to the left (Fig. 4). Therefore, pressure build-up now takes place in the right-hand (upper) cylinder chamber.

The control grooves of the valve rotor are displaced counter-clockwise and allow the steering fluid to flow through the opened inlet slots (1b) to the axial grooves (3b) from where there is a connection to the right-hand cylinder chamber.

The steering fluid from the left-hand cylinder chamber flows to the return grooves (4) of the valve rotor, via the ball screw thread and the opened return slots (2a), and can then flow off to the steering fluid tank through the central bore in the valve rotor and the worm.



- | | |
|---------------|-----------------|
| 1 Inlet Slot | 3 Axial Groove |
| 2 Return Slot | 4 Return Groove |

Fig. 4 — Steering Motion to the Left

Operation Of The Hydraulic Steering Limiter

The hydraulic steering limiter (Fig. 4) prevents steering to the lock stops at full hydraulic pressure. It, thus, protects the pump and the steering linkage and prevents excessively high steering fluid temperatures.

A double-acting steering limiting valve with spring-loaded valve pins (1 and 2) is arranged in the longitudinal direction in the piston (7). The valve pins project over the right-hand and the left-hand front faces of the piston.

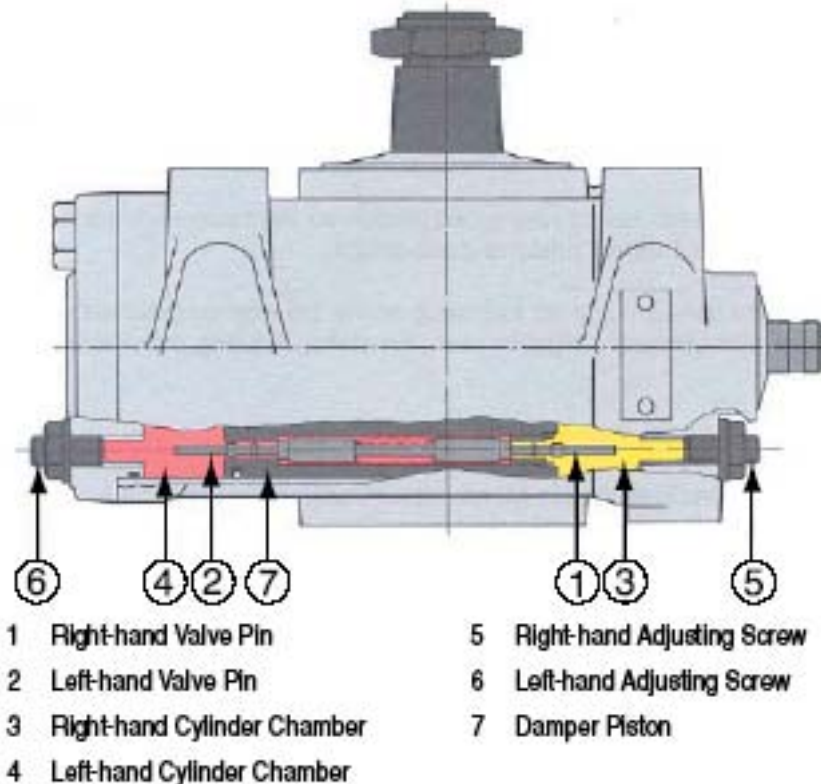


Figure 5 — Hydraulic Steering Limiter

If the piston is shifted to the right or to the left towards the lock stop, the valve pins (1 and 2) are actuated by the adjusting screws (5 and 6) fastened in the housing and in the cylinder cover. The steering limiting valve remains closed until one of the valve pins hits against an adjusting screw.

If, for example, the piston is displaced to the right, the right-hand valve pin (1) will hit against the adjusting screw (5) before the piston end position is reached, moving the right-hand plunger away from its seat. The left-hand valve pin (2) and plunger is displaced to the left by the steering fluid pressure so that the steering fluid can flow away from cylinder chamber (4) to cylinder chamber (3) and from there to the return line, reducing operating pressure. When the piston is displaced to the left, the same sequence of operations will take place.

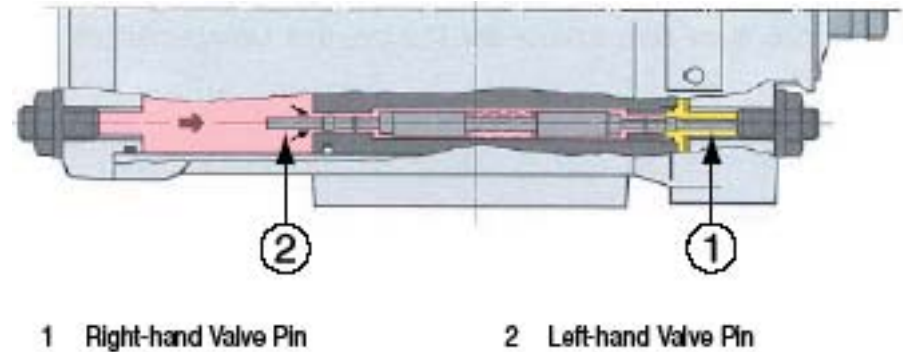


Figure 6 — Steering Limiter Piston Shifted Right

When the steering limiting valve opens, the steering gear can be turned further, but with an increased steering effort and with greatly reduced hydraulic assistance until the lock stop is reached.

Alignment Of Steering Gear

CAUTION

DO NOT turn the steering to full lock if the steering linkage is removed. Damage to parts will result.

WARNING !

Park the vehicle on a level surface. Block the wheels to prevent the vehicle from moving. Support the vehicle with safety stands. DO NOT work under a vehicle supported only by jacks. Jacks can slip and fall over. Serious personal injury and damage to components can result.

- 1 Park the vehicle on a level surface. Block the rear wheels to prevent the vehicle from moving. Set the parking brake.
- 2 Use jacks to raise the vehicle so that front tires are off the ground. Support the front of the vehicle with safety stands. The correct safety stand placement locations are inboard of the spring pads on the Ibeam front axle.
- 3 Move the steering gear to mid-position by rotating it half the total number of steering wheel turns. Then, move it further until the marks are aligned as indicated.
- 4 The steered wheels should now be in the straight ahead driving position.
- 5 If there is a noticeable difference between the straight ahead position of the steering wheel and that of the front wheels, and there is no reason to believe that the steering wheel, column, gears or linkage have been tampered with, the steering gear may be internally damaged. Install an exchange replacement steering gear.

CAUTION

If the steering wheel position is not correct and/or if an adjustment of the steering linkage turns out to be necessary, the vehicle may have been damaged in an accident.

Inspect whether the sector shaft serration is twisted (to do so, remove the Pitman arm), whether the input shaft is installed in a twisted position and whether some or all steering linkage parts are bent or have cracks. Bent or cracked components must be replaced.

INSTALLATION AND ASSEMBLY

WARNING !

To prevent serious eye injury, always wear safe eye protection when performing vehicle maintenance or service.

Replace damaged or out-of-specification components.

DO NOT bend, repair or recondition components by welding or heat-treating. Serious personal injury and damage to components can result.

Prepare Parts For Assembly

Replace Worn Or Damaged Parts

DO NOT repair or recondition steering components. Replace damaged or out-of-specification components. All major components are heat-treated and tempered.

WARNING !

Solvent cleaners can be flammable, poisonous and cause burns. Examples of solvent cleaners are carbon tetrachloride, emulsion-type cleaners and petroleum-based cleaners. To avoid serious personal injury when using solvent cleaners, carefully follow the manufacturer's product instructions and these procedures:

- **Wear safe eye protection.**
- **Wear clothing that protect skin.**
- **Work in a well-ventilated area.**
- **DO NOT use gasoline, or solvents that contain gasoline. Gasoline can explode.**
- **Use hot solution tanks or alkaline solutions correctly.**

Follow the manufacturer's instructions carefully.

CAUTION

DO NOT use hot solution tanks or water and alkaline solutions to clean ground or polished parts. Damage to parts will result.

Clean Ground Or Polished Parts

Use a cleaning solvent to clean the ground or polished parts and surfaces. Kerosene or diesel fuel can be used for this purpose. **DO NOT USE GASOLINE.**

DO NOT clean ground or polished parts in a hot solution tank or with water, steam or alkaline solutions. These solutions will cause corrosion of the parts.

Clean Rough Parts

Rough parts can be cleaned with the ground or polished parts. Rough parts also can be cleaned in hot solution tanks with a weak alkaline solution.

Parts must remain in the hot solution tanks until they are completely cleaned and heated.

Dry Cleaned Parts

Parts must be dried immediately after cleaning. Dry parts with clean paper or rags, or compressed air. **DO NOT** dry bearings by spinning with compressed air.

Prevent Corrosion On Cleaned Parts

Apply a light steering fluid to cleaned and dried parts that are not damaged and are to be immediately assembled.

If the parts are to be stored, apply a good corrosion preventative to all surfaces. Store the parts inside special paper or other material that prevents corrosion.

NOTE:

All tapered joints must be clean and dry with no lubrication or corrosion preventative applied to the mating surfaces.

- 10 Move the steered wheels of the vehicle to the straight ahead driving position. This position is reached when the front wheels are in line with the rear wheels.
- 11 Assemble the Pitman arm onto the splines of the steering gear sector shaft. Make sure that the match marks on the Pitman arm and on the sector shaft coincide.
- 12 Screw on the locking nut and tighten it, applying 275 - 330 lb-ft torque.
- 13 Attach the drag link to the Pitman arm and tighten it.
- 14 Rotate the steering gear to the left to the steering stop.
- 15 Remove the drag link from the Pitman arm.
- 16 Screw out the automatic adjusting steering limiter screws (6mm Allen screws) by two turns.
- 17 Check at the steering wheel whether any further movement to the left is possible.
- 18 If the steering gear cannot be rotated any further to the left, the lock stop or the axle stop must be re-set.

CAUTION

Steering angle limitation must occur at the axle stops and not by the steering box.

- 19 Attach the drag link to the Pitman arm and tighten.

