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Steering Driveline Replacement

Replacement

- Position the front tires straight ahead. If possible, drive the vehicle in a straight line for a short distance, stopping at the spot where service operations will be done.
- 2. Shut down the engine, apply the parking brakes, chock the tires, and open the hood.
- Remove the steering column from the steering driveline.
 - 3.1 Remove the capscrews that attach the lower steering column cover to the steering column. Remove the lower and upper steering column covers. See Fig. 1.

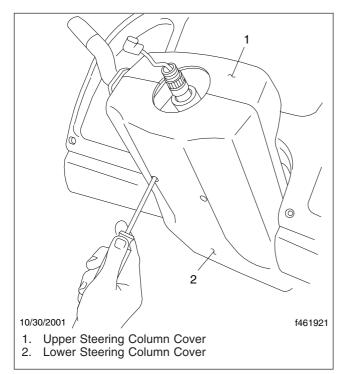


Fig. 1, Steering Column Covers

- 3.2 Remove and discard the pinch bolt and nut that attach the steering column to the steering driveline.
- 4. Remove the boot bushing. See Fig. 2.
- 5. Remove and discard the pinch bolt and nut that attach the steering driveline to the steering gear. Then remove the steering driveline.

- 6. Place a new steering driveline through the boot and the frontwall.
- 7. Using a new pinch bolt and nut, attach the steering driveline to the steering gear input shaft.

 Torque the nut 30 to 35 lbf·ft (41 to 47 N·m).
 - Apply torque seal, OGP F900WHITE, to the exposed threads of the pinch bolt and to the nut.
- 8. Install the boot clamp on the steering driveline.
- Using a new pinch bolt and nut, attach the steering driveline to the steering column. Torque the nut 30 to 35 lbf·ft (41 to 47 N·m).
 - Apply torque seal, OGP F900WHITE, to the exposed threads of the pinch bolt and to the nut.
- Using capscrews, attach the upper and lower steering column covers to the steering column.
- Lower the hood and remove the chocks from the tires.

Steering Driveline Replacement

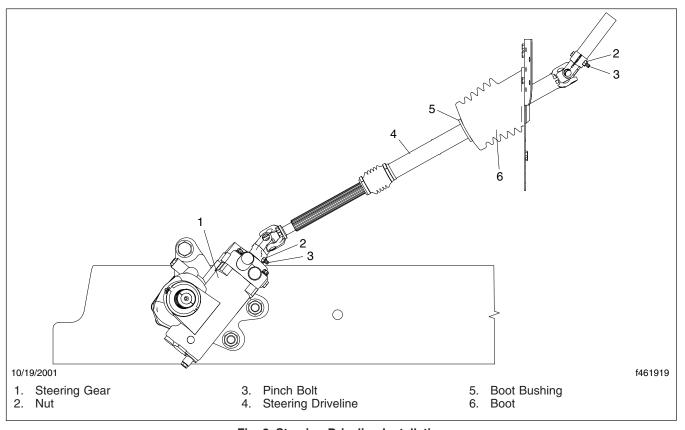


Fig. 2, Steering Driveline Installation

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General Information

General Description

A fixed-length drag link assembly connects the steering gear pitman arm to the axle steering arm. The ball stud and socket assemblies at each end of the drag link prevent binding when the relative angles of the pitman arm and steering arm change, which happens when the vehicle is steered or the front axle moves up or down.

Both ball stud sockets of a fixed-length drag link assembly are an integral part of the drag link; they cannot be moved to change its length. See **Fig. 1**. The ball studs and sockets are a dual-seat design.

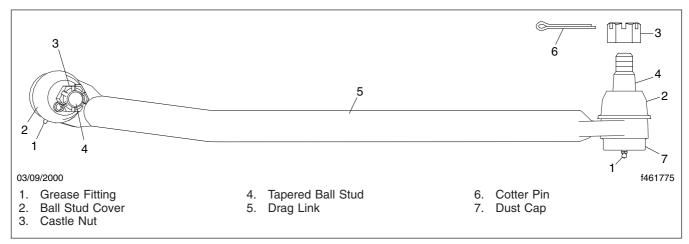


Fig. 1, Fixed-Length Drag Link Assembly

The tie rod links both tie rod arms on the steering knuckles so that the steering knuckle turned by the gear also turns the steering knuckle on the other side of the vehicle. See **Fig. 2**.

The tie rod assembly consists of a cross tube and tie rod ends. The ball studs are held to the tie rod arms by castle nuts and cotter pins. Like the ball studs on the drag link, the ball stud and socket assemblies at each end of the tie rod prevent binding when the relative angles of the steering components change.

General Information

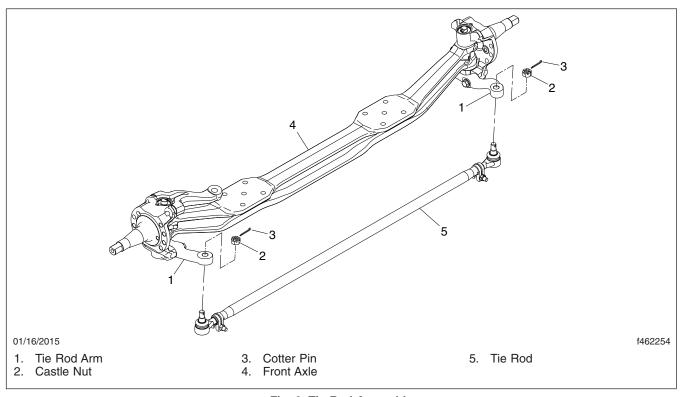


Fig. 2, Tie Rod Assembly

Drag Link Removal and Installation

Removal

 Position the front tires straight ahead. If possible, drive the vehicle in a straight line for a short distance, stopping at the spot where service work will be done.

IMPORTANT: Do not move the tires from the straight-ahead position during removal or at any time while the drag link is removed.

- 2. Apply the parking brakes, chock the rear tires, and open the hood.
- At both ends of the drag link, remove the cotter pins and castle nuts from the ball studs. See Fig. 1.

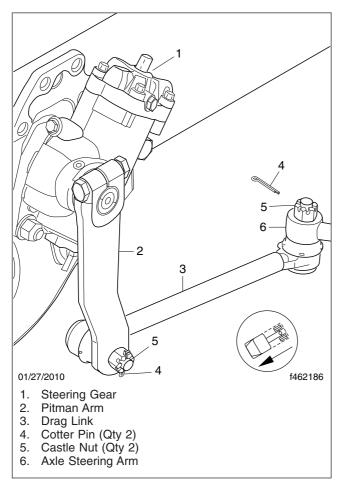


Fig. 1, Drag Link Assembly

- Using a ball stud removal tool, remove the ball studs from the pitman arm and the axle steering arm.
- Check the ball stud cover for damage. If necessary, replace the cover using the instructions in Subject 120.

Installation

- 1. Insert the axle-end ball stud up through the bottom of the axle steering arm, then install the castle nut and tighten it finger-tight. See Fig. 1.
- Turn the steering wheel as needed to align the hole in the lower end of the pitman arm with the forward ball stud. Insert the ball stud in the pitman arm from the inboard side. Install the castle nut.

IMPORTANT: Do not back off the castle nut to align it with the cotter pin hole.

Tighten the ball stud castle nuts according to the values in Table 1.

Torque Values		
Size Torque: lbf-ft (N·m)		
3/4–16	90 to 170 (122 to 230)	
7/8–14	160 to 300 (217 to 407)	

Table 1, Torque Values

A WARNING

Install and lock new cotter pins in the ball studs and nuts. Failure to do so could result in disengagement of the components, causing loss of steering control, which could result in personal injury and property damage.

- Install and lock a new cotter pin in each of the ball studs and nuts.
- Check the vehicle maintenance manual to determine if lubrication of the drag link is required. If so, follow the instructions in the maintenance manual.
- 6. Check the axle stop settings, and adjust them if needed. For instructions, see **Group 33**.
- 7. Check the settings of the steering gear poppet valves. Adjust them if needed. For instructions on

Drag Link Removal and Installation

- checking and adjusting, see the applicable steering gear section in **Group 46**.
- 8. With the front tires pointing straight ahead and no load on the vehicle, the steering wheel spokes should be within ±10 degrees of center as shown in Fig. 2. If not, remove the steering wheel and install it in the correct position.

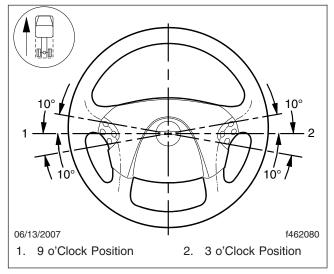


Fig. 2, Four-Spoke Steering Wheel Centered

On-Vehicle Ball Stud Testing

Testing

- Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.
- Have someone gently turn the steering wheel back and forth. As the steering wheel is turned, check for looseness between the ball stud end and the pitman arm, then check for looseness between the other ball stud end and the axle steering arm.
- As the steering wheel is turned, check for looseness of the ball stud castle nut.
- If the ball stud end is loose, replace the drag link.

If the ball stud *castle nut* is loose, replace the castle nut and cotter pin. Tighten the ball stud castle nut according to the values in **Table 1**.

Torque Values			
Size Torque: lbf·ft (N·m)			
3/4–16	90 to 170 (122 to 230)		
7/8–14	160 to 300 (217 to 407)		

Table 1, Torque Values

A WARNING

Install and lock new cotter pins in the ball studs and nuts. Failure to do so could result in disengagement of the components, causing loss of steering control, which could result in personal injury and property damage.

IMPORTANT: Do not back off the castle nut to align it with the cotter pin hole.

- 5. Check each ball stud joint for wear:
 - Grasp the drag link near the pitman arm end and push and pull laterally.
 - Grasp the drag link near the steering arm end and push and pull vertically.
 - For each tie rod end, grasp tie rod end and push and pull vertically.
- 6. If there is looseness at either end of the drag link, replace the drag link. If there is looseness at either tie rod end, replace that tie rod end. If there is 1/8-inch (3-mm) looseness or more, do

- not drive the vehicle until the component is replaced. See **Subject 100** for replacement instructions.
- 7. Pump fresh grease into the ball studs until the old grease is purged.

Ball Stud Cover Replacement

Replacement

 Remove the drag link. For removal instructions, see Subject 100.

NOTICE -

Use care when removing the ball stud cover. Damage to the sealing surface of the socket forging could occur.

- 2. Using a screwdriver, press or tap on the flanged portion of the cover and remove it from the ball stud socket assembly. See Fig. 1.
- 3. Using a clean rag, wipe off all grease and dirt from around the ball stud and socket throat.
- 4. Grease the socket throat and ball stud with a multipurpose chassis grease NLGI Grade 2 (8% 12-hydroxy lithium stearate grease) or NLGI Grade 1 (6% 12-hydroxy lithium stearate grease); Grade 2 is preferred. Using the same grease, fill the new ball stud cover three-quarters full.
- Position the socket assembly in a large vise, or on a press so that the ball stud is perpendicular to the socket stem.

- NOTICE ---

Do not use a screwdriver, chisel, or punch (or any other sharp-pointed tool) to install the ball stud cover. Using these types of tools could cut and damage the cover.

IMPORTANT: To install the stud cover, use a section of tubing that has an inside diameter as close as possible to the outside diameter of the stud cover. Also, make sure that the inside edge of the tube is chamfered (angled) to avoid cutting the rubber stud cover.

Using a section of tubing, press on the new stud cover. The cover is in place when the flanged portion of the cover is seated on the machined section (sealing face) of the socket forging.

NOTICE —

Do not apply excessive pressure when pressing on the seal. Too much pressure during installation could deform the cover and result in incorrect sealing.

7. Install the drag link. For instructions, see **Subject 100**.

Ball Stud Cover Replacement

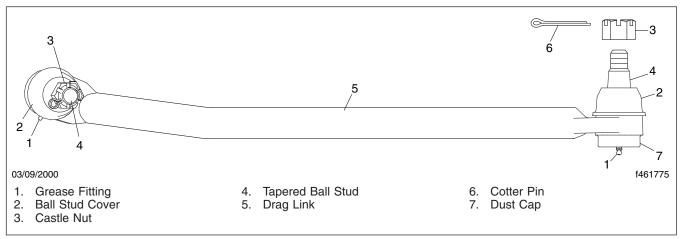


Fig. 1, Drag Link Assembly

Tie Rod End Replacement

Replacement

- Position the front tires straight ahead. If possible, drive the vehicle in a straight line for a short distance, stopping at the spot where service work will be done.
- At both ends of the tie rod, remove the cotter pins and castle nuts from the ball studs.
- 3. Disconnect the balls studs from the tie rod arms to remove the tie rod. See **Fig. 1**. If available, use a tie rod end puller to separate the tie rod end from the tie rod arm.
- Install the tie rod ends into the cross tube to the position marked during their removal. The threaded portion of the tie rod end must be installed into the cross tube beyond the end of the slot.
- The replacement cross tube must be the same length and diameter as the original tube. Use the thread count as a guide. Install the tie rod ends into the threaded cross tube ends to the approximate depth marked during the tie rod assembly removal.
- 9. Thread the tie rod ends to the approximate origi-

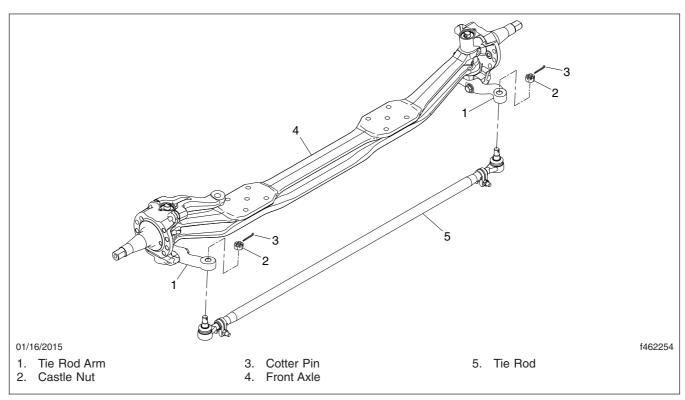


Fig. 1, Tie Rod Assembly

- 4. Mark the position of each tie rod end in the cross tube. Count and note the number of threads outside the cross tube.
- 5. Remove the clamp fasteners on the cross tube.
- 6. Remove the tie rod ends from the cross tube.

NOTE: The cross tube has right-hand threads on one end and left-hand threads on the other end.

- nal depth inside the cross tube. Both tie rod ends must be installed into the cross tube at least one thread deeper than the length of the cross tube slot.
- 10. Verify that the tab on the clamp, when available, is firmly seated against the end of the cross tube. Otherwise, verify the clamp-guiding female emboss seats into the tube male emboss.

Tie Rod End Replacement

11. Install the nuts and the bolts into the clamps. Tighten according to the values in **Table 1**.

Tie Rod Clamp Torque Values by Axle			
Axle	Pinch Bolt Size	Torque: lbf·ft (N·m)	
Meritor	5/8-11	40 to 60 (54 to 81)	
Meritor AWD - MX Series	5/8-11	40 to 60 (54 to 81)	
Dana E series	5/8-18	45 to 60 (61 to 81)	
Dana EFA series	5/8-18	45 to 60 (61 to 81)	
Hendrickson Steertek	5/8-11	50 to 60 (68 to 81)	
Detroit	5/8-11	60 to 80 (81 to 108)	

Table 1, Tie Rod Clamp Torque Values by Axle

IMPORTANT: Do not back off the castle nut to align it with the cotter pin hole.

12. Tighten the ball stud castle nuts according to the values in **Table 2**.

Castle Nut Torque Values			
Axle	Size	Torque: lbf·ft (N·m)	
Meritor	7/8-14	160-300 (217 to 407)	
Meritor AWD - MX Series	7/8-14	initially 160-215 (217- 292); max 320 (434)	
Dana E series	7/8-14	120-160 (163-217)	
Dana EFA series	7/8-14	165-230 (224-312)	
Hendrickson Steertek	7/8-14	185 (251)	
Detroit	7/8-14	120 to 170 (163 to 230)	

Table 2, Castle Nut Torque Values



Install and lock new cotter pins in the ball studs and nuts. Failure to do so could result in disengagement of the components, causing loss of steering control, which could result in personal injury and property damage.

- Install and lock a new cotter pin in each of the ball studs and nuts.
- 14. Align the wheels and tires. See Group 33.

46.02

Steering Wheel and Column, Fixed and Adjustable

Contents

Subject	Subject Number
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Steering Wheel Removal and Installation

Procedures under these headings apply to the following vehicle models, as specified:

- M2 models built before June 5, 2006.
- M2 models built on or after June 5, 2006.

M2 Built Before June 5, 2006

Steering wheels on vehicles built before June 5, 2006 have threaded holes and require the use of a steering wheel puller for removal.

Removal

- Put the front wheels in the straight ahead position. If possible, drive the vehicle in a straight line for a short distance, stopping at the place where the work will be done. Don't turn the steering wheel at any time during the removal procedure.
- 2. Shut down the engine, apply the parking brakes, and chock the tires.
- Using a small screwdriver, carefully pry out the horn button assembly and disconnect the two wires
- 4. Using a deep socket to avoid damaging the wires, remove the steering wheel nut.

IMPORTANT: Be careful when removing the steering wheel, or the horn wires could be damaged. Use a steel block measuring approximately 1-5/8 x 5/8 x 1/4 inch (41 x 16 x 6.4 mm) as a spacer to protect the wires during steering wheel removal.

5. Using a steering wheel puller and a spacer on top of the steering shaft, remove the steering wheel from the steering column, see Fig. 1.

Installation

NOTE: Before installing the steering wheel, make sure the front tires are pointed straight ahead and that the steering gear is centered.

- 1. Thread the horn wiring harness through the steering wheel center hole and set the steering wheel on the steering column, see Fig. 2.
- 2. Make sure that the steering wheel is within ±10 degrees of center as shown in Fig. 3.

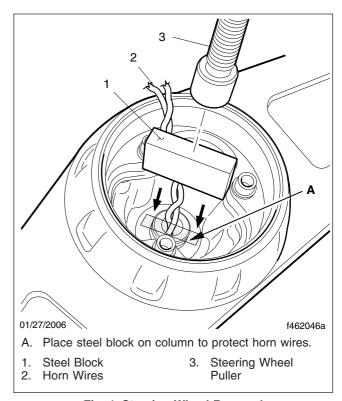


Fig. 1, Steering Wheel Removal

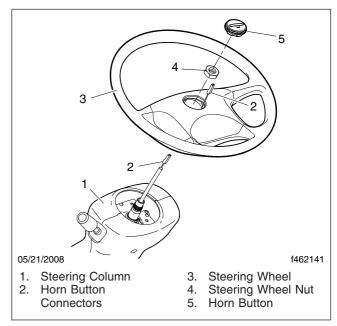


Fig. 2, Steering Wheel and Connectors

Steering Wheel Removal and Installation

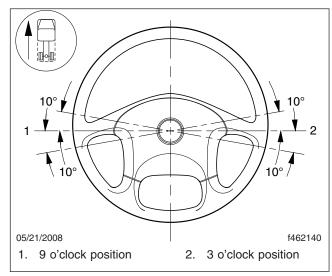


Fig. 3, Steering Wheel Position

- Install a new steering wheel nut and tighten 55 to 65 lbf·ft (75 to 88 N·m).
- 4. Connect the wiring harness to the horn button.
- 5. Align the logo on the horn button assembly so that it is horizontal. Then press the horn button assembly into the steering wheel.

M2 Built On or After June 5, 2006

Steering wheels on vehicles built on or after June 5, 2006 do not have threaded holes. The tapered fit between the steering wheel and the column allows the steering wheel to be removed by hand.

Removal

- Put the front wheels in the straight ahead position. If possible, drive the vehicle in a straight line for a short distance, stopping at the place where the work will be done. Don't turn the steering wheel at any time during the removal procedure.
- 2. Shut down the engine, apply the parking brakes, and chock the tires.
- Using a small screwdriver, carefully pry out the horn button assembly and disconnect the two wires.

- Using a deep socket to avoid damaging the wires, loosen the nut that holds the steering wheel on the steering column. Leave the nut on the shaft.
- Remove the wheel from the tapered fit by striking it from below, at the rim/spoke intersections, with both hands.
- 6. Remove the steering wheel nut and the wheel.

Installation

NOTE: Before installing the steering wheel, make sure the front tires are pointed straight ahead and that the steering gear is centered.

 Thread the horn wiring harness through the steering wheel center hole and set the steering wheel on the steering column, see see Fig. 4.

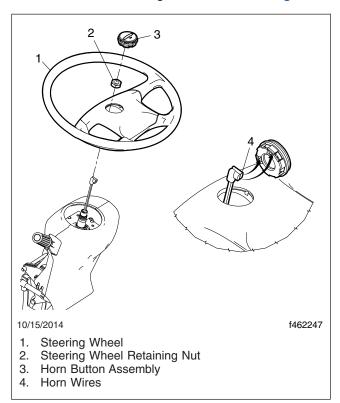


Fig. 4, Steering Wheel and Connectors

- Make sure that the steering wheel is within ±10 degrees of center as shown in Fig. 3.
- 3. Install a new steering wheel nut and tighten the nut 33 to 41 lbf·ft (45 to 55 N·m).

Steering Wheel Removal and Installation

- 4. Connect the wiring harness to the horn button.
- 5. Align the logo on the horn button assembly so that it is horizontal. Then press the horn button assembly into the steering wheel.

Steering Column Removal and Installation

Removal

- Position the front tires straight ahead. If possible, drive the vehicle in a straight line for a short distance, stopping at the spot where service work will be done. Do not move the tires from the straight-ahead position during removal or at any time while the steering column is removed.
- 2. Shut down the engine and apply the parking brakes. Chock the tires.
- 3. Disconnect the batteries at the negative terminals or at the battery shutoff switch.
- Remove the steering wheel. For instructions, see Subject 100.
- On a vehicle with a fixed steering column, remove the screws that attach the lower and upper clamshell covers to the steering column and remove the covers. See Fig. 1.

For vehicles with adjustable steering columns, also remove the screws that attach the center and lower covers to the steering column and remove the covers. See Fig. 2.

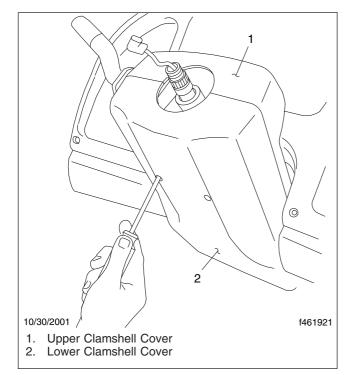


Fig. 1, Fixed Steering Column Covers

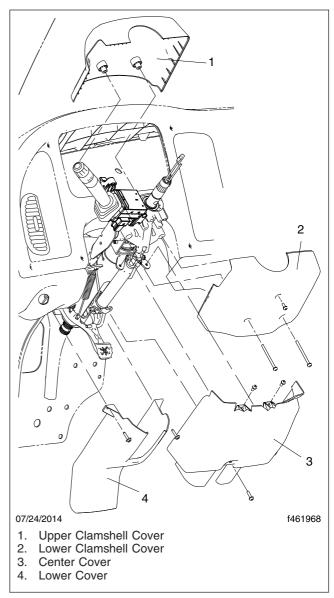


Fig. 2, Adjustable Steering Column Covers

- If the vehicle is equipped with electronic stability control (ESC), remove the steering angle sensor (SAS). See Fig. 3.
- 7. Remove the self-canceling turn signal cam from the steering column.
- 8. Remove the turn signal lever.
 - 8.1 Disconnect the horn wire from the turn signal wiring harness.