- 20 Repeat Steps 14 through 18 to check the right-hand side and, if necessary, re-set the lock stop or the axle stop.
- 21 Screw in the automatic adjusting steering limiter screws (6mm Allen screws) by two turns. Tightening torque: 106-133 lb-in.
- 22 Attach the drag link to the Pitman arm and tighten.
- 23 Peen the locking nut.
- 24 Reconnect the hydraulic lines between the pump and the steering gear. Tighten the fasteners to the required torque value for that size fastener. Refer to 10.00.
- 25 Prior to removing the power steering fluid dipstick, thoroughly clean the steering fluid tank and its immediate surroundings to protect the steering fluid from being contaminated by impurities.
- 26 Fill the steering system with the proper fluid and bleed the system.

MAINTENANCE

WARNING !

Park the vehicle on a level surface. Block the wheels to prevent the vehicle from moving. Support the vehicle with safety stands. DO NOT work under a vehicle supported only by jacks. Jacks can slip and fall over. Serious personal injury and damage to components can result.

External Leaks

- 1 Turn the engine off.
- 2 Check the power-assisted steering gear (with its bellows), the protecting caps, pumps, valves, lines and threaded connectors for leaks and damage.
- 3 Prior to removing the power steering fluid dipstick, thoroughly clean the steering fluid tank and its immediate surroundings to protect the steering fluid from being contaminated by impurities.

NOTE:

When cleaning with a high pressure cleaning unit, make sure not to direct the water jet directly towards the sealing elements of the steering system. Penetrating water and impurities may cause malfunctions.

CAUTION

Too low an steering fluid level may cause malfunctions which can entail a failure of the steering system.

- 4 Remove the power steering fluid dipstick.
- 5 If the indicated fluid level is below the upper mark on the dipstick, add sufficient fluid to reach the top mark.

Filter Change

- 1 Turn the engine off.
- 2 Prior to removing the power steering fluid dipstick, thoroughly clean the steering fluid tank and its immediate surroundings to protect the steering fluid from being contaminated by impurities.
- 3 Pull the filter insert out of the tank.

NOTE:

Take care that oil from the filter insert does not contaminate the oil tank.

- 4 Install a new filter.

Steering Fluid Change

NOTE:

An oil change will only be needed if hydraulic components of the steering system are repaired or replaced.

CAUTION

DO NOT re-use the oil once it has been drained. Also, avoid any blending of oils.

- 1 Jack up the steered axle. Support the front of the vehicle with safety stands. The correct safety stand placement locations are inboard of the spring pads on the I-beam front axle.
- 2 Fix a container beneath the pressure and return lines to collect the draining power steering fluid.
- 3 Unscrew the pressure and return lines at the steering box.
- 4 Start the engine and allow it to run for a short time (10 seconds maximum) to evacuate the oil from the pump and from the oil tank.
- 5 Fix a container beneath the steering gear to collect the draining power steering fluid.
- 6 Remove the screw from the bottom of the steering gear.
- 7 Rotate the steering gear by hand from lock to lock until no more oil is draining from the bottom of the steering gear.

NOTE:

Even if all components mentioned above have been opened, there may be some residual fluid left in the steering box. A complete draining of the steering gear may be necessary depending on the amount of impurities in the oil. If this is the case, the steering gear must be removed from the vehicle and sent to a ZF Service Center.

- 8 Attach the pressure and return lines.
- 9 Attach the screw to the bottom of the steering gear. Apply 106 - 133 lbin torque.

Steering Fluid Filling

CAUTION

There is risk of impurities entering the steering system when additions are made to the reservoir. Maximum cleanliness is required to prevent contamination.

- 1 Remove the power steering fluid dipstick.
- 2 Fill the tank to the rim with power steering fluid.
- 3 Start the engine and run it at idle speed to fill the steering system with fluid.

NOTE:

During this operation, the oil level in the tank will quickly drop. Therefore, to avoid getting air in the system, the oil tank must be watched and topped up as the fluid level drops.

- 4 When the steering system is filled to such an extent that the oil level does not drop below the upper mark of the oil dipstick any longer, allow the engine to idle for 2-3 more minutes. Rotate the steering wheel from lock to lock several times and, while doing so, watch the fluid level. If required, top up with fluid.
- 5 With the engine running, open the bleeder until only steering fluid, free of bubbles, is coming out.
- 6 Close the bleeder and tighten to 266 lb-in torque. Replace bleeder dust cap.

A preliminary inspection of the system may be performed for problem identification, prevention or problem-solving. A problem may be suspected because of irregular functioning of the steering system or operator complaint.

Removal may be necessary to gain access to other components. Perform a thorough visual inspection to check for:

- Broken attachment brackets

Steer Axle Performance

Check performance of the steering axle to ensure that any steering concerns are not caused by or made worse by incorrect adjustment or broken parts in the steering axle, knuckles, tie rods or other components covered this manual.

INSTALLATION

WARNING !

To prevent serious eye injury, always wear safe eye protection when performing vehicle maintenance or service. Replace damaged or out-of-specification pumps or components.

Prepare Parts For Assembly

Replace Worn Or Damaged Parts

DO NOT repair or recondition steering components. Replace damaged or out-of-specification components. All major components are heat-treated and tempered.

WARNING !

Solvent cleaners can be flammable, poisonous and cause burns. Examples of solvent cleaners are carbon tetrachloride, emulsion-type cleaners and petroleum based cleaners. To avoid serious personal injury when using solvent cleaners, carefully follow the manufacturer's product instructions and these procedures:

- *Wear safe eye protection.*
- *Wear clothing that protects skin.*
- *Work in a well-ventilated area.*
- *DO NOT use gasoline, or solvents that contain gasoline. Gasoline can explode.*
- *Use hot solution tanks or alkaline solutions correctly.*

Follow the manufacturer's instructions carefully.

CAUTION

DO NOT use hot solution tanks or water and alkaline solutions to clean ground or polished parts. Damage to parts will result.

Clean Ground Or Polished Parts

Use a cleaning solvent to clean the ground or polished parts and surfaces. Kerosene or diesel fuel can be used for this purpose. DO NOT USE GASOLINE.

DO NOT clean ground or polished parts in a hot solution tank or with water, steam or alkaline solutions. These solutions will cause corrosion of the parts.

Clean Rough Parts

Rough parts can be cleaned with the ground or polished parts. Rough parts also can be cleaned in hot solution tanks with a weak alkaline solution. Parts must remain in the hot solution tanks until they are completely cleaned and heated.

Dry Cleaned Parts

Parts must be dried immediately after cleaning. Dry parts with clean paper or rags, or compressed air. DO NOT dry bearings by spinning with compressed air.

Prevent Corrosion On Cleaned Parts

Apply a light oil to cleaned and dried parts that are not damaged and are to be immediately assembled. If the parts are to be stored, apply a good corrosion preventative to all surfaces. Store the parts inside special paper or other material that prevents corrosion.

NOTE:

All tapered joints must be clean and dry with no lubrication or corrosion preventative applied to the mating surfaces.

INSPECT PARTS

Inspect and replace any parts that are worn, cracked or damaged.

LUBRICATION AND MAINTENANCE

WARNING !

To prevent serious eye injury, always wear safe eye protection when performing vehicle maintenance or service.

NOTE:

Refer to inspection procedures in this section. Refer to lubrication, inspection and maintenance schedules based on vehicle usage.

SCHEDULES AND SPECIFICATIONS

Specification

The approved lubricant for the power steering system on Workhorse vehicles is automatic transmission fluid meeting GM Dexron-VI specification.

Maintenance

WARNING !

Park the vehicle on a level surface. Block the wheels to prevent the vehicle from moving. Support the vehicle with safety stands. DO NOT work under a vehicle supported only by jacks. Jacks can slip and fall over. Serious personal injury and damage to components can result.

External Leaks

- 1 Turn the engine off.
- 2 Check the power-assisted steering gear (with its bellows), the protecting caps, pumps, valves, lines and threaded connectors for leaks and damage.
- 3 Prior to removing the power steering fluid dipstick, thoroughly clean the steering fluid tank and its immediate surroundings to protect the steering fluid from being contaminated by impurities.

NOTE:

When cleaning with a high pressure cleaning unit, make sure not to direct the water jet directly towards the sealing elements of the steering system. Penetrating water and impurities may cause malfunctions.

CAUTION

Insufficient steering fluid level may cause malfunctions which can result in failure of the steering system.

- 4 Remove the power steering fluid dipstick.
- 5 If the indicated fluid level is below the upper mark on the dipstick, add sufficient fluid to reach the top mark.

FILTER CHANGE

- 1 Turn the engine off.
- 2 Prior to removing the power steering fluid dipstick, thoroughly clean the steering fluid tank and its immediate surroundings to protect the steering fluid from being contaminated by impurities.
- 3 Pull the filter insert out of the tank.

NOTE:

Take care that oil drops from the filter insert do not contaminate the oil tank.

- 4 Install a new filter.

Steering Fluid Change

NOTE:

An oil change will only be needed if hydraulic components of the steering system are repaired or replaced.

CAUTION

DO NOT re-use the oil once it has been drained. Also, avoid any blending of oils.

- 1 Jack up the steered axle.
- 2 Place a container beneath the pressure and return lines to collect the draining power steering fluid.
- 3 Unscrew the pressure and return lines at the steering box.
- 4 Start the engine and allow it to run for a short time (10 seconds maximum) to evacuate the oil from the pump and from the oil tank.
- 5 Place a container beneath the steering gear to collect the draining power steering fluid.
- 6 Remove the screw from the bottom of the steering gear.
- 7 Rotate the steering gear by hand from lock to lock until no more oil is draining from the bottom of the steering gear.

NOTE:

Even if all components mentioned above have been opened, there may be some residual fluid left in the steering box. A complete draining of the steering gear may be necessary depending on the amount of impurities in the oil. If this is the case, the steering gear must be removed from the vehicle and sent to a ZF Service Center.

- 8 Attach the pressure and return lines.
- 9 Attach the screw to the bottom of the steering gear.
Apply 106 - 133 lb in torque.
- 10 Continue to 8.02-04 if refilling immediately.

POWER STEERING PUMP

The W Series chassis uses an engine-mounted belt-driven power steering pump.

INITIAL INSPECTION

WARNING !

To prevent serious eye injury, always wear safe eye protection when performing vehicle maintenance or service. Park the vehicle on a level surface. Block the wheels to prevent the vehicle from moving. Support the vehicle with safety stands. DO NOT work under a vehicle supported only by jacks. Jacks can slip and fall over. Serious personal injury and damage to components can result. Replace damaged or out-of-specification steering components.