Steering Column Removal and Installation

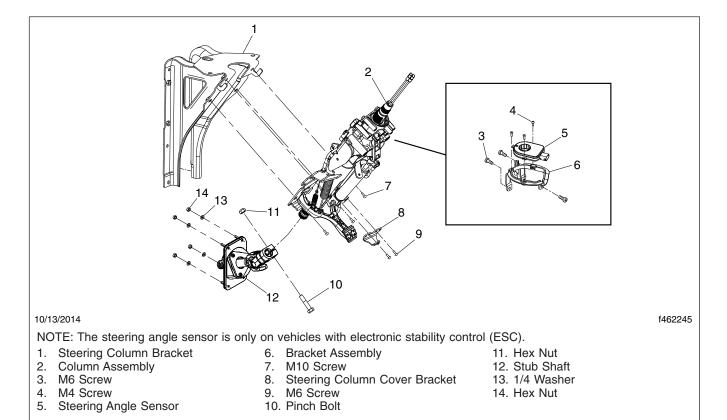


Fig. 3, Steering Column Assembly

- 8.2 Remove the capscrews that attach the turn signal lever to the steering column.
- 9. Make a timing mark on the steering driveline yoke and the steering column spline.
- 10. Remove and discard the pinch bolt and nut from the steering driveline yoke. See Fig. 4.
- 11. Remove the capscrews that attach the steering column to the mounting bracket.
- 12. Remove the steering column from the steering driveline yoke.

Installation

NOTE: The steering column yoke must be installed in the same orientation that it was in when it was removed.

 Using a new pinch bolt and nut, attach the steering column to the steering driveline yoke. Tighten the nut 30 to 35 lbf·ft (41 to 47 N·m).

- Apply torque seal, OGP F900WHITE, to the exposed threads of the pinch bolt and to the nut.
- 2. Using capscrews, attach the steering column to the mounting bracket. Tighten the capscrews 24 to 30 lbf·ft (33 to 40 N·m).
- 3. Install the self-canceling turn signal cam on the steering column.
- 4. Using capscrews, attach the turn signal lever to the steering column.
- Attach the horn wire to the turn signal wiring harness.
- 6. On a vehicle with an adjustable steering column, use screws to attach the lower and center steering column covers to the steering column.
- 7. Using screws, attach the upper and lower clamshell covers to the steering column.
- Install the steering wheel. For instructions, see Subject 100.

Steering Column Removal and Installation

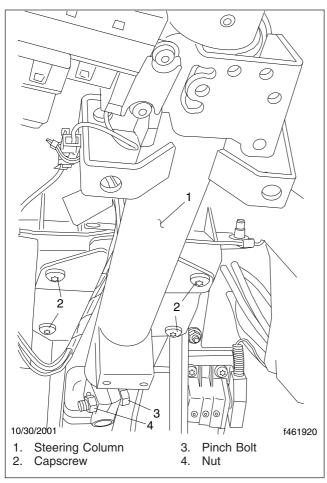


Fig. 4, Fixed Steering Column

- 9. Connect the batteries at the negative terminals or at the battery switch.
- 10. If the vehicle is equipped with ESC, go through the ESC calibration for the SAS as needed. See "Electronic Stability Control," **Section 54.31**.

Adjustable Steering Column Lock Adjustments

Tilt Lock Adjustment

- 1. Put the front wheels in the straight ahead position. If possible, drive the vehicle in a straight line for a short distance, stopping where the work will take place.
- Shut down the engine and set the parking brake. Chock the tires.
- Remove the screws that attach the upper and lower clamshell covers to the steering column and remove the covers. Remove the screws that attach the center and lower covers to the steering column and remove the covers.
- 4. Loosen the cable jam nut located on the top side of the mounting bracket flange, see Fig. 1.

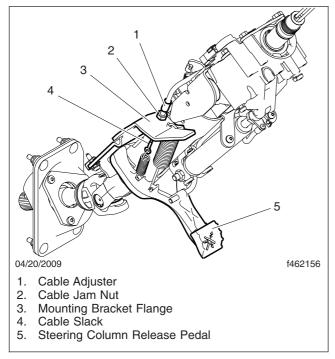


Fig. 1, Steering Column Tilt Lock Adjustment

5. Use the cable adjuster to remove all slack from the steering column release pedal.

NOTE: Removing too much cable slack can prevent the tilt lock mechanism from locking, regardless of the steering column release pedal position. Adding too much cable slack can prevent the tilt lock mechanism from unlocking when the pedal is fully depressed.

- 6. Test to verify proper steering column tilt function.
 - 6.1 Fully depress the steering column release pedal. The tilt mechanism should unlock.
 - 6.2 Release the pedal and let it revert to the standard position. The tilt mechanism should lock.
- 7. Adjust the cable slack if necessary.
- 8. Tighten the cable jam nut 25 to 30 lbf·in (290 to 340 N·cm).
- Attach the lower and center steering column covers to the steering column first, then install the upper and lower clamshell covers.

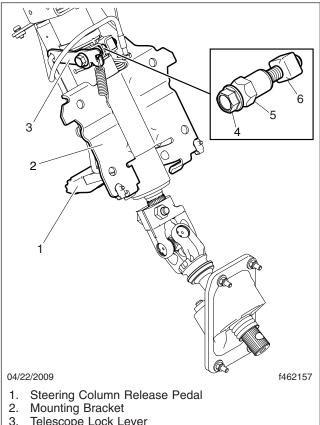
Telescope Lock Adjustment

- 1. Put the front wheels in the straight ahead position. If possible, drive the vehicle in a straight line for a short distance, stopping where the work will take place.
- Shut down the engine and set the parking brake. Chock the tires.
- Remove the screws that attach the upper and lower clamshell covers to the steering column and remove the covers. Remove the screws that attach the center and lower covers to the steering column and remove the covers.
- 4. Loosen the telescope lock bolt, see Fig. 2.
- 5. While holding the telescope lock rod in place, rotate the telescope lock lever to adjust the telescope lock. Counterclockwise rotation will tighten the telescope lock, while clockwise rotation will loosen the telescope lock. The lever can be easily rotated by moving the steering column release pedal up or down.

NOTE: Rotating the lever too much can prevent the telescope lock mechanism from unlocking with the steering column release pedal depressed, or locking when the steering column release pedal is released.

- Continue holding the telescope lock rod in place and tighten the lock bolt.
- 7. Test to verify proper steering column telescope function.

Adjustable Steering Column Lock Adjustments



- 3. Telescope Lock Lever
- Telescope Lock Bolt
- Telescope Lock Rod
- 6. Telescope Lock Rod Nut

Fig. 2, Steering Column Telescope Lock Adjustment

- 7.1 Fully depress the steering column release pedal. The telescoping mechanism should unlock.
- 7.2 Release the pedal and let it revert to the standard position. The telescoping mechanism should lock.

If the telescoping mechanism does not lock, adjust it and test it again until it locks.

- Once the telescope lock has been properly adjusted, tighten the lock bolt 145 to 150 lbf-in (1640 to 1690 N·cm).
- 9. Attach the lower and center steering column covers to the steering column first, then install the upper and lower clamshell covers.

46.05

Power Steering Gears, TRW THP/PCF Models

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General Information

General Description

NOTE: Procedures in this section have been slightly modified from the original component manufacturer's service manual. See the manufacturer's service literature (trucksteering.trw.com) for additional information.

The TRW THP and PCF power steering gears are integral hydraulic power steering gears that contain a manual steering mechanism, a hydraulic control valve, and a hydraulic power cylinder.

The pressure required for the steering gear to overcome resistance at the steered wheels is provided by the power steering pump. The rotary control valve directs the flow of hydraulic fluid to the appropriate cylinder cavity in the steering gear (and in the auxiliary cylinder in a dual steering gear system) at the proper flow rate and pressure. As the steering wheel is turned faster or slower, more or less fluid is required by the gear.

Principles of Operation

When the driver turns the steering wheel, that force travels from the steering wheel to the steering gear input shaft. A torsion bar, pinned at one end to the input shaft and at the other end to the worm shaft, turns with the input shaft and exerts a rotational force on the worm shaft. In response to the force exerted by the torsion bar, the worm shaft moves the rack piston forward or backward in the gear housing by means of a series of recirculating balls in the spiral channels of the worm shaft. As the rack piston slides back and forth, it turns the sector shaft. The sector shaft swings the pitman arm, which pulls or pushes the drag link. The drag link moves the axle steering arm, steering the vehicle.

The rack piston's axial movement is resisted by its engagement to the sector shaft, which is linked to the steered wheels. Because of this resistance, the torsion bar activates the control valve, which directs pressurized fluid to the upper or lower cylinder cavity (depending on the direction of turn). The pressurized fluid assists in moving the rack piston up or down in the cylinder bore.

Most THP and PCF steering gears are equipped with two poppet (unloading) valves, one at each end of the rack piston. As the front wheels reach the axle stop—the farthest the wheels can turn in either direction—one poppet or the other, depending on the direction of the turn, will trip to prevent steering system damage. The tripped poppet reduces pressure in the gear, heat generated by the power steering pump, and outside forces acting on the steering linkage.

Some THP and PCF steering gears are also supplied with an internal pressure relief valve (PRV). The PRV limits maximum supply pressure to protect the power steering gear, but it does not reduce pressure as the steered wheels approach the axle stops.

See Fig. 1 for an exploded view of the steering gear.

General Information

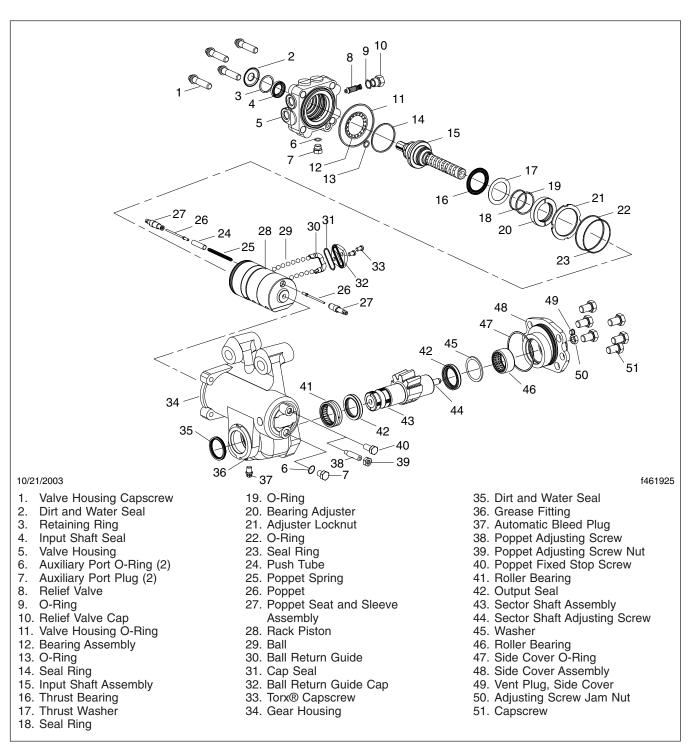


Fig. 1, TRW THP/PCF Steering Gear

Steering Gear Removal and Installation

Removal

- Verify that the axle stops are adjusted correctly. Ensuring correct axle stop adjustment will eliminate the possibility of resetting steering gear poppet valves after the gear is installed. See Group 33 for instructions.
- 2. Place the front tires in the straight-ahead position. If possible, drive the vehicle in a straight line for a short distance, stopping where the work is to be done.
- 3. Shut down the engine, apply the parking brakes, and chock the tires.
- 4. Disconnect the batteries and open the hood.
- 5. Clean all fittings and hose connections on the steering gear until they are free of dirt.
- 6. Drain the fluid from the power steering system. Disconnect the hydraulic lines from the steering gear, marking the lines for later reference. Plug the lines and the fittings to keep out dirt.
- Remove the pitman arm. Refer to Section 46.08 for instructions.
- 8. Disconnect the steering driveline from the steering gear input shaft.
 - 8.1 Remove and discard the pinch bolt and nut from the steering driveline lower end yoke.

- NOTICE -

Do not pound the U-joint or lower end yoke on or off the input shaft. Internal damage to the steering gear can result.

8.2 Remove the end yoke from the input shaft.

A WARNING

The steering gear is heavy. Use caution when removing, lifting, or carrying the steering gear. Failure to do so could cause personal injury.

Remove the fasteners that secure the steering gear to the frame rail. Remove the steering gear.