DO NOT bend, repair or recondition steering components by welding or heat-treating. Serious personal injury and damage to components can result.

A preliminary inspection of the system may be performed for problem identification, prevention or problem-solving. A problem may be suspected because of irregular functioning of the steering system, operator complaint or to gain access to componentry.

Perform a thorough visual inspection to check for:

- Broken attachment brackets
- Visible fluid leaks
- Damaged or worn bushings
- Poorly mounted parts

Specifically observe leaking or worn hose fittings and tubing, interference between parts and the tightness of mounting of the gear.

Inspect Parts

Fasteners

- 1 Verify that all fasteners in the steering system (steering column, steering gear, drag links, idler arm and tie rods) are tightened to the specified torque. Refer to 10.00 and Sec 3.1 or Sec 3.2.
- 2 Use a torque wrench to check the torque. As soon as the fastener starts to move, record the torque. Correct if necessary.
- 3 Replace any worn or damaged fasteners.
- 4 Check whether the locking plate and split pin are still secured.

Wear And Damage

Inspect the parts of the steering gear for wear and damage. Look for bent, leaking or cracked parts. Replace all worn or damaged parts.

PIVOT POINTS AND U-JOINTS

Verify that pivot points are not loose. Verify that the pivot points are lubricated.

OPERATION

Verify that all the parts move smoothly through the complete turning arc.

STEERING COLUMN ATTACHMENT BOLTS

Check the torque on all steering gear bolts every 200,000 miles.

FUNCTIONAL TEST

CAUTION

If the specified values called for are not met, the pump **must be replaced.**

NOTE:

The test equipment required for this series of tests is part number 5517641, Pressure Flow & Test Kit from R.H. Sheppard Co. Refer to 0.07.

The pump does not need to be removed from the vehicle to perform the following tests.

1 Connect the tester into the pressure line between the pump and the steering gear. Ideally, disconnect the pressure line at the pump outlet and install the tester in the line at that location.

CAUTION

The lines and fittings must be rated at least 1450 psi capacity.

2 Verify that the fluid in the test system meets the Workhorse specification.

NOTE:

During the following tests, pay special attention to the possible appearance of external leaks of fluid and increase in noise level from the pump.

3 Run the pump at engine idle rpm and 145 psi for 1 minute.

NOTE:

Pressure and flow rate are adjustable by turning the hand wheel shut-off valve on the tester.

4 Run the pump at 1000 engine rpm and 145 psi for 1 minute.

5 Verify that the fluid temperature is in the range 104°F to 140°F.

CAUTION

DO NOT fully close the shut-off valve. Extreme high pressure will destroy the pump.

6 Record the maximum pressure from the type plate on the pump.

7 Run the engine at 1300 rpm.

8 Slowly close the shut-off valve on the tester until the pressure reaches the maximum (step 6) plus 290 psi.

9 Open the valve to permit the pressure to drop to at least the maximum (step 6).

10 Repeat steps 8 and 9 two more times.

11 Run the engine at 1700 rpm and 145 psi.

12 Verify that the flow rate indicated is within tolerance of +20% to -10% of the maximum pressure from the type plate on the pump (step 6).

Example

If indicated flow rate is 6.1 L / min (=1.61 gal / min), the acceptable flow rate is 1.47 to 1.93 gal / min.

13 Run the engine at 2200 rpm and 145 psi.

14 Repeat step 12.

REMOVAL AND DISASSEMBLY

WARNING !

To prevent serious eye injury, always wear safe eye

protection when performing vehicle maintenance or service. Park the vehicle on a level surface. Block the wheels to prevent the vehicle from moving. Support the vehicle with safety stands. DO NOT work under a vehicle supported only by jacks. Jacks can slip and fall over.

Serious personal injury and damage to components can result.

To guarantee a safe functioning of the pump, absolute cleanliness must be the top priority during disassembly and storage of the parts. During disassembly, DO NOT use any force for this may damage o-rings, seats, sealing surfaces, etc., which may lead to the failure of the pump.

Steering Pump Removal

1 Park the vehicle on a level surface.

2 Block the wheels to prevent the vehicle from moving.

3 Raise the steering axle so that the wheels are off the ground. Use a suitable jack or other lifting tool. Support the front of the vehicle with safety stands. The correct safety stand placement locations are inboard of the spring pads on the I-beam front axle.

4 Position a container beneath the pressure and return lines to collect the draining power steering fluid.

5 Unscrew the pressure and return lines at the steering box. Mark the lines and the pump body to ensure that the lines may be returned to their correct location.

- 6 Start the engine and allow it to run for a short time (10 seconds maximum) to evacuate the oil from the pump and from the oil tank.
- 7 When the pump and lines are clear of fluid, turn off the engine and then disconnect the lines from the pump.
- 8 Remove the bolts attaching the pump to the engine.

Steering Pump Disassembly

NOTE:

The ZF Vane Pump used in the power steering system on Workhorse W Series chassis is not servicable by Workhorse Service Centers at this time. Contact ZF directly.

The power steering pump may not be disassembled. If internal service is required, it must be returned to ZF Industries.

INSTALLATION

WARNING !

To prevent serious eye injury, always wear safe eye protection when performing vehicle maintenance or service.

Replace damaged or out-of-specification pumps or components.

Prepare Parts For Assembly

Replace Worn Or Damaged Parts

DO NOT repair or recondition steering components. Replace damaged or out-of-specification components. All major components are heat-treated and tempered.

WARNING !

Solvent cleaners can be flammable, poisonous and cause burns. Examples of solvent cleaners are carbon tetrachloride, emulsion-type cleaners and petroleum based cleaners. To avoid serious personal injury when using solvent cleaners, carefully follow the manufacturer's product instructions and these procedures:

- **Wear safe eye protection.**
- **Wear clothing that protects skin.**
- **Work in a well-ventilated area.**
- **DO NOT use gasoline, or solvents that contain gasoline. Gasoline can explode.**
- **Use hot solution tanks or alkaline solutions correctly.**

Follow the manufacturer's instructions carefully.

CAUTION

DO NOT use hot solution tanks or water and alkaline solutions to clean ground or polished parts. Damage to parts will result.

Clean Ground Or Polished Parts

Use a cleaning solvent to clean the ground or polished parts and surfaces. Kerosene or diesel fuel can be used for this purpose. DO NOT USE GASOLINE.

DO NOT clean ground or polished parts in a hot solution tank or with water, steam or alkaline solutions. These solutions will cause corrosion of the parts.

Clean Rough Parts

Rough parts can be cleaned with the ground or polished parts. Rough parts also can be cleaned in hot solution tanks with a weak alkaline solution. Parts must remain in the hot solution tanks until they are completely cleaned and heated.

Dry Cleaned Parts

Parts must be dried immediately after cleaning. Dry parts with clean paper or rags, or compressed air. **DO NOT** dry bearings by spinning with compressed air.

Prevent Corrosion On Cleaned Parts

Apply a light oil to cleaned and dried parts that are not damaged and are to be immediately assembled.

If the parts are to be stored, apply a good corrosion preventative to all surfaces. Store the parts inside special paper or other material that prevents corrosion.

NOTE:

All tapered joints must be clean and dry with no lubrication or corrosion preventative applied to the mating surfaces.

INSPECT PARTS

Inspect and replace any parts that are worn, cracked or damaged.

Fastener Adhesives

Install Fasteners Using Liquid Adhesive

WARNING !

Take care when using Loctite® to avoid serious personal injury. Follow the manufacturer's instructions to prevent irritation to the eyes and skin.

- 1 Clean the oil, dirt and old adhesive from all threads and thread holes. Use a wire brush.

CAUTION

DO NOT apply adhesive to the fastener threads. Air pressure in the hole will push the adhesive out as the fastener is installed. Damage to components can result.

- 2 Use four or five drops of Meritor liquid adhesive, Loctite® 680 adhesive or equivalent, into each threaded hole or bore only.

NOTE:

There is no drying time required for Meritor liquid adhesive 2297-C- 7049, Loctite® 680 adhesive or equivalent.

- 3 Tighten the fasteners to the required torque value for that size fastener.

Check Torque Of Dri-Loc Fasteners Not Requiring Removal

If Dri-Loc fasteners do not require removal from components, use the following procedure to check the fasteners for the correct torque value. Apply the minimum amount of torque required for that size fasteners. The fastener must not rotate.

- If the fastener rotates: Remove the fastener from the component. Inspect the fastener and the hole for wear and damage. Repair as necessary.
- If the fastener and the hole are in good condition: Apply adhesive into the threaded hole. Follow the procedure to install old Dri-Loc fasteners.

Fasteners With Pre-Applied Adhesive Patches - New Fastener Installation

- 1 Clean the oil and dirt from threaded holes. Use a wire brush to remove old patch material. There is no special cleaning required.

CAUTION

DO NOT apply adhesives or sealants on new fasteners with pre-applied adhesive patches or in the threaded holes. If other adhesives or sealants are used, the new adhesive will not function correctly. Damage to components can result.

- 2 Assemble the parts using the new pre-applied adhesive fasteners.

NOTE:

There is no drying time required for fasteners with pre-applied adhesive.

- 3 Tighten the fasteners to the required torque value for that size fastener.

Power Steering Pump Installation

- 1 Attach the pump to the engine in the location from which it was removed. Replace and tighten the attaching bolts if they are in good condition.
- 2 Reattach and tighten the pressure and return lines at the pump.
- 3 Reattach and tighten the pressure and return lines at the steering box.
- 4 Refill the steering system as described in “Steering Fluid Filling”.

ADJUSTMENTS

WARNING !

To prevent serious eye injury, always wear safe eye protection when performing vehicle maintenance or service.

There are no adjustments required on the power steering pump.

TROUBLESHOOTING

Condition	Cause	Correction
Noisy Pump	Low on fluid	Add fluid and check connections - Bleed system.
	Sucking air - oil foaming	Check connections - Bleed system
	Return flow too low	Replace steering pump - Bleed system
	Growling noise	Check for hose restrictions
	Rattling noise	Check contact between pressure hose and chassis parts
No Pressure	Stuck pressure relief valve	Remove, clean and ensure PRV smooth movement - Bleed system
	Pressure relief valve clogged	Remove foreign particles - Bleed system
Pressure too low / too high	Pressure relief valve clogged	Remove foreign particles - Bleed system
Flow rate too low - too high	Worn cam ring	Replace pump - Bleed system
	Clogged orifice	Remove foreign particles - Bleed system

FINAL INSPECTION

ROAD TEST

Test drive the vehicle to ensure smooth operation after performing service or repairs. Verify that the steering system controls the direction of the vehicle in a fully controlled manner. Return to the engine to top up the power steering pump reservoir with additional fluid as needed.

STEERING COLUMN SERVICE

DIAGNOSTIC INFORMATION AND PROCEDURES

Symptoms - Steering Wheel and Column

Review the system description and operation in order to familiarize yourself with the system functions.

Refer to Steering Wheel and Column Description and Operation.

Visual/Physical Inspection

Inspect for aftermarket devices which could affect the operation of the steering wheel and column. Inspect the easily accessible or visible system components for obvious damage or conditions which could cause the symptom.

Symptoms List

- Lock System Does Not Unlock
- Lock System Does Not Lock
- Lock System Sticks in Start
- Key Cannot Be Removed in the Off Lock Position
- High Lock Effort
- Noise in Steering Column
- High Shift Effort
- Looseness in Steering Column
- Steering Column Tilt Function Inoperative diagnostic procedure from the following list in order to diagnose the symptom: Repair Instructions

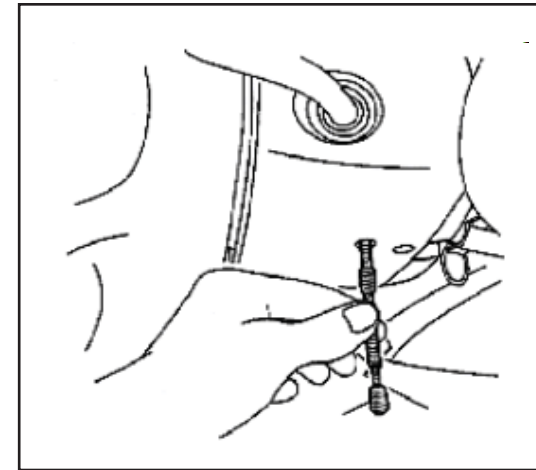
INTERMEDIATE STEERING SHAFT REPLACEMENT

Tools Required

J 42640 Steering Column Pin

Removal Procedure

1. Install the J 42640 in the steering column lower access hole.
2. Remove the protective cover from the steering column



3. Remove the bolt retaining the intermediate shaft to the steering column.
4. Mark the intermediate shaft to/Steering gear alignment before removal.
5. Position the intermediate shaft for access to the lower shaft pinch bolt. Turn the steering wheel to allow access to the pinch bolt.

IMPORTANT:

The intermediate shaft bolt contains an epoxy patch. When the intermediate shaft retaining bolt is removed it must be replaced Apply Loctite 272) N 12345493 or equivalent to the threads of the bolts.

6. Remove the intermediate shaft retaining bolt from the steering gear stub shaft.
7. Remove the intermediate shaft from the vehicle.

Installation Procedure

1. Make sure to align the marks made at removal.
2. Install the intermediate shaft to the steering gear stub shaft.

IMPORTANT:

The intermediate shaft removing bolt contains an epoxy patch. When the intermediate shaft retaining bolt is removed it must be replaced or – 5 Apply Loctite 272),~PN 12345493 or equivalent to the threads of the bolt

NOTICE

Refer to Fastener Notice in Cautions and Notices.

Install the intermediate shaft retaining bolt to the steering gear stub shaft.

Tighten

Tighten the intermediate shaft retaining bolt to the steering gear stub shaft to 61 N.m (45 lb ft).

3. Install the intermediate shaft (2) to the steering column (1).

Steering Steering Wheel and Column 2-12

IMPORTANT:

Make sure the upper cover to the steering column is inside the intermediate shaft cover.

4. Install the intermediate shaft retaining bolt (3) to the steering column (1).

Tighten

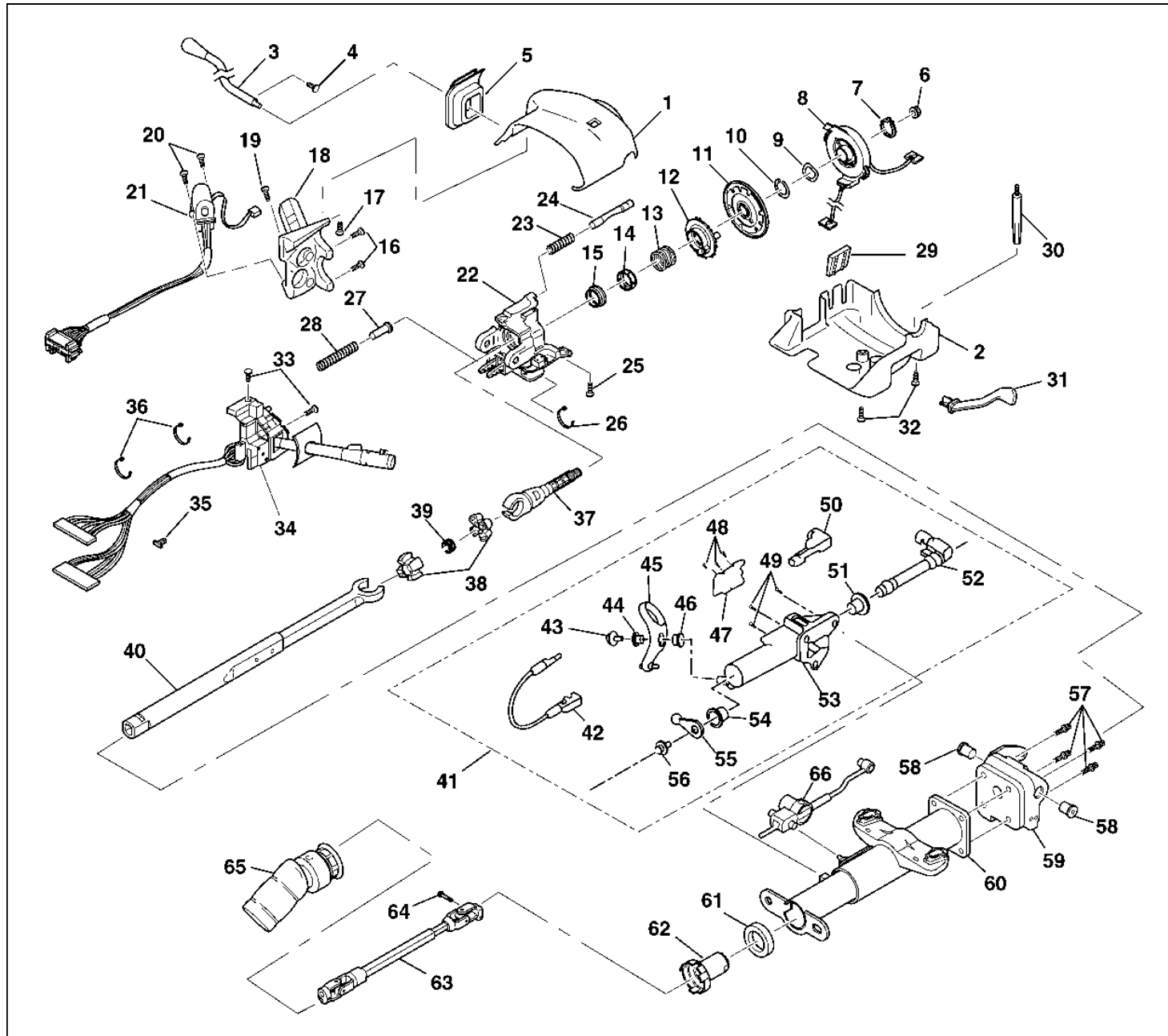
Tighten the intermediate shaft bolt to the steering column to 47 N.m (35 lb ft).

5. Remove the J 42640 from the steering column lower access hole.

STEERING STEERING WHEEL AND COLUMN

Steering Column Accident Damage Inspection

- Vehicles involved in accidents resulting in frame damage, major body or sheet metal damage or where the steering column has been impacted may also have a damaged or misaligned steering column.
- Check the capsules on the steering column bracket assembly; all must be securely seated in the bracket slots and checked for any loose conditions when pushed or pulled by hand. If not, the bracket should be replaced if bolted to the jacket assembly. If the bracket is welded to the jacket assembly replace the jacket assembly.
- Check for jacket assembly collapse by measuring the distance from the lower edge of the upper jacket to a defined point on the lower jacket. If measured dimensions are not within specifications, a new jacket must be installed.
- Visually inspect steering shaft for sheared injected plastic (1). If steering shaft shows sheared plastic, a new steering shaft must be installed.
- Any frame damage that could cause a bent steering shaft must have the steering shaft runout checked in the following manner. Using a dial indicator at the lower end of the steering shaft, have the steering wheel rotated. Runout must not exceed 1.60 mm (0.625 in).



Steering Column Assembly Exploded View

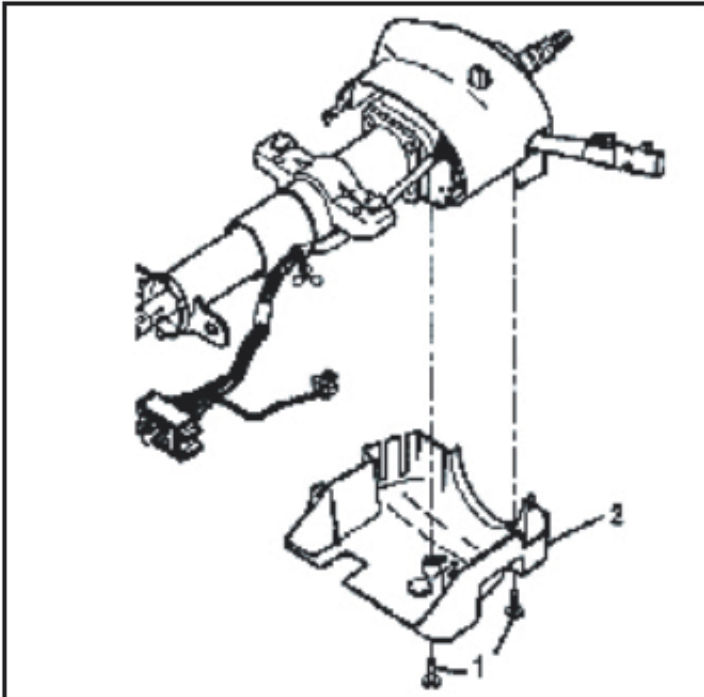
Note: Refer to the preceding illustration when performing the following operations.