Installation

- 1. Mount the steering gear on the frame rail and install the mounting fasteners. Tighten the fasteners 342 to 434 lbf·ft (464 to 588 N·m).
- 2. Center the steering gear so that the timing mark on the sector shaft is aligned with the timing mark on the steering gear. Keep the steering gear centered as the installation continues.
- 3. Connect the steering driveline to the steering gear input shaft.
 - 3.1 Align the hole in the steering driveline lower end yoke with the indentation on the input shaft.
 - 3.2 Using a new pinch bolt and nut, attach the driveline lower end yoke to the input shaft. Tighten the nut 30 to 35 lbf·ft (41 to 47 N·m).
 - 3.3 Apply torque seal, OGP F900WHITE, to the exposed bolt threads and the nut to indicate the fasteners have been properly tightened.
- Install the pitman arm. Refer to Section 46.08 for instructions.
- 5. If the hydraulic line fittings were removed, attach them to the steering gear. Tighten the fittings 37 lbf·ft (50 N·m). Tighten the jam nut on the pressure line fitting to a maximum 41 lbf·ft (56 N·m).
- Remove the plugs from the hydraulic lines. Connect the hydraulic lines to the steering gear.
 Tighten the nut on each fitting finger tight, then use a wrench to tighten the nut until there is firm resistance. Tighten one-sixth turn more.
- 7. Connect the batteries.
- Fill and bleed the steering system. For instructions, refer to Subject 110.
- Close the hood and perform the post-service checks in Subject 150.

Air Bleeding the System

Filling and Air Bleeding the System

A WARNING

Fill the power steering system with only approved, clean hydraulic fluid. Mixing hydraulic fluids and using unapproved hydraulic fluid could lead to seal deterioration and leaks. Leaks could result in loss of power steering assist and spillage on the roadway, which could cause personal injury or property damage.

- 1. Fill the power steering reservoir nearly full with automatic transmission fluid. Do not turn the steering wheel.
- 2. Start the engine and let it idle for ten seconds, then shut it off. Check and fill the reservoir. Repeat this step at least three times, checking the fluid level in the reservoir each time.

IMPORTANT: Do not let the fluid level drop significantly or allow the reservoir to empty. Doing so may introduce air into the system.

- Start the engine and let it idle for two minutes.
 Do not turn the steering wheel. Shut off the engine and check the fluid level in the reservoir. If needed, add more fluid.
- 4. Start the engine again. Turn the steering wheel from full-left to full-right several times. If needed, add more fluid to the reservoir.

Automatic bleed systems should now be free of trapped air.

If the vehicle has a manual bleed system (**Fig. 1**), proceed to the next step.

IMPORTANT: Do not turn the steering wheel while the bleed screw is loosened.

- With the wheels in the straight-ahead position, loosen the manual bleed screw two to three turns. Allow air and aerated fluid to bleed out until only clear fluid is seen. Close the bleed screw and add fluid to the reservoir if needed.
 - Repeat this step until all air is out of the system.
- 6. Tighten the bleed screw 45 lbf·in (509 N·cm).

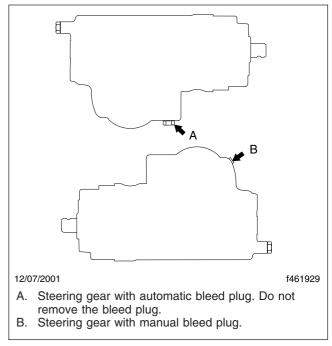


Fig. 1, Steering Gear Bleed Systems

Replacement

NOTE: The power steering pump is used in this procedure to force out the input shaft seal. To use this procedure, the power steering pump should have a minimum of 1500 psi (10 342 kPa) available.

- Shut down the engine, apply the parking brake, and chock the tires.
- 2. Disconnect the return line from the steering gear and plug the line. See **Fig. 1**. Cap the return port of the steering gear with a high pressure fitting.

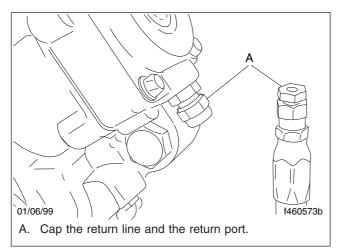


Fig. 1, Disconnected Return Line

NOTICE -

Do not pound the U-joint or lower end yoke on or off the input shaft. Internal damage to the steering gear can result.

- 3. Disconnect the steering driveline from the steering gear input shaft.
- Remove the dirt and water seal from the steering gear. Save this seal to determine the correct size of the new seal.
- 5. Using a clean cloth, remove all grease from around the input shaft.
- 6. Using a screwdriver inserted into the notch formed in the end of the retaining ring, remove the retaining ring. See **Fig. 2**. Be careful not to scratch the bore with the screwdriver.

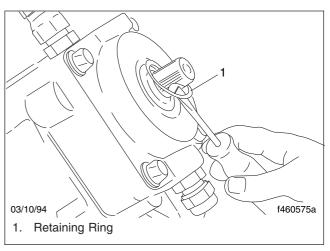


Fig. 2, Retaining Ring Removal

7. Using a pinch bolt and nut, attach the steering driveline to the input shaft but do not tighten the nut. See Fig. 3.

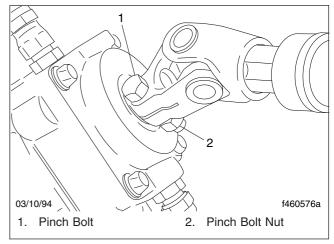


Fig. 3, Pinch Bolt Installation

8. Tie or wrap a shop towel around the input shaft and place a drain pan under the steering gear to catch the oil. See **Fig. 4**.



Fill the power steering system with only approved, clean hydraulic fluid. Mixing hydraulic fluids and using unapproved hydraulic fluid could lead to seal deterioration and leaks. Leaks could result in loss of power steering assist and

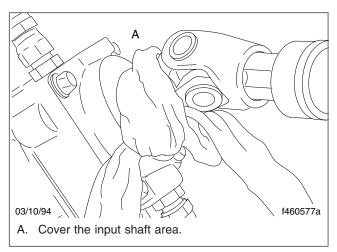


Fig. 4, Shop Towel Covering the Input Shaft

spillage on the roadway, which could cause personal injury or property damage.

- If needed, fill the power steering reservoir with automatic transmission fluid.
- With the vehicle in neutral, momentarily turn the starter. If the engine starts, quickly turn it off. This should force out the input shaft seal.
- Remove the shop towel, pinch bolt, and input yoke. Remove the input shaft seal. See Fig. 5.

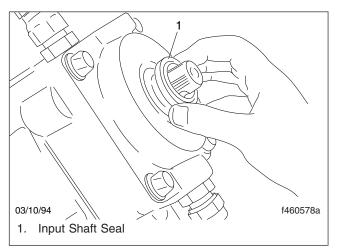


Fig. 5, Input Shaft Seal Removal

- 12. Inspect the seal area of the valve housing for seal fragments. Remove all seal fragments.
- 13. Check the input shaft seal for heat damage. If the seal is stiff and brittle, it is probably heat

damaged. Determine and fix the cause of excessive heat in the vehicle.

A WARNING

Do not use a socket to install the input shaft seal. You will not be able to control the seal installation depth with a socket and this could lead to leaks. Leaks could result in loss of steering assist and spillage on the roadway, which could result in personal injury or property damage.

- 14. Install a new input shaft seal.
 - 14.1 Using Exxon Polyrex® EP2 grease (045422), lubricate the inside diameter of the new input shaft seal and install it on the input shaft.
 - 14.2 Using a hammer and seal driver (J37073), tap the driver until the shoulder of the driver is square against the valve housing. See Fig. 6. Remove any seal material that may have sheared off in the seal bore or retaining ring groove.

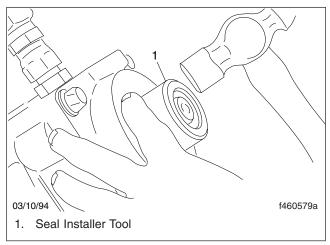


Fig. 6, Seal Installer Tool Position

- 15. Install a new retaining ring in the groove.
- 16. Using Exxon Polyrex EP2 grease (045422), pack the end of the valve housing bore.
- 17. Install a new dirt and water seal.
 - 17.1 Choose the correct size dirt and water seal by comparing the replacement seals to the old seal.

17.2 Apply Exxon Polyrex EP2 grease to the new dirt and water seal and install it on the input shaft. See Fig. 7. Seat it in the groove behind the serrations and against the valve housing.

Wipe any excess grease from the valve housing bore and input shaft once the seal has been installed.

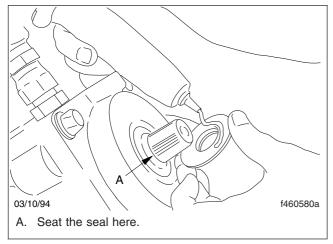


Fig. 7, Dirt and Water Seal Installation

- 18. Using a new pinch bolt and nut, attach the steering driveline to the input shaft. Tighten the nut 30 to 35 lbf·ft (41 to 47 N·m).
- 19. Apply torque seal, OGP F900WHITE, to the exposed bolt threads and the nut to indicate the fasteners have been properly tightened.
- 20. Connect the return line to the steering gear return port.
- 21. Bleed the air from the system. For instructions, see **Subject 110**.

Sector Shaft Adjustment

Adjustment

NOTE: If the steering gear is installed on the frame rail, sector shaft adjustment can only be completed if the adjusting screw jam nut (located on the side cover) is accessible.

- Apply the parking brakes and chock the rear tires.
- With the engine on, turn the steering wheel until
 the timing mark on the sector shaft lines up with
 the timing mark on the housing. The sector shaft
 is now at its center of travel. Shut down the engine.
- 3. Remove the cotter pin and castle nut that attach the drag link to the pitman arm. Remove the drag link from the pitman arm.

IMPORTANT: To avoid resetting the poppets, do not turn the input shaft more than 1-1/2 turns from the center-of-travel position while the drag link is disconnected.

- 4. From the center-of-travel position, grasp the pitman arm at the lower end of the arm and gently try to move the arm back and forth. If the pitman arm is loose or lash (free play) is detected, the sector shaft is out of adjustment.
- 5. Loosen the adjusting screw jam nut.
- 6. If no lash was detected in step 4, use a screwdriver to turn the sector shaft adjusting screw counterclockwise until you feel lash at the sector shaft. See **Fig. 1**.

IMPORTANT: Do not use more than 10 lbf·ft (14 N·m) of force when tightening the adjusting screw.

- 7. Slowly turn the shaft adjusting screw clockwise until you feel no lash at the sector shaft. From this position, turn the screw clockwise 1/8 to 3/16 of a turn more. Hold the adjusting screw in place and tighten the jam nut 43 lbf·ft (58 N·m).
- 8. Turn the steering wheel 1/4 of a turn each side of center then back to center and check the pitman arm for lash. There should be no lash. If lash is detected, loosen the jam nut and repeat the previous step as well as this step.
- Using a castle nut, attach the drag link to the pitman arm. Tighten the castle nut using the appropriate torque value:

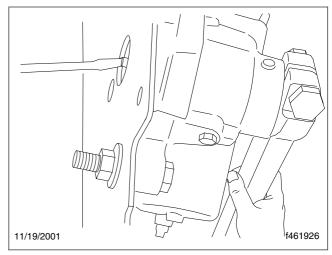


Fig. 1, Adjusting the Sector Shaft

- 3/4–16: 90 to 170 lbf·ft (122 to 230 N·m)
- 7/8-14: 160 to 300 lbf·ft (217 to 407 N·m)

A WARNING

Failure to install and lock a new cotter pin in the ball stud and nut could result in disengagement of the parts and loss of steering control, which could result in personal injury or property damage.

10. Continue to tighten the castle nut until a slot on the nut aligns with the hole in the ball stud. Do **not** reverse the tightening direction of the nut when locating the cotter pin hole. Install a new cotter pin in the ball stud and nut, then lock the cotter pin in place.

- NOTICE ----

Do not use a power grease gun to add grease to the sector shaft bearing. Doing so could damage the high-pressure seal and contaminate the hydraulic fluid.

11. Using only a hand-operated grease gun, add grease to the sector shaft bearing through the grease fitting in the housing until grease begins to extrude past the dirt and water seal.

Poppet Adjustment on a Single Gear

Resetting the Poppet Valves

- Check that the axle stops are adjusted properly.
 See Group 33 for instructions.
- 2. Start the engine and allow the vehicle to idle for 5 to 10 minutes to warm the hydraulic fluid.
- Shut down the engine, apply the parking brakes, and chock the rear tires.
- Hold the poppet screw with a wrench and turn the sealing nut back toward the wrench until the nut is flush with the base of the hex area of the poppet screw.
- 5. Make sure that the engine is off and the wheels are in the straight-ahead position.