Steering Column Trim Covers

Replacement

REMOVAL PROCEDURE

1. Remove the steering wheel. Refer to Steering Wheel Replacement in this section.
2. Remove the tilt lever. Refer to Tilt Lever Replacement in this section.
3. Remove the 2 pan head tapping screws (1) from the lower shroud (2).
4. Tilt the lower shroud down.
5. Slide the lower shroud backward in order to disengage the locking tabs.
6. Remove the lower shroud from the upper shroud.
7. Remove the shroud protector (1) from the lower shroud (2).
8. Remove the 2 TORX® head screws (1) from the upper shroud (2).



9. Remove the ignition lock cylinder. Refer to Ignition Lock Cylinder Replacement in this section.
10. Remove the upper shroud (2) from the steering column.

Installation Procedure

1. Install the upper shroud (2) onto the steering column.
2. Install the ignition lock cylinder. Refer to Ignition Lock Cylinder Replacement.

NOTICE:

Refer to Fastener Notice in *Cautions and Notices*.

3. Screw the 2 TORX® head screws (1) into the upper shroud (2).

Tighten

Tighten the 2 TORX® head screws to 1.5 N•m (13 lb in).

4. Install the shroud protector (1) onto the lower shroud (2).

IMPORTANT:

The shift lever seal must be seated in the shrouds.

5. Install the lower shroud onto the upper shroud.
6. Match the tab slots on the lower shroud with the locking tabs on the upper shroud.
7. Tilt the lower shroud up.
8. Slide the lower shroud forward until the locking tabs snap into the tab slots.
9. Screw the 2 pan head tapping screws (1) into the lower shroud (2).

Tighten

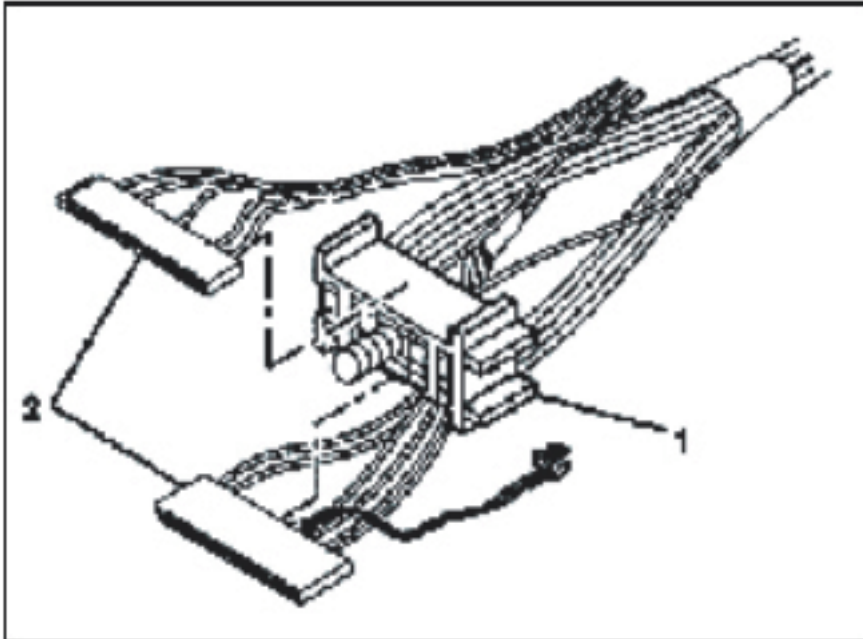
Tighten the 2 pan head tapping screws to 3.5 N.m (31 lb in).

10. Install the tilt lever. Refer to Tilt Lever Replacement in this section.
11. Install the steering wheel. Refer to Steering Wheel Replacement in this section.

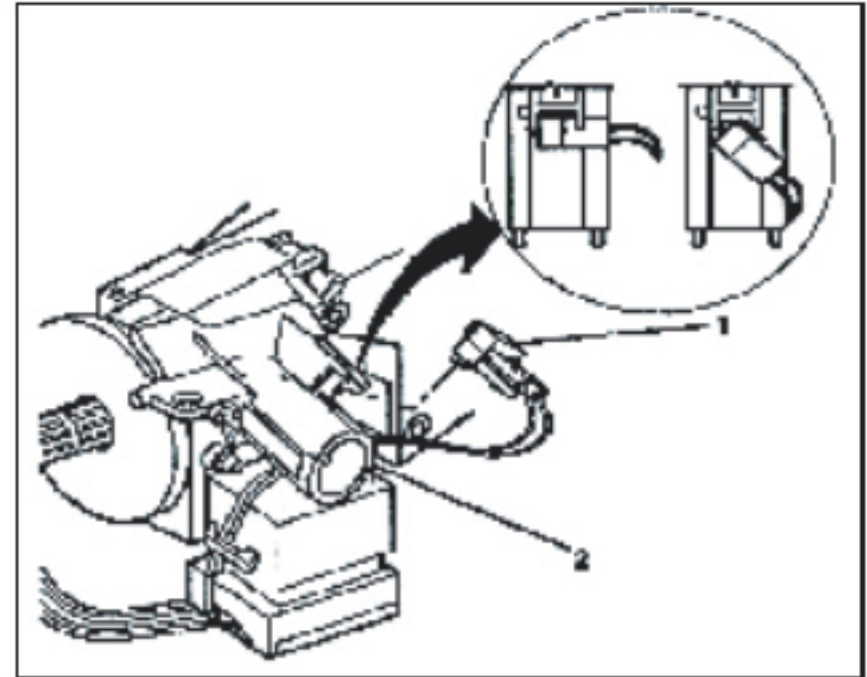
IGNITION SWITCH REPLACEMENT

Removal Procedure

1. Remove the tilt lever. Refer to Tilt Lever Replacement in this section.
2. Remove the trim covers from the column. Refer to Steering Column Trim Covers Replacement in this section.
3. Remove the knee bolster, if equipped.
4. Disconnect the steering column electrical connectors.
5. Remove the wire harness assembly (1) from the wire harness strap (2).



6. Remove and dispose of the smaller wire harness straps.
7. Slide the 2 connectors of the turn signal and multifunction switch assembly out of the harness connector.



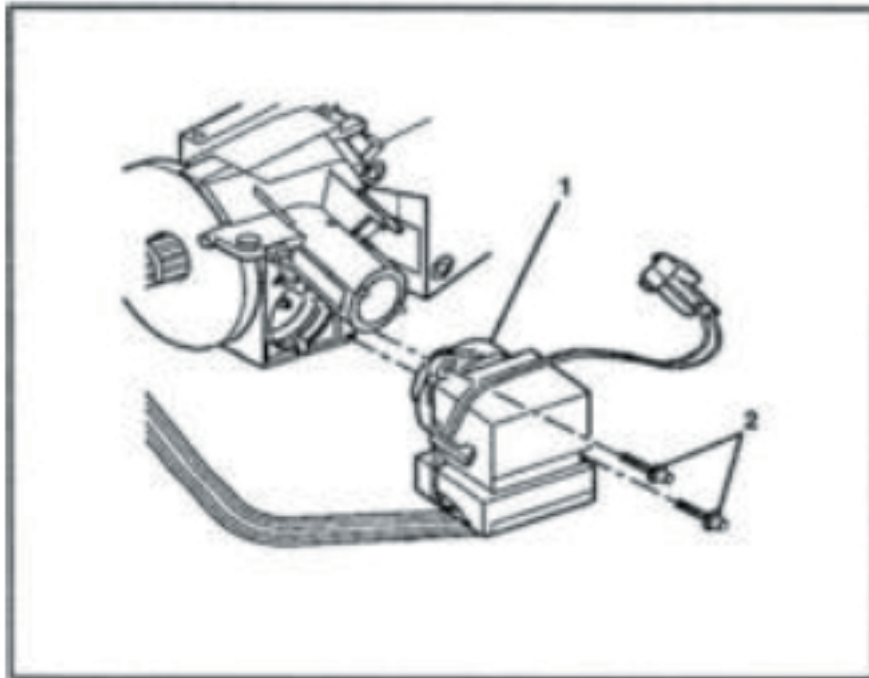
8. Remove the key alarm connector (1) from the ignition lock cylinder case assembly (2).
 - 8.1. Rotate the key alarm connector (1) 90 degrees.
 - 8.2. Pull the key alarm connector (1) out of the ignition lock cylinder case assembly (2).
9. Remove the 2 tapping screws (2) from the ignition and key alarm switch assembly (1).
10. Remove the ignition switch assembly (1) from the ignition lock cylinder case assembly.

Installation Procedure

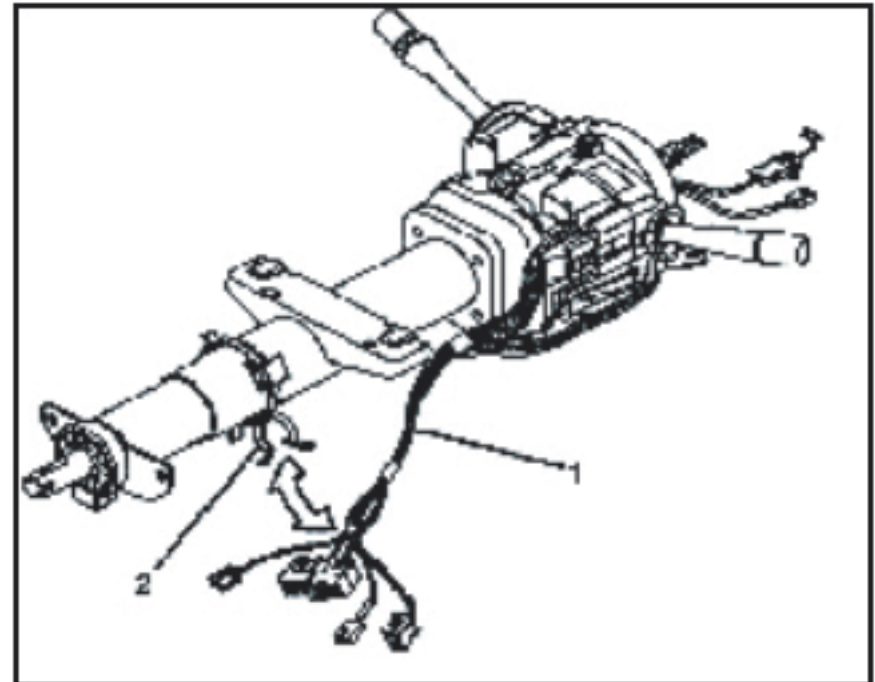
1. Install the ignition switch assembly (1) onto the ignition lock cylinder case assembly.
2. Screw the 2 tapping screws into the ignition switch assembly.

Tighten

- Tighten the 2 tapping screws to 3.5 N.m (13 lb in).
3. Install the key alarm connector (1) into the ignition lock cylinder case assembly (2).
 - 3.1. Push the key alarm connector (1) into the ignition lock cylinder case assembly (2).
 - 3.2. Rotate the key alarm connector (1) 90 degrees so that the key alarm connector (1) locks into place



4. Connect the 2 connectors of the turn signal and multifunction switch assembly into the harness connector.
5. Connect the steering column electrical connectors.
6. Attach new wire harness straps to the wire harness

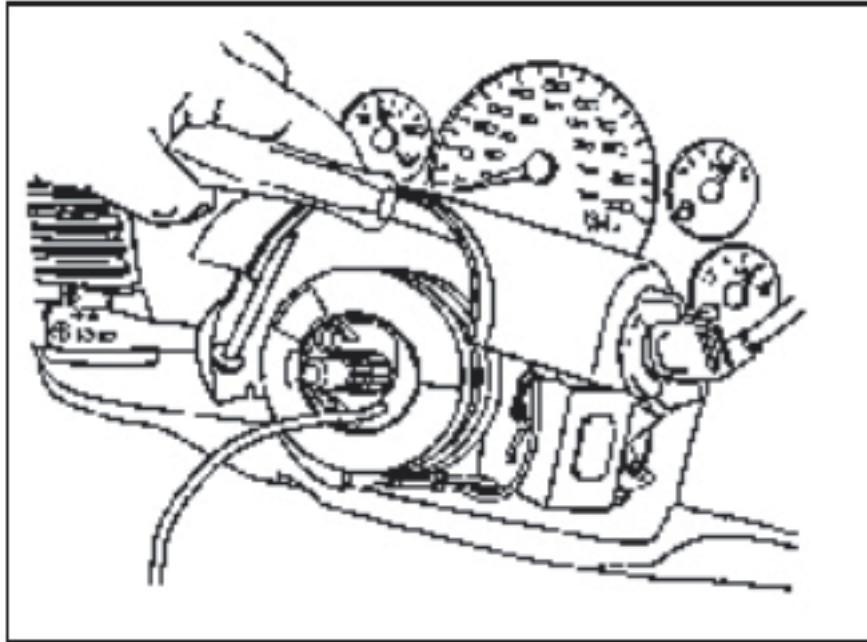


- assembly.
7. Attach the wire harness assembly (1) to the wire harness strap (2).
 8. Install the trim covers to the column.
 9. Install the tilt lever. Refer to Tilt Lever Replacement in this section.
 10. Connect the steering column electrical connectors.

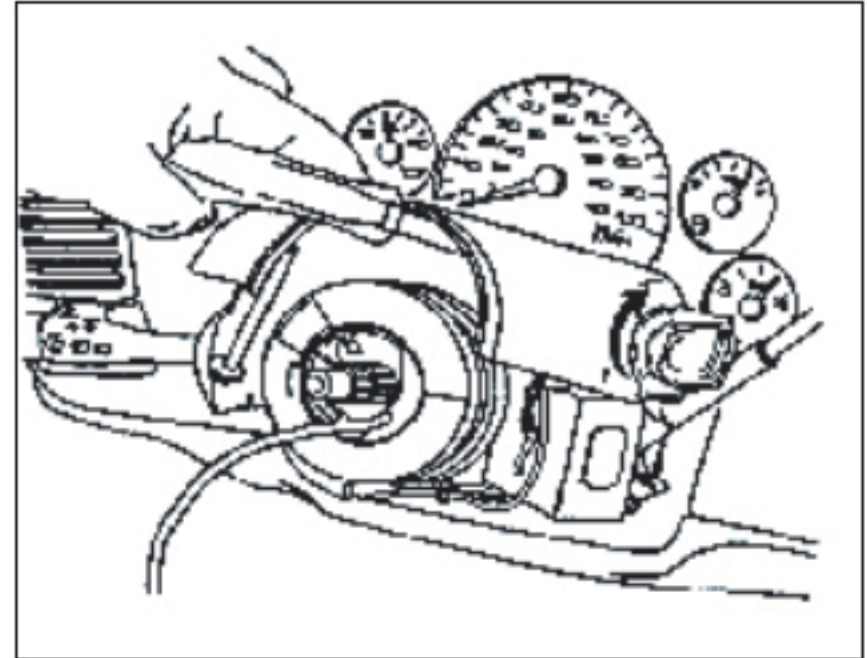
IGNITION LOCK CYLINDER REPLACEMENT

Removal Procedure

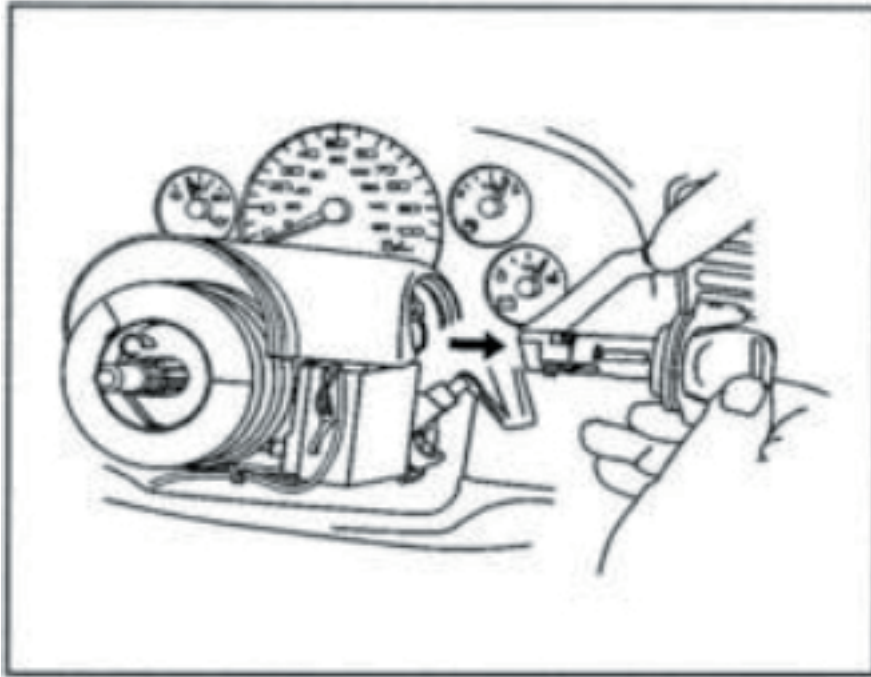
1. Position the steering wheel half way between the upper and lower tilt stops.
2. Remove the steering wheel. Refer to Steering Wheel Replacement in this section.
3. Roll back the shift lever seal from the upper and the lower shrouds.
4. Remove the tilt wheel lever. Refer to Tilt Lever Replacement in this section.
5. Remove the steering column trim covers.
6. Lift the upper steering column shroud to gain access to the lock cylinder access hole.
7. Using a bent tip awl, insert the tip into the ignition lock cylinder access hole.



8. Turn the ignition lock cylinder to the START position.
9. Using the bent tip awl, push down on the ignition lock cylinder retaining pin.



10. Release the ignition lock cylinder to the RUN position.
11. Remove the ignition lock cylinder from the ignition lock cylinder case assembly by pulling the ignition lock cylinder away from the steering column.



Replacement in this section.
Ignition Lock Cylinder Case

REPLACEMENT

Removal Procedure

1. Remove the steering wheel. Refer to Steering Wheel Replacement.
2. Remove the shift lever. Refer to Shift Lever Replacement.
3. Remove the ignition lock cylinder. Refer to Ignition Lock Cylinder Replacement in this section.
4. If tilt column, remove the steering column tilt head components.
5. If standard column, remove the steering column components..
6. If necessary, remove the park lock cable assembly (1) from the ignition lock cylinder case assembly.
 - 6.1. Place the lock cylinder in the OFF-LOCK position.
 - 6.2. Place the shift lever into the PARK position.
 - 6.3. Insert a small screwdriver into the slot on the ignition lock cylinder case assembly. Push against the locking tab on the end of the park lock cable assembly (1).
 - 6.4. Disconnect the park lock cable assembly (1) from the ignition lock cylinder case assembly.
7. Rotate the key alarm connector (1) 90 degrees.
8. Pull the key alarm connector (1) out of the ignition lock cylinder case assembly (2).
9. Remove the 2 tapping screws from the ignition switch (3).
10. Remove the ignition switch (3) from the ignition lock cylinder case assembly (2).
11. Let the ignition switch (3) hang freely.