NOTICE -

Make sure the drive end of the adjusting screw is not below the face of the nut. If the drive end of the adjusting screw is below the face of the nut, the poppet seat flange will break when the upper poppet is prepared for setting.

6. Using a 7/32-inch Allen wrench, turn the adjusting screw and nut assembly (without turning the nut on the screw) into the housing until the nut is firmly against the housing. Tighten the nut against the housing. See Fig. 1.

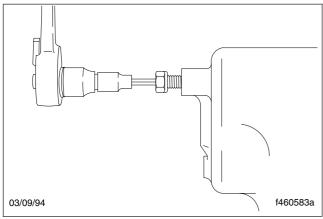


Fig. 1, Adjusting Screw and Nut Assembly

- Place a jack under the center of the front axle and jack up the front of the vehicle so the steer axle tires are off the ground.
- 8. Push the upper poppet out to prepare it for set-

- 8.1 Start the engine and let it idle.
- 8.2 Note which sector shaft timing mark is nearest the housing piston bore.

NOTICE -

Do not hold the steering wheel at full turn for more than 10 seconds at a time. The heat buildup at pump relief pressure may damage components.

- 8.3 Turn the steering wheel in the direction that makes this timing mark move toward the adjusting screw just installed. Turn the wheel in this direction until axle stop contact is made.
- 8.4 Pull hard on the steering wheel. Put up to 30 lbf (133 N) pull on a 20-inch diameter steering wheel.
- 9. Set the upper poppet.
 - 9.1 Turn the steering wheel in the opposite direction (the timing mark will move away from the adjusting screw) until the other axle stop is contacted.
 - 9.2 Pull hard on the steering wheel. Put up to 30 lbf (133 N) pull on a 20-inch diameter steering wheel.
 - 9.3 Release the steering wheel and shut off the engine.
- Loosen the sealing nut and back out the adjusting screw until the adjusting screw is one inch
 (2.5 cm) past the nut. See Fig. 2. Tighten the nut
 against the housing.
- 11. Set the lower poppet.
 - 11.1 Start the engine and let it idle.
 - 11.2 Turn the steering wheel in the original direction (the timing mark will move toward the adjusting screw) until axle stop contact is made.
 - 11.3 Hold the steering wheel in this position with up to 30 lbf (133 N) pull on a 20-inch diameter steering wheel for 10 seconds, then release. Repeat this hold-and-release process as many times as necessary while completing the next step.
- 12. Position the adjusting screw.

Poppet Adjustment on a Single Gear

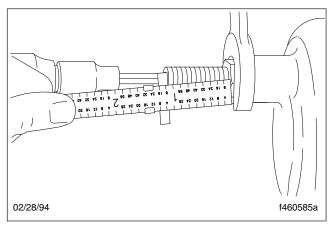


Fig. 2, Adjusting Screw Position

- 12.1 With the steering wheel held tightly at full turn, loosen the nut and hold it in place with a wrench.
- 12.2 Using an Allen wrench and finger pressure only, turn the adjusting screw clockwise until the Allen wrench stops. Do not attempt to turn the adjusting screw in any farther. Pause the turning-in process each time the driver releases the steering wheel. Continue turning only while the steering wheel is held at full turn.
- 12.3 Back off the adjusting screw 3-1/4 turns and tighten the nut 35 lbf·ft (47 N·m).

WARNING

If the adjusting screw protrudes more than 1-1/16 inches (27 mm) from the sealing nut, the screw could fall out of the steering gear, resulting in loss of power steering. This could cause an accident resulting in personal injury or property damage.

IMPORTANT: Once the poppet adjusting screw and sealing nut are in place, and the poppet valves have been manually adjusted, the adjustment procedure must be repeated if steering travel is either increased or decreased in the future.

WARNING

Fill the power steering system with only approved, clean hydraulic fluid. Mixing hydraulic fluids and using unapproved hydraulic fluid could lead to seal deterioration and leaks. Leaks could result in loss of power steering assist and spillage on the roadway, which could cause personal injury or property damage.

- 13. The poppets have now been completely reset. Check the power steering reservoir. The power steering fluid level should be between the MIN COLD mark and the middle mark just above it. If needed, add fluid.
- 14. Lower the vehicle.

Post-Service Checks

Post-Service Checks

After power steering components have been worked on and before the vehicle is placed into service, the following items must be checked.

WARNING

Failure to check the following items could result in damage to the power steering system. This could cause loss of steering assist and spillage on the roadway, which could cause personal injury or property damage.

- Operate the engine at idle while turning the steering wheel through several full-left and fullright turns. With the engine running and the power steering system at operating temperature, turn the steering wheel slowly from stop to stop while checking the power steering reservoir for frothing or a change in the fluid level (signs that air is trapped in the system).
 - If air is present, inspect the system for leaking hoses or loose fittings. Replace the hoses or tighten the fittings as necessary. Bleed the air from the system. Refer to **Subject 110** for instructions.
- 2. With the engine turned off and warm, check the power steering reservoir fluid level. If needed, add power steering fluid.
- 3. At full-left and full-right turns, be sure the axle stops on the rear side of the spindle are set so there is at least 1/2 inch (13 mm) of clearance between the tires and any fixed components that are attached to the vehicle. Clearance between moving components should be at least 3/4 inch (19 mm). If clearance is less than the above, reset the axle stops.
- 4. Check that the poppets are set correctly. If needed, adjust them. For instructions, refer to **Subject 140**.
- 5. Test drive the vehicle. Check the steering wheel spoke position. If, during straight-ahead driving on a level road, the steering wheel spokes are not within ±10 degrees of the 9 o'clock and 3 o'clock positions, remove the steering wheel and reposition it. See Fig. 1.

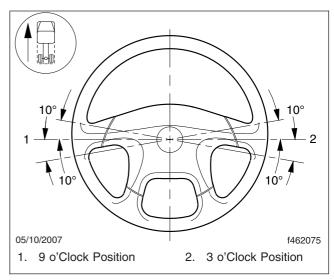


Fig. 1, Steering Wheel Centered

Specifications

WARNING

Fill the power steering system with only approved, clean hydraulic fluid. Mixing hydraulic fluids and using unapproved hydraulic fluid could lead to seal deterioration and leaks. Leaks could result in loss of power steering assist and spillage on the roadway, which could cause personal injury or property damage.

THP and PCF power steering gears use automatic transmission fluid that meets Dexron II, Dexron III, Mercon, or ATF $+4^{TM}$ specifications.

Exxon Polyrex® EP2 Grease (045422) is approved for use on steering gear components.

Special tools can be ordered from:

SPX Kent-Moore 28635 Mound Road Warren, Michigan 48092-3499 1-800-328-6657

SPX Kent-Moore Tools				
Tool Name	Part Number			
Bearing and Seal Tool	J37071 and J37071-A			
Special Tool	J36452-A			
Bearing Adjuster Tool	J37070			
Seal Driver Tool	J37073			
Adjuster Locknut Tool	J37464			

Table 1, SPX Kent-Moore Tools

46.06

Power Steering Pump, ZF FN4

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General Information

General Information

The ZF FN4 power steering pump supplies power steering fluid for the operation of the power steering gear. The pump is a sliding-vane pump with an internal flow control and pressure relief valve. The primary parts of the pump include the input shaft, rotor, vanes, and cam ring; all contained in a lightweight alloy housing. The oval-shaped cam ring surrounds the cylindrical rotor, creating two pumping pockets positioned 180 degrees from each other. The position of the pumping pockets balances the internal forces within the pump. Flow rate and maximum pressure are not adjustable.

Principles of Operation

As the input shaft turns the rotor inside the cam ring, the centrifugal force pushes ten vanes out toward the surface of the cam ring. The pumping element has two pumping pockets opposed 180 degrees from each other that balance the internal forces using the pressure generated by the pumping action. Fluid entering via the inlet port is forced by the vanes through the pumping pockets in the cam ring, and out through the outlet port, to the steering gear. Once through the steering gear, the fluid returns to the power steering reservoir, then back to the power steering pump.

The pump outputs a fixed volume for each revolution of the input shaft. This volume is determined by the internal contour of the cam ring.

Power Steering Pump Removal and Installation

Removal

- Turn off the engine, apply the parking brakes, and chock the tires.
- Disconnect the batteries at the negative terminals, and open the hood.
- 3. Clean all the fittings and hose connections on the power steering reservoir, the power steering pump, and the pressure line on the power steering gear until they are free of dirt. See Fig. 1.

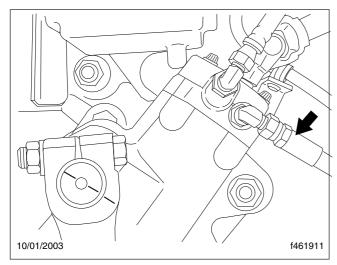


Fig. 1, Pressure Line on the Power Steering Gear

- Drain the fluid from the power steering system.
 Disconnect the hydraulic lines from the power steering reservoir, marking the lines for later reference. Plug the lines and the fittings to keep out dirt.
- Remove the bolts, nuts, and washers that attach the power steering reservoir to the mounting bracket. Remove the power steering reservoir.
- 6. Remove the pressure line at the power steering gear and plug the line.
- 7. On vehicles with a Caterpillar 3126 engine, the power steering pump may be mounted on the engine or the air compressor. If the power steering pump is mounted on the engine, remove the mounting bolts, nuts, and washers, then remove the pump. If the power steering pump is mounted on the air compressor, remove the mounting capscrews, then remove the pump.

- 8. On vehicles with an MBE900 engine, remove the capscrews that attach the power steering pump to the engine or to the air compressor.
- 9. Remove the power steering pump and discard the gasket or O-ring.
- If the power steering pump is being replaced, remove the fittings on the pump and attach the fittings to the new pump.

Installation

- 1. On vehicles with a Caterpillar 3126 engine, install the power steering pump.
 - 1.1 Install a new gasket on the power steering pump.
 - 1.2 If the power steering pump is mounted on the air compressor, use capscrews to attach the steering pump to the air compressor and tighten the capscrews 27 to 32 lbf·ft (37 to 43 N·m).

If the power steering pump is mounted on the engine, use bolts, nuts, and washers to attach the steering pump to the engine. Tighten the bolts 27 to 32 lbf·ft (37 to 43 N·m).

- 2. On vehicles with an MBE900 engine, install the power steering pump.
 - 2.1 Make sure the O-ring is in place on the power steering pump.
 - 2.2 Using capscrews, attach the power steering pump to the engine or the air compressor. Tighten the capscrews 27 to 32 lbf·ft (37 to 43 N·m).
- 3. Unplug the pressure line and attach it to the steering pump.
- 4. Unplug the remaining hydraulic lines and fittings and connect the lines.
- 5. Using bolts, nuts, and washers, attach the power steering reservoir to the mounting bracket.
- 6. Connect the batteries.
- Fill the power steering reservoir to between the MAX HOT and MIN COLD lines. For approved power steering fluids, see Specifications 400.

Power Steering Pump Removal and Installation

- 8. Start the engine and turn the steering wheel from full right to full left two or three times to remove air from the lines.
- 9. Check the power steering reservoir again and add fluid if needed.
- 10. Check the hydraulic lines for leaks.
- 11. Turn off the engine, close the hood, and remove the chocks from the tires.

Specifications

Approved lubricants for the ZF FN4 power steering pump are:

- Automatic Transmission Fluid (ATF), Dexron® II or Dexron® III
- Engine Oil 15W40, 76 Lubricants or equivalent

IMPORTANT: Do not use engine oil in vehicles built from November 4, 2002.

46.07

Power Steering Gears, TRW TAS Models

Contents

Subject	Subject Number
General Information	
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General Information

General Description

NOTE: Procedures in this section have been slightly modified from the original component manufacturer's service manual. See the manufacturer's service literature (trucksteering.trw.com) for additional information.

TRW TAS power steering gears are integral hydraulic power steering gears that contain a manual steering mechanism, a hydraulic control valve, and a hydraulic power cylinder.

The pressure required for the steering gear to overcome resistance at the steered wheels is provided by the power steering pump. The rotary control valve directs the flow of hydraulic fluid to the appropriate cylinder cavity in the steering gear (and in the auxiliary cylinder in a dual steering gear system) at the proper flow rate and pressure. As the steering wheel is turned faster or slower, more or less fluid is required by the gear.

Principles of Operation

When the driver turns the steering wheel, that force travels from the steering wheel to the steering gear input shaft. A torsion bar, pinned at one end to the input shaft and at the other end to the worm shaft, turns with the input shaft and exerts a rotational force on the worm shaft. In response to the force exerted by the torsion bar, the worm shaft moves the rack piston forward or backward in the gear housing by means of a series of recirculating balls in the spiral channels of the worm shaft. As the rack piston slides back and forth, it turns the sector shaft. The sector shaft swings the pitman arm, which pulls or pushes the drag link. The drag link moves the axle steering arm, steering the vehicle.

The rack piston's axial movement is resisted by its engagement to the sector shaft, which is linked to the steered wheels. Because of this resistance, the torsion bar activates the control valve, which directs pressurized fluid to the upper or lower cylinder cavity (depending on the direction of turn). The pressurized fluid assists in moving the rack piston up or down in the cylinder bore.

Most TAS steering gears are equipped with two poppet (unloading) valves, one at each end of the rack piston. As the front wheels reach the axle stop—the farthest the wheels can turn in either direction—one

poppet or the other, depending on the direction of the turn, will trip to prevent steering system damage. The tripped poppet reduces pressure in the gear, heat generated by the power steering pump, and outside forces acting on the steering linkage.

Some TAS steering gears are also supplied with an internal pressure relief valve (PRV). The PRV limits maximum supply pressure to protect the power steering gear, but it does not reduce pressure as the steered wheels approach the axle stops.

See Fig. 1 for an exploded diagram of a TRW TAS power steering gear.

General Information

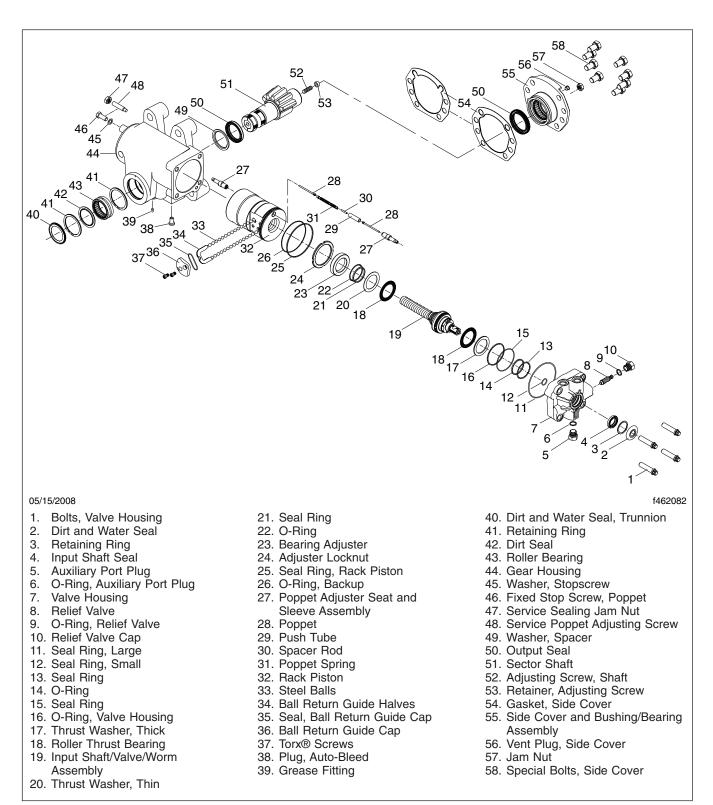


Fig. 1, TRW TAS85 Power Steering Gear Components

Sector Shaft Adjustment

NOTE: If the steering gear is installed on the frame rail, sector shaft adjustment can only be completed if the adjusting screw jam nut (located on the side cover) is accessible.

- Apply the parking brakes and chock the rear tires.
- 2. With the engine on, turn the steering wheel until the timing mark on the sector shaft lines up with the timing mark on the housing. The sector shaft is now at its center of travel. See **Fig. 1**. Shut down the engine.

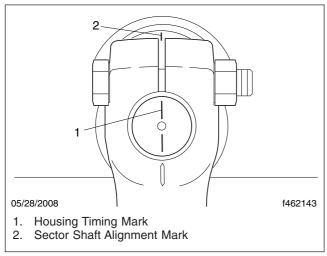


Fig. 1, Timing Mark Placement

3. Remove the cotter pin and castle nut that attach the drag link to the pitman arm. Disconnect the drag link from the pitman arm.

IMPORTANT: To avoid resetting the poppets, do not turn the input shaft more than 1-1/2 turns from the center-of-travel position while the drag link is disconnected.

- 4. From the center-of-travel position, grasp the pitman arm at the lower end of the arm and gently try to move the arm back and forth. See Fig. 2. If the pitman arm is loose or lash (free play) is detected, the sector shaft is out of adjustment.
- 5. Loosen the adjusting screw jam nut.
- 6. If no lash was detected in step 4, use a screwdriver to turn the sector shaft adjusting screw

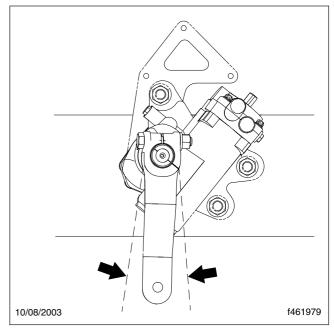


Fig. 2, Lash Check

counterclockwise until you feel lash at the sector shaft. See Fig. 3.

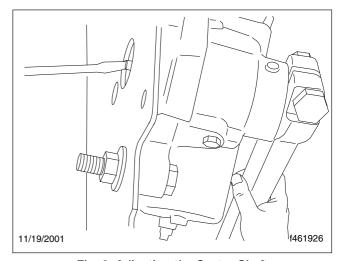


Fig. 3, Adjusting the Sector Shaft

IMPORTANT: Do not use more than 10 lbf·ft (14 $N \cdot m$) of force when tightening the adjusting screw.

7. Slowly turn the adjusting screw clockwise until no lash is felt at the pitman arm. From this position, turn the adjusting screw clockwise 1/8 to 3/16 of

- a turn more. Hold the adjusting screw in place and tighten the jam nut 43 lbf·ft (58 N·m).
- 8. Turn the steering wheel 1/4 of a turn to each side of center and recheck the pitman arm for lash. If lash is detected, adjust the sector shaft again.
- Attach the drag link to the pitman arm. See Section 46.08 for instructions.

A WARNING

Failure to install and lock a new cotter pin in the ball stud and nut could result in disengagement of the parts and loss of steering control, which could result in personal injury or property damage.

10. Continue to tighten the castle nut until a slot on the nut aligns with the hole in the ball stud. Do not reverse the tightening direction of the nut when locating the cotter pin hole. Install a new cotter pin in the ball stud and nut, then lock the cotter pin in place.

NOTICE -

Do not use a power grease gun to add grease to the sector shaft bearing. Doing so could damage the high-pressure seal and contaminate the hydraulic fluid.

11. Using only a hand-operated grease gun, add grease to the sector shaft bearing through the grease fitting in the housing until grease begins to extrude past the dirt and water seal.

Resetting the Poppet Valves

IMPORTANT: The axle stops must be set so that there are at least 1-3/4 steering wheel turns from a straight-ahead position to both a full-left and a full-right turn; otherwise the poppet valves will not work.

- 1. Verify that the axle stops are adjusted properly. See **Group 33** for instructions.
- 2. Start the engine and allow the vehicle to idle for 5 to 10 minutes to warm the hydraulic fluid.
- 3. Shut down the engine, apply the parking brakes, and chock the rear tires.

- Hold the poppet screw with a wrench and turn the sealing nut back toward the wrench until the nut is flush with the base of the hex area of the poppet screw.
- 5. Make sure that the engine is off and the wheels are in the straight-ahead position.

NOTICE -

Make sure the drive end of the adjusting screw is not below the face of the nut. If the drive end of the adjusting screw is below the face of the nut, the poppet seat flange will break when the upper poppet is prepared for setting.

Using a 7/32-inch Allen wrench, turn the adjusting screw and nut assembly (without turning the nut on the screw) into the housing until the nut is firmly against the housing. Tighten the nut against the housing. See Fig. 4.

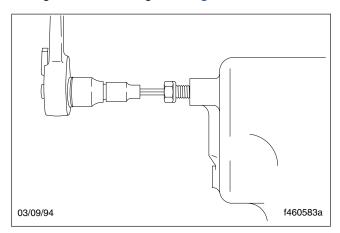


Fig. 4, Adjusting Screw and Nut Assembly



Fill the power steering system with only approved, clean hydraulic fluid. Mixing hydraulic fluids and using unapproved hydraulic fluid could lead to seal deterioration and leaks. Leaks could result in loss of power steering assist and spillage on the roadway, which could cause personal injury or property damage.

7. Fill the power steering reservoir nearly full with automatic transmission fluid. Do not turn the steering wheel.

- 8. Place a jack under the center of the front axle and jack up the front of the vehicle so the steer axle tires are off the ground.
- 9. Push the upper poppet out to prepare it for setting.
 - 9.1 Start the engine and let it idle.
 - 9.2 Note which sector shaft timing mark is nearest the housing piston bore.

NOTICE

Do not hold the steering wheel at full turn for more than 10 seconds at a time. The heat buildup at pump relief pressure may damage components.

- 9.3 Turn the steering wheel in the direction that makes this timing mark move toward the adjusting screw just installed. Turn the wheel in this direction until axle stop contact is made.
- 9.4 Pull hard on the steering wheel. Put up to 40 lbf (178 N) pull on a 20-inch diameter steering wheel.
- 10. Set the upper poppet.
 - 10.1 Turn the steering wheel in the opposite direction (the timing mark will move away from the adjusting screw) until the other axle stop is contacted.
 - 10.2 Pull hard on the steering wheel. Put up to 40 lbf (178 N) pull on a 20-inch diameter steering wheel.
 - 10.3 Release the steering wheel and shut off the engine.
- Loosen the sealing nut and back out the adjusting screw until the adjusting screw is 1 inch (2.5 cm) past the nut. See Fig. 5. Tighten the nut against the housing.
- 12. Set the lower poppet.
 - 12.1 Start the engine and let it idle.
 - 12.2 Turn the steering wheel in the original direction (the timing mark will move toward the adjusting screw) until axle stop contact is made.
 - 12.3 Hold the steering wheel in this position with up to 40 lbf (178 N) pull on a 20-inch

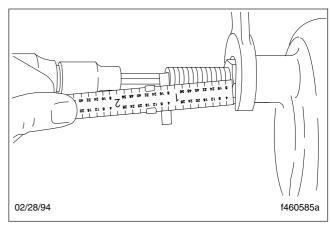


Fig. 5, Adjusting Screw Position

diameter steering wheel for 10 seconds, then release. Repeat this hold-and-release process as many times as necessary while completing the next step.

- 13. Position the adjusting screw.
 - 13.1 With the steering wheel held tightly at full turn, loosen the nut and hold it in place with a wrench.

IMPORTANT: Do not attempt to turn the adjusting screw in any farther. Pause the turning-in process each time the driver releases the steering wheel. Continue turning only while the steering wheel is held at full turn.

13.2 Using an Allen wrench and finger pressure only, turn the adjusting screw clockwise until the Allen wrench stops.



If the adjusting screw protrudes more than 1-1/16 inches (27 mm) from the sealing nut, the screw could fall out of the steering gear, resulting in loss of power steering. This could cause an accident resulting in personal injury or property damage.

13.3 Back off the adjusting screw 3-1/4 turns and tighten the nut 35 lbf·ft (47 N·m).

WARNING

Fill the power steering system with only approved, clean hydraulic fluid. Mixing hydraulic fluids and using unapproved hydraulic fluid could lead to seal deterioration and leaks. Leaks could result in loss of power steering assist and spillage on the roadway, which could cause personal injury or property damage.

- The poppets have now been completely reset. Check the power steering reservoir. If needed, add fluid.
- 15. Lower the vehicle.