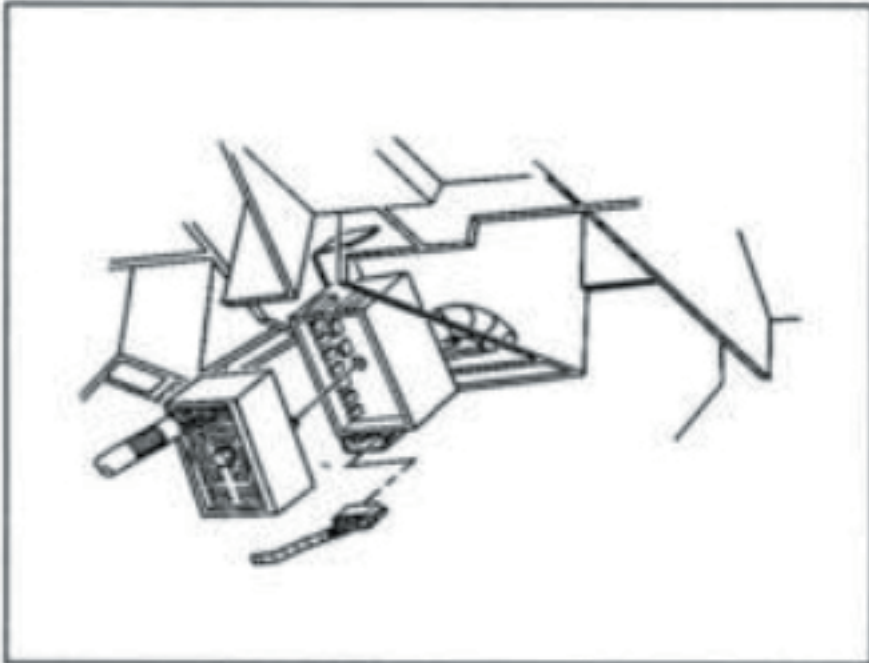
Installation Procedure

1. Insert the ignition lock cylinder through the upper shroud.
2. Install the ignition lock cylinder to the ignition lock cylinder case assembly by doing the following procedures:
 - 2.1. Align the positioning slot and locking tab slot on the ignition lock cylinder case assembly to the positioning tab and locking tab on the ignition lock cylinder.
 - 2.2. Push the ignition lock cylinder into the ignition lock cylinder case assembly until the locking tab locks against the locking tab.
3. Install the steering column trim covers. Refer to Steering Column Trim Covers Replacement in this section.
4. Install the shift lever seal to the upper and the lower shrouds.
5. Install the steering wheel. Refer to Steering Wheel Replacement in this section.
6. Install the tilt wheel lever. Refer to Tilt Lever

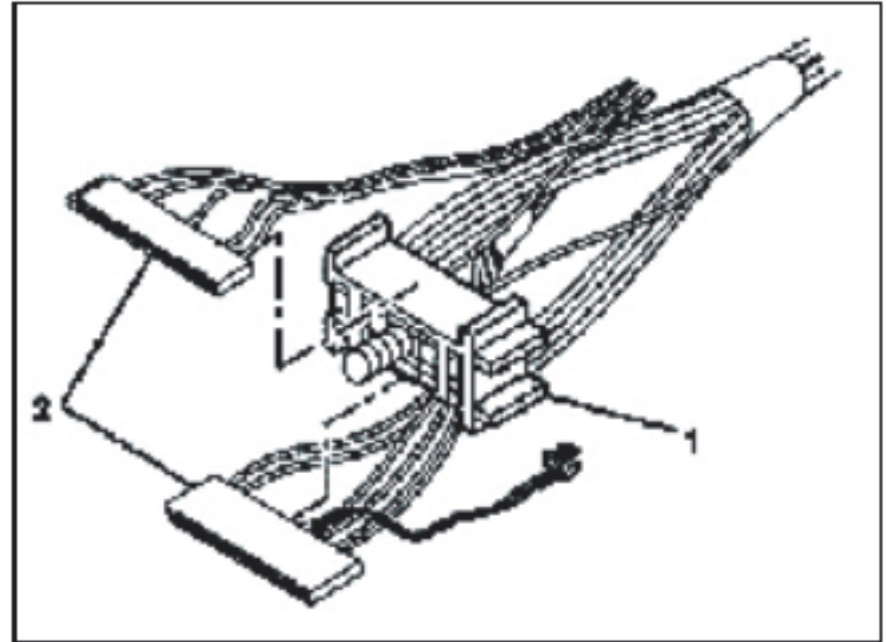
MULTIFUNCTION SWITCH REPLACEMENT

Removal Procedure

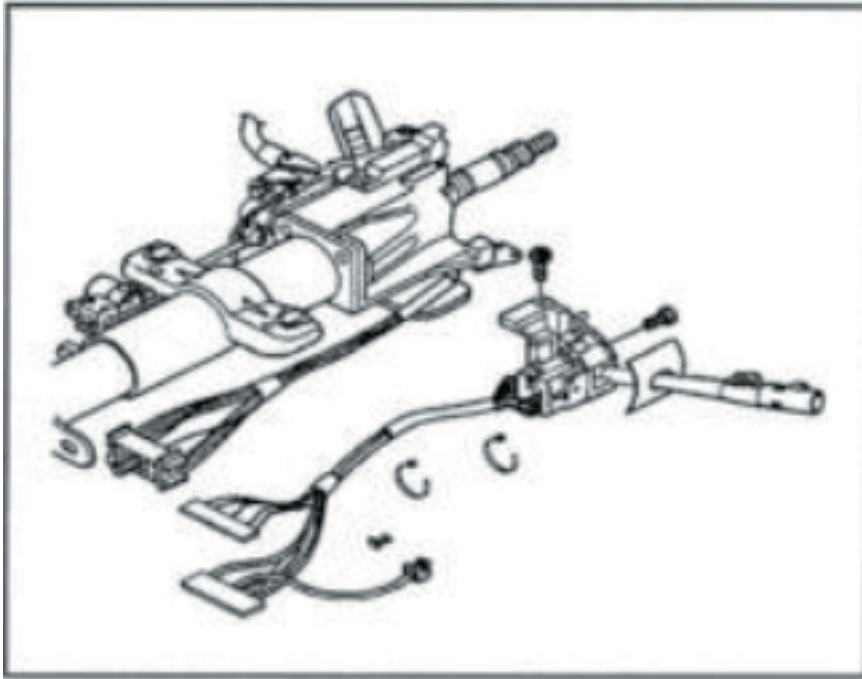
1. Loosen the steering column bracket nuts.
2. Remove the steering column trim covers.
3. Disconnect the steering column bulkhead connector from the vehicle harness.



4. Disconnect the gray and black connectors (2) of the switch from the column bulkhead connector.



5. Remove the retaining screws from the switch.
6. Remove the multifunction.



Installation Procedure

1. Install the multifunction switch to the steering column.

NOTICE:

Refer to Fastener Notice in Cautions and Notices.

2. Install the screws that retain the multifunction switch to the steering column.

Tighten

- Tighten the screws to 6 N.m (53 lb in).
3. Install the gray and black wiring harness connectors (2) to the steering column bulkhead connector.
 4. Install the steering column bulkhead connector to the vehicle wire harness.

Tighten

- Tighten the center screw to 6 N.m (53 lb in).
5. Install the electrical connector to the ATSLC.
 6. Install the straps that secure the steering column wiring harness.
 7. Install the steering column trim covers. Refer to Steering Column Trim Covers Replacement.
 8. Install the steering column bracket nuts.

Tighten

- Tighten the nuts to 30 N.m (22 lb ft).
9. Place the lever in the center or the OFF position.

SHIFT LEVER REPLACEMENT

Removal Procedure

1. Roll the shift lever boot back until the TORX® head screw is exposed.
2. Remove the TORX® head screw.
3. Remove the shift lever.

Installation Procedure

1. Install the shift lever.
- Notice: Refer to Fastener Notice in Cautions and Notices.
2. Install the TORX® head screw.

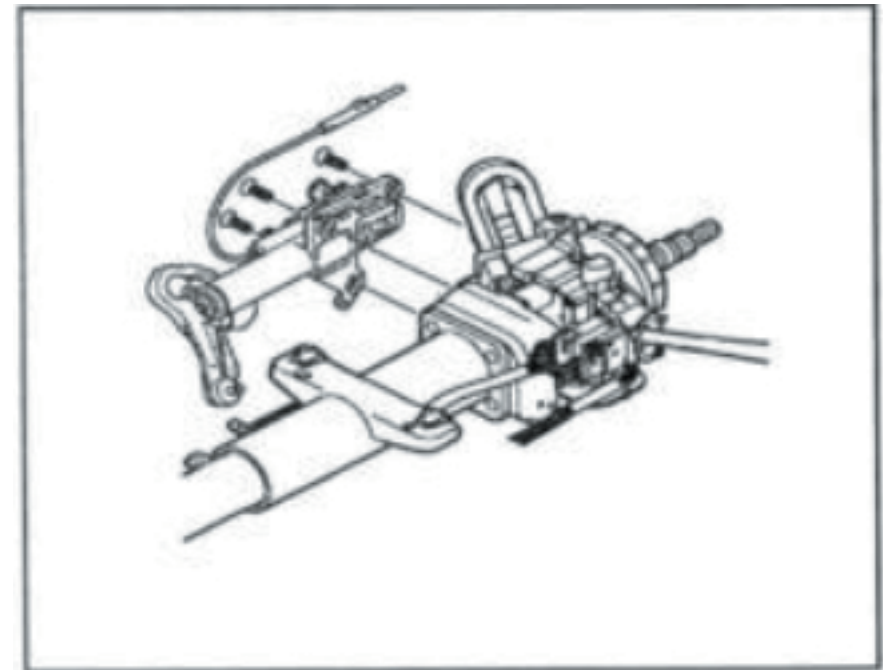
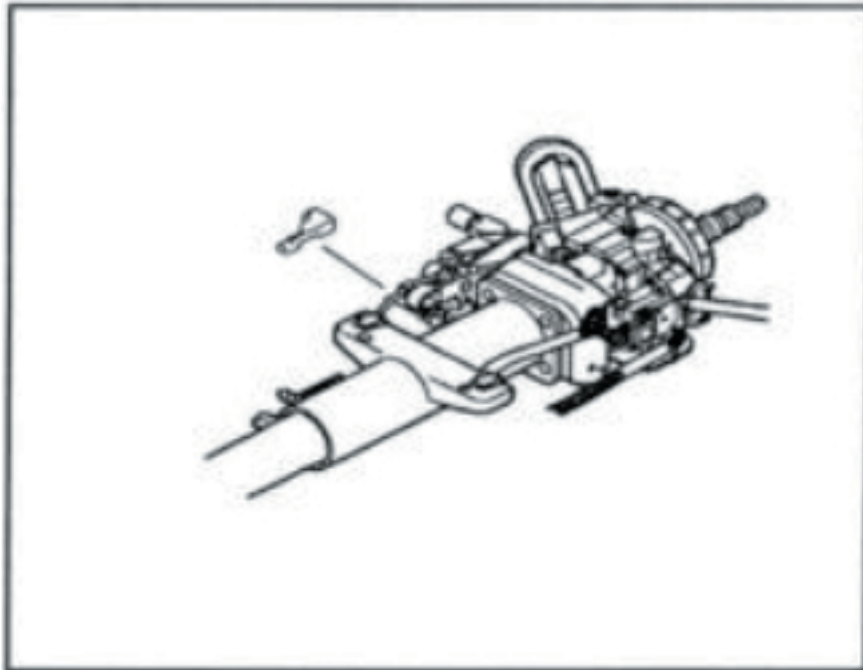
Tighten

- Tighten the TORX® head screw to 18 N.m (14 lb in).
3. Roll the shift lever boot over the TORX® head screw.