Steering Gear Removal and Installation

Removal

- Verify correct axle stop adjustment. Ensuring correct axle stop adjustment now will eliminate the need to reset the steering gear poppet valves after the gear is installed. For instructions, refer to Group 33.
- Place the front tires in the straight-ahead position. If possible, drive the vehicle in a straight line for a short distance, stopping where the work is to be done.
- 3. Shut down the engine, apply the parking brakes, and chock the tires.
- 4. Remove the left bumper extension, if equipped.
- 5. Clean all fittings and hose connections on the steering gear until they are free of dirt.
- 6. Drain the fluid from the power steering system. Disconnect all hydraulic lines from the gear, marking the lines for later reference. Seal the lines and the fittings to keep out dirt.
- Disconnect the pitman arm from the steering gear sector shaft. See Section 46.08 for instructions.
- 8. Disconnect the steering driveline from the steering gear input shaft.
 - 8.1 Remove and discard the pinch bolt and nut from the steering driveline lower end yoke.

- NOTICE -

Do not pound the U-joint or lower end yoke on or off the input shaft. Internal damage to the steering gear can result.

8.2 Remove the lower end yoke from the input shaft.



The steering gear is heavy. Use caution when removing, lifting, or carrying the steering gear. Failure to do so could cause personal injury.

9. Remove the fasteners that attach the steering gear to the frame rail. Remove the steering gear.

Installation

- Install the steering gear and fasteners as shown in Fig. 1. Tighten the fasteners 278 to 352 lbf-ft (377 to 477 N·m).
- Center the steering gear so that the timing mark on the sector shaft is aligned with the timing mark on the steering gear housing. See Fig. 2. Keep the steering gear centered as the installation continues.
- 3. Connect the steering driveline to the steering gear input shaft.
 - 3.1 Clean the steering gear input shaft and the inside of the driveline yoke.
 - 3.2 Apply a thin film of grease to the yoke spline.
 - 3.3 Slide the yoke on the input shaft and install a new pinch bolt and nut. Tighten the nut 30 to 35 lbf·ft (41 to 47 N·m).
 - 3.4 Apply torque seal, OGP F900WHITE, to the exposed bolt threads and the nut to indicate the fasteners have been properly tightened.

A WARNING

Never leave a chisel wedged in the pitman arm slot. When using a chisel to spread the slot in the pitman arm, maintain a firm grip on the chisel at all times. Otherwise the chisel may fly loose, which could cause an injury.

- 4. Install the pitman arm. See **Section 46.08** for instructions.
- If they were removed, attach the hydraulic line fittings to the steering gear. Tighten the fittings 38 lbf·ft (52 N·m). Tighten the pressure line fitting jam nut 41 lbf·ft (56 N·m).
- Remove the plugs from the hydraulic lines. Connect the lines to the steering gear as previously marked. Tighten the nut on each fitting finger tight. Then, use a wrench to tighten the nut until there is firm resistance. Tighten 1/6 of a turn more.
- 7. Connect the batteries.
- 8. Fill and bleed the steering system.

Steering Gear Removal and Installation

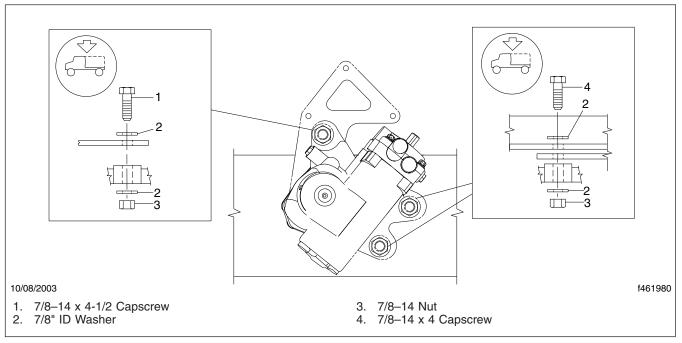


Fig. 1, Steering Gear Installation

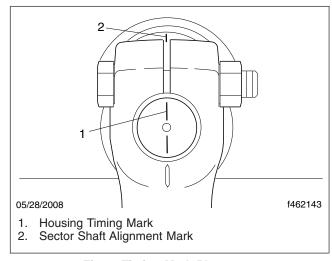


Fig. 2, Timing Mark Placement



Fill the power steering system with only approved, clean hydraulic fluid. Mixing hydraulic fluids and using unapproved hydraulic fluid could lead to seal deterioration and leaks. Leaks could result in loss of power steering assist and

spillage on the roadway, which could cause personal injury or property damage.

- 8.1 Fill the power steering reservoir nearly full with automatic transmission fluid. Do not turn the steering wheel.
- 8.2 Start the engine and let it idle for ten seconds, then shut it off. Check and fill the reservoir. Repeat this step at least three times, checking the fluid level in the reservoir each time.

IMPORTANT: Do not let the fluid level drop significantly or allow the reservoir to empty. Doing so may introduce air into the system.

- 8.3 Start the engine and let it idle for two minutes. Do not turn the steering wheel. Shut off the engine and check the fluid level in the reservoir. If needed, add more fluid.
- 8.4 Start the engine again. Steer the vehicle from full left to full right several times. Check and, if necessary, refill the reservoir.

Automatic bleed systems should now be free of trapped air. Skip to the last step in this procedure.

Steering Gear Removal and Installation

If the vehicle has a manual bleed system (**Fig. 3**), proceed to the next step.

IMPORTANT: Do not turn the steering wheel while the bleed screw is loosened.

8.5 With the wheels in the straight-ahead position, loosen the manual bleed screw two to three turns. Allow air and aerated fluid to bleed out until only clear fluid is seen. Close the bleed screw and add fluid to the reservoir if needed.

Repeat this step until all air is out of the system.

Tighten the bleed screw 45 lbf⋅in (509 N⋅cm).

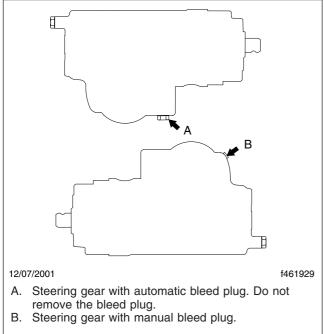


Fig. 3, Steering Gear Bleed Systems

9. Close the hood, install the left bumper extension (if equipped), and perform the post-service checks in **Subject 130**.

Replacement

NOTE: The power steering pump is used in this procedure to force out the input shaft seal. To use this procedure, the power steering pump should have a minimum of 1500 psi (10 342 kPa) available.

- Shut down the engine, apply the parking brake, and chock the tires.
- 2. Disconnect the return line from the steering gear and plug the line. See **Fig. 1**. Cap the return port of the gear with a high-pressure fitting.

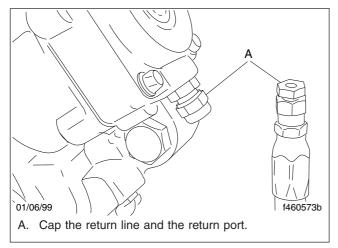


Fig. 1, Disconnected Return Line

NOTICE -

Do not pound the U-joint or lower end yoke on or off the input shaft. Internal damage to the steering gear can result.

- Disconnect the steering driveline from the steering gear input shaft.
 - 3.1 Remove and discard the pinch bolt and nut from the steering driveline lower end yoke.

IMPORTANT: Do not turn the steering gear input shaft when removing the lower end yoke.

3.2 Remove the lower end yoke from the input shaft. Push the driveline shaft into the driveline tube as you remove the lower end voke.

- 4. Remove the dirt and water seal from the steering gear. Save this seal to determine the correct size of the new seal.
- 5. Using a clean cloth, remove all grease from around the input shaft.
- 6. Using a screwdriver inserted into the notch formed in the end of the retaining ring, remove the retaining ring. See **Fig. 2**. Be careful not to scratch the bore with the screwdriver.

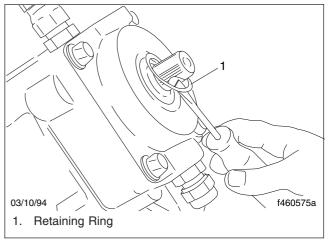


Fig. 2, Retaining Ring Removal

 Slip the driveline lower end yoke back on the input shaft, then insert but do not tighten the pinch bolt. See Fig. 3.

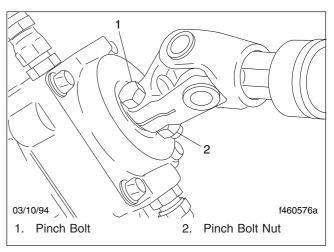


Fig. 3, Pinch Bolt Installation

8. Tie or wrap a shop towel around the input shaft area and place a drip pan under the vehicle to catch the oil. See Fig. 4.

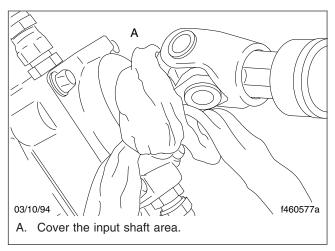


Fig. 4, Shop Towel Covering the Input Shaft



Fill the power steering system with only approved, clean hydraulic fluid. Mixing hydraulic fluids and using unapproved hydraulic fluid could lead to seal deterioration and leaks. Leaks could result in loss of power steering assist and spillage on the roadway, which could cause personal injury or property damage.

- 9. If needed, fill the power steering reservoir with automatic transmission fluid.
- With the vehicle in neutral, momentarily turn the starter. If the engine starts, quickly turn it off. This should force out the input shaft seal.
- 11. Remove the shop towel, pinch bolt, and input yoke. Remove the input shaft seal. See Fig. 5.
- Inspect the seal area of the valve housing for seal fragments. Remove any seal fragments.
- 13. Check the seal for heat damage. If the seal is stiff and brittle, and not pliable like the new seal, it is probably heat damaged. Determine and fix the cause of any excessive heat in the vehicle. Discard the old seal.

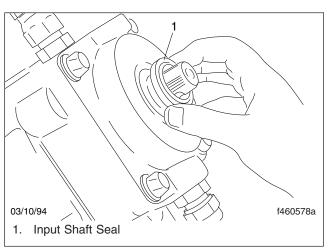


Fig. 5, Input Shaft Seal Removal



Do not use a socket to install the input shaft seal. You will not be able to control the seal installation depth with a socket and this could lead to leaks. Leaks could result in loss of steering assist and spillage on the roadway, which could result in personal injury or property damage.

- 14. Install a new input shaft seal.
 - 14.1 Using Exxon Polyrex® EP2 grease (045422), lubricate the inside diameter of the new input shaft seal and install it on the input shaft.
 - 14.2 Using a hammer and seal driver (J37073), tap the driver until the shoulder of the driver is square against the valve housing. See Fig. 6. Remove any seal material that may have sheared off in the seal bore or retaining ring groove.
- 15. Install a new retaining ring in the groove.
- 16. Using Exxon Polyrex EP2 grease, pack the end of the valve housing bore and around the input shaft with clean grease.
- 17. Install a new dirt and water seal.
 - 17.1 Choose the correct size dirt and water seal by comparing the replacement seals to the old seal.
 - 17.2 Apply Exxon Polyrex EP2 grease to the new dirt and water seal and install it on the input shaft. See Fig. 7. Seat it in the

Input Shaft Seal Replacement

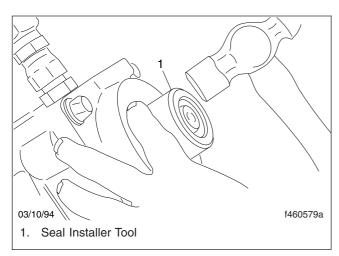


Fig. 6, Seal Installer Tool Position

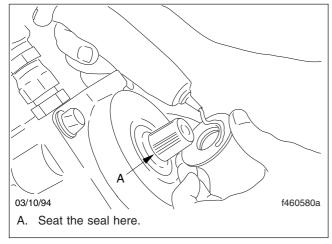


Fig. 7, Dirt and Water Seal Installation

groove behind the serrations and against the valve housing.

Wipe any excess grease from the valve housing bore and input shaft once the seal has been installed.

- 18. Connect the steering driveline to the steering gear input shaft.
 - 18.1 Clean the input shaft and the inside of the driveline yoke.
 - 18.2 Apply a thin film of grease to the yoke splines.

- 18.3 Slide the yoke on the input shaft and install a new pinch bolt and nut. Tighten the nut 30 to 35 lbf·ft (41 to 47 N·m).
- 18.4 Apply torque seal, OGP F900WHITE, to the exposed bolt threads and the nut to indicate the fasteners have been properly tightened.
- 19. Connect the return line to the steering gear return port.
- 20. Fill and bleed the steering system.