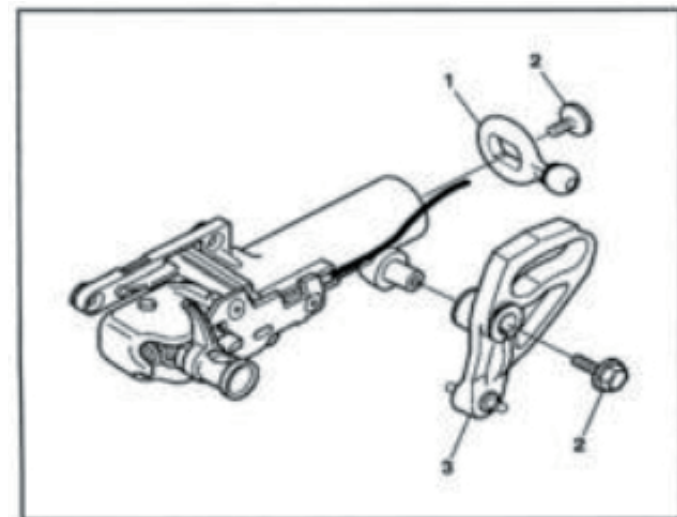
LINEAR SHIFT ASSEMBLY

Removal Procedure

1. Remove the shift lever. Refer to Shift Lever Replacement.
2. The steering column lock cylinder set should be in the OFF-LOCK position.
3. Insert a small screwdriver into the slot on the ignition lock cylinder case assembly and push against the locking tab to remove the park lock cable assembly (1).

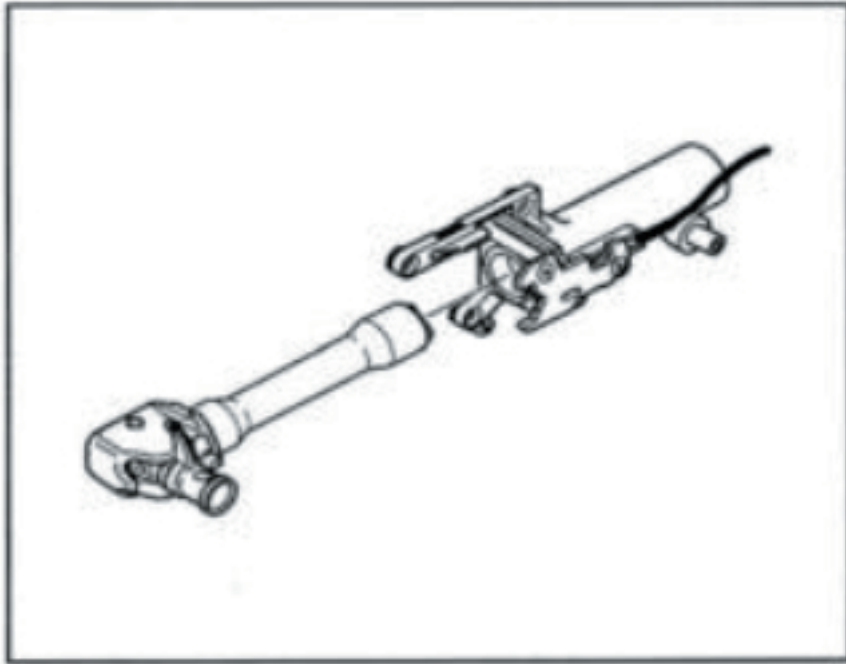


9. To disassemble the linear shift assembly, remove the 2 hexagon flange head bolts (2).
10. Remove the ball and actuator assembly (1).
11. Remove the cable shift cam assembly (3).



7. Remove the 3 TORX® screws from the linear shift assembly.
8. Remove the linear shift assembly from the steering column support assembly.

12. Remove the shift lever shaft.



13. Remove the 2 actuator bushings.
14. Remove the 3 oval head screws (2) from the shift lever gate (3).
15. Remove the shift lever gate (3) from the support bracket (1) on the gear shift lever assembly.

Installation Procedure

If installing the linear shift assembly as an assembly, proceed to step 11.

1. Install the shift lever gate (3) onto the gear shift lever assembly support bracket (1).
- Notice: Refer to Fastener Notice in Cautions and Notices.
2. Install the 3 oval head screws (2) onto the shift lever gate (3).

Tighten

Tighten the screws to 7 N.m (62 lb in).

3. Install the 2 actuator bushings.

4. Install the shift actuator shaft.
5. Install the cable shift cam assembly (3).
6. Install the ball and actuator assembly (1).
7. Install the 2 hexagon flange head bolts (2).

Tighten

- Tighten the bolts to 18 N.m (13 lb ft).
8. Install the A/T shift lock control. Install the shift lever clevis and put the column in the neutral position, which is 2 positions from the park position.
 9. Slide the park position switch assembly onto the linear shift assembly.
 10. Connect the A/T shift lock control connector onto the park position switch assembly.
 11. Install the linear shift assembly onto the steering column support assembly.
 12. Secure the linear shift assembly to the steering column with 3 flat head tapping screws. Move the linear shift assembly out of the PARK position to install the lower socket tapping screw.

Tighten

- Tighten the bolts to 10 N.m (89 lb in).
13. Connect the park lock cable assembly (1) to the lock module assembly using the following procedure:
 - Place the steering column lock cylinder set into the OFF position.
 - Place the shift lever clevis into the PARK position.
 - Press the locking tab on the end of the park lock cable assembly (1) into the slot in the lock module assembly.
 14. Install the shift lever.

TILT LEVER REPLACEMENT

Removal Procedure

Pull the tilt steering column lever (1) out from the steering column (2).

Installation Procedure

Align the tilt steering column lever (1) and push the lever into the steering column (2).

STEERING WHEEL REPLACEMENT

Tools Required

J 1859-A Steering Wheel Puller

Removal Procedure

1. Mark the relationship of the steering wheel (1) to the column.
2. Remove the steering wheel and the nut (2).
3. Use the J 1859-A in order to remove the steering wheel from the column.

Installation Procedure

1. With the marked relationship references in line, install the steering wheel (1) onto the column.

Notice: Refer to Fastener Notice in Cautions and Notices.

2. Install the steering wheel nut (2).

Tighten

Tighten the bolts to 41 N.m (30 lb ft).

TILT SPRING REPLACEMENT

Removal Procedure

1. Remove the upper and lower trim covers.
2. Install the tilt lever onto the steering column tilt head assembly.
3. Use the tilt lever to tilt the column to the UP position.

CAUTION

The tilt spring and the spring guide are under pressure. The tilt spring and the spring guide may become a projectile. Secure the spring with locking pliers during removal. Secure the spring with locking pliers during installation.

Bodily injury may result during removal and installation of the tilt spring and the spring guide. Always use caution during removal and installation of the tilt spring and the spring guide.

4. Remove the tilt spring (1) from the steering column support assembly (2) and from the steering column tilt head assembly (3) by using the following procedure:
 - 4.1. Pry up the tilt spring (1) until a bulge occurs and most of the tilt spring tension is removed.
 - 4.2. Secure the tilt spring (1) with locking pliers.
 - 4.3. Continue prying up the tilt spring (1) until the tilt spring disengages from the post on the steering column support assembly (2) and from the steering column tilt head assembly (3).
5. Remove the spring guide (1) from the tilt spring (2).

Installation Procedure

1. Use the tilt lever to tilt the column to the UP position.
2. Install the spring guide into the tilt spring.

CAUTION

The tilt spring and the spring guide are under pressure. The tilt spring and the spring guide may become a projectile. Secure the spring with locking pliers during removal. Secure the spring with locking pliers during installation.

Bodily injury may result during removal and installation of the tilt spring and the spring guide. Always use caution during removal and installation of the tilt spring and the spring guide.

3. Install the tilt spring (1) onto the steering column support assembly (2) and onto the steering column tilt head assembly by using the following procedure:
 - 3.1. Install the tilt spring (1) onto the steering column tilt head assembly.
 - 3.2. Install the tilt spring (1) onto the post on the steering column support assembly (2).
4. Install the upper and lower trim covers.

TURN SIGNAL CANCEL CAM AND UPPER

Bearing Inner Race Replacement

Tools Required

- J 23653-SIR Lock Plate Compressor
- J 42137 Cam Orientation Plate Adapter

Removal Procedure

1. Compress the shaft lock shield assembly using J 23653-SIR and J 42137.
2. Remove the bearing retainer (1) from the steering shaft assembly.
3. Discard the bearing retainer.
4. Remove J 23653-SIR and J 42137 from the steering shaft assembly.
5. Remove the following parts from the steering shaft assembly:
 - 5.1. The shaft lock shield assembly (5)
 - 5.2. The turn signal cancel cam assembly (4)
 - 5.3. The upper bearing spring (3)
 - 5.4. The upper bearing inner race seat (2)
 - 5.5. The inner race (1)

Installation Procedure

1. Lubricate the lower brass surface of the turn signal cancel cam assembly (4) with GM P/N 12377900 (Canadian P/N 10953529).
2. Lubricate the inner race with GM P/N 12345718 (Canadian P/N 10953516)
3. Install the following parts onto the steering shaft assembly:
 - 3.1. The inner race (1)
 - 3.2. The upper bearing inner race seat (2)
 - 3.3. The upper bearing spring (3)
 - 3.4. The turn signal cancel cam assembly (4)
 - 3.5. The shaft lock shield assembly (5)