A WARNING

Fill the power steering system with only approved, clean hydraulic fluid. Mixing hydraulic fluids and using unapproved hydraulic fluid could lead to seal deterioration and leaks. Leaks could result in loss of power steering assist and spillage on the roadway, which could cause personal injury or property damage.

- 20.1 Fill the power steering reservoir nearly full with automatic transmission fluid. Do not turn the steering wheel.
- 20.2 Start the engine and let it idle for ten seconds, then shut it off. Check and fill the reservoir. Repeat this step at least three times, checking the fluid level in the reservoir each time.

IMPORTANT: Do not let the fluid level drop significantly or allow the reservoir to empty. Doing so may introduce air into the system.

- 20.3 Start the engine and let it idle for two minutes. Do not turn the steering wheel. Shut off the engine and check the fluid level in the reservoir. If needed, add more fluid.
- 20.4 Start the engine again. Steer the vehicle from full left to full right several times. Check and, if necessary, refill the reservoir

Automatic bleed systems should now be free from trapped air.

If the vehicle has a manual bleed system (Fig. 8), proceed to the next step.

IMPORTANT: Do not turn the steering wheel while the bleed screw is loosened.

Input Shaft Seal Replacement

20.5 With the wheels in the straight-ahead position, loosen the manual bleed screw two to three turns. Allow air and aerated fluid to bleed out until only clear fluid is seen. Close the bleed screw and add fluid to the reservoir if needed.

Repeat this step until all air is out of the system.

Tighten the bleed screw 45 lbf·in (509 N·cm).

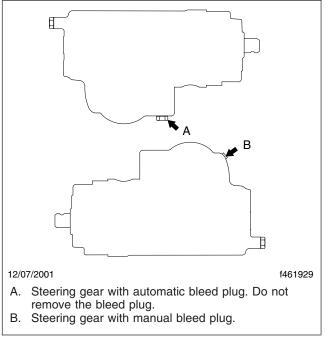


Fig. 8, Steering Gear Bleed Systems

21. Perform the post-service checks in Subject 130.

Post-Service Checks

Post-Service Checks

After power steering components have been worked on and before the vehicle is placed into service, the following items must be checked.

A WARNING

Failure to check the following items could result in damage to the power steering system. This could cause loss of steering assist and spillage on the roadway, which could cause personal injury or property damage.

- Operate the engine at low idle while turning the steering wheel through several full-left and fullright turns. With the engine running and the power steering system at operating temperature, turn the steering wheel slowly from stop to stop while checking the power steering reservoir for frothing or a change in the fluid level (signs that air is trapped in the system).
 - If air is present, inspect the system for leaking hoses or loose fittings. Replace the hoses or tighten the fittings as necessary. Bleed the air from the system.
- 2. With the engine turned off and warm, check the power steering reservoir fluid level. If needed, add power steering fluid.
- 3. At full-left and full-right wheel cuts, be sure the axle stops (on the rear-side of the spindle) are set so there is at least 1/2-inch (13-mm) clearance between the tires and any fixed components that are attached to the vehicle. Clearance between moving components should be 3/4 of an inch (19 mm). If clearance is less than this, reset the axle stops.
- Check that the poppets are set correctly. If necessary, adjust them. For instructions, see Subject 100.
- 5. If there are still problems with the power steering system, perform the troubleshooting procedures in **Section 46.09**. Otherwise, go to the next step.
- 6. Test drive the vehicle and check the steering wheel spoke position. With the front tires pointing straight ahead, check the position of the steering wheel spokes. They must be pointing within ±10 degrees of the 9 o'clock and 3 o'clock positions on a four-spoke steering wheel. If not, remove

the steering wheel and install it in the correct position. See Fig. 1.

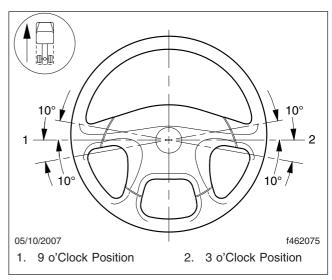


Fig. 1, Steering Wheel Centered

Specifications

WARNING

Fill the power steering system with only approved, clean hydraulic fluid. Mixing hydraulic fluids and using unapproved hydraulic fluid could lead to seal deterioration and leaks. Leaks could result in loss of power steering assist and spillage on the roadway, which could cause personal injury or property damage.

TRW TAS power steering gears use automatic transmission fluid that meets Dexron II, Dexron III, Mercon, or ATF $+4^{\text{TM}}$ specifications.

Exxon Polyrex® EP2 Grease (045422) is approved for use on steering gear components.

Special tools can be ordered from:

SPX Kent-Moore 28635 Mount Road Warren, Michigan 48092-3499 1-800-328-6657

SPX I	SPX Kent-Moore Part Numbers				
Part Number	Tool				
J37070	Adjuster Tool				
J37464	Adjuster Locknut Tool				
J38779	Bearing and Seal Tool				
J37073	Input Seal Installer				
J38713	Poppet Adjuster Seat Tool, Heavy- Duty (preferred)				
J36452	Poppet Adjuster Seat Tool				
J37130	Relief Valve Plug				
J8092	Tool Handle				

Table 1, SPX Kent-Moore Part Numbers

See Fig. 1 for a steering system plumbing diagram.

Specifications

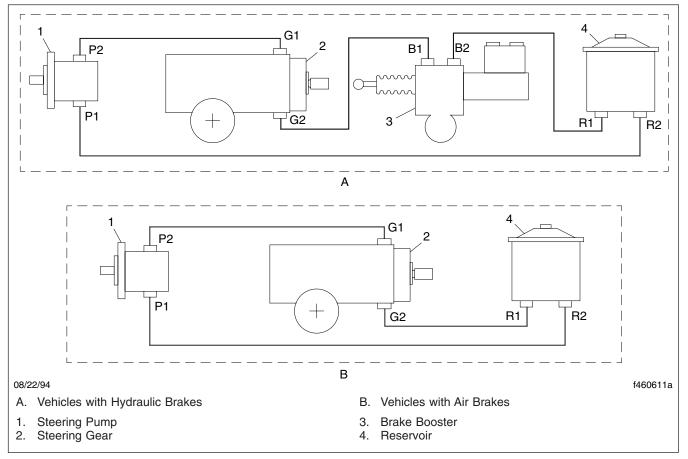


Fig. 1, Steering System Plumbing Diagram

Pitman Arm 46.08

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Subject	Subject Number
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Pitman Arm 46.08

Pitman Arm Removal and Installation

Removal

- 1. Identify the timing marks on the pitman arm and the steering gear sector shaft.
- 2. Remove the pinch bolt and nut that attach the pitman arm to the steering gear.
- Remove the cotter pin from the castle nut that attaches the pitman arm to the drag link. Remove the castle nut.
- 4. Remove the pitman arm.

Installation



Never leave a chisel wedged in the pitman arm slot. When using a chisel to spread the slot in the pitman arm, maintain a firm grip on the chisel at all times. Otherwise the chisel may fly loose, which could cause an injury.

- 1. Install the pitman arm on the steering gear aligning the timing marks on the pitman arm with the timing marks on the sector shaft. See Fig. 1.
 - The pitman arm may not fit over the splines on the sector shaft without spreading the slot in the pitman arm. To wedge the slot open, clamp the pitman arm in a vise with the slot at the top. Use a ball peen hammer to drive a chisel into the slot. Hold the chisel in place, remove the pitman arm from the vise, and install the pitman arm on the sector shaft. Remove the chisel from the slot.
- 2. Using a new pinch bolt and nut, attach the pitman arm to the steering gear. Torque the nut 130 to 155 lbf·ft (177 to 211 N·m).

WARNING

Failure to install and lock a new cotter pin in the ball stud and nut could result in disengagement of the parts and loss of steering control, which could result in personal injury or property damage.

 Using a castle nut, attach the drag link to the pitman arm. Torque the castle nut 90 to 170 lbf·ft (122 to 230 N·m). If necessary, continue tightening the castle nut until a slot on the nut aligns with a hole in the ball stud. Do not back off the nut.

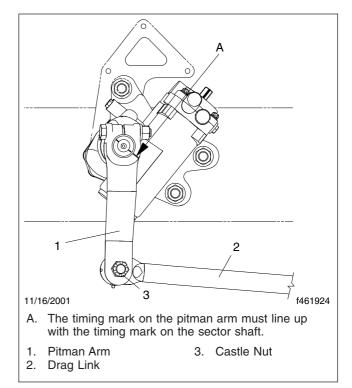


Fig. 1, Pitman Arm

- 4. Install a new cotter pin through the ball stud and the castle nut and lock the cotter pin in place.
- 5. Apply torque seal, OGP F900WHITE, to the exposed bolt threads and the nut to indicate the fasteners have been properly tightened.
- 6. Wipe the grease fittings clean at both ball stud sockets. Using a pressure gun, fill the sockets with chassis grease.

Power Steering System Troubleshooting Procedures

46.09

Contents

Subject	Subject Number
Troubleshooting Procedures	300

General Information

A Checklist for Troubleshooting Power Steering Problems, form STI-492, has been developed to accompany the procedures below. Form STI-492 can be downloaded or printed here after logging into www.AccessFreightliner.com.

Each step and substep in these troubleshooting procedures corresponds to a step or substep on form STI-492. Use **Table 1** to determine which steps should be completed, based on the customer's complaint. It is very important that the information provided by the driver is communicated accurately to prevent wasting of diagnostic time. For example, if complaints include "Pulling to one side" and "Noisy steering," steps 1, 3, 4, 5, and 6 will be the tests for the most likely failure modes.

Start with the lowest test number and work up to the highest. For example, when completing steps 1, 3, and 6 to determine the cause of a vehicle pulling to one side, start with step 1 and finish with step 6.

Troubleshooting Steps

NOTE: Some of these inspections and procedures can be found in the Pretrip and Post-Trip

Inspections and Maintenance chapter in the vehicle driver's/operator's manual.

Steps 1 through 4 may have been performed by the customer. Verify the vehicle service history with the customer to prevent redundant testing.

All measurements and readings must be recorded on STI-492.

Refer to the applicable section in this manual to repair or replace steering system components.

- 1. Check the tire pressure and load.
 - 1.1 Check the tires for damage.
 - 1.2 Check that the front tires are inflated to the correct pressure, and the tire pressure is equal on both sides. Correct the pressure if needed.

Low pressure causes increased steering effort due to friction with the road surface. Unequal tire pressure causes unequal friction between the tire and the road. This can cause pulling to one side.

		1	Steering Complaint a	and Iroubi	esnoot							
LH	RH	Both	Complaint	Troubleshooting Steps								
LII	NII	Botti	Complaint	1	2	3	4	5	6	7	8	9
			Hard or heavy steering									
			Low assist									
			Binding	•	•		•	•	•	•	•	•
			Locking									
			Occasional loss of assist									
			Reduced wheel cut								•	
			Pulling to one side*	•		•			•			
			Darting/oversteering				_					
			Wandering	•	•	•	•		•			
			Noisy steering				•	•	•			
			External seals leaking									_
			Excessive heat					•	•			•

^{*} If there is consistent pull to one side, a braking issue could feel like a steering assist problem. Refer to **Group 42** in this manual to ensure the brake system is functioning properly.

Table 1, Steering Complaint and Troubleshooting Steps Checklist

- 1.3 Check that the rear tires are inflated to the correct pressure, and the tire pressure is equal on both sides. Correct the pressure if needed.
- 1.4 Check that the tire sizes are correctly matched, and whether duplex or oversized tires (that were not originally specified for the vehicle) have been installed.
 - Extra tire width causes increased steering effort due to extra friction with the road surface. If the axle stops were turned out to reduce wheel cut due to a change in tires, the power steering gear poppets may need to be adjusted.
- 1.5 Communicate with the driver or operator to determine whether the vehicle is operated at or over the rated load.
 - Increased load causes greater steering effort. Make sure the vehicle is being operated within rated capacities.
- 2. Check fifth wheel lubrication and condition.
 - A dry fifth wheel plate makes it difficult to change direction. Check the plate surface for burrs, gouges, and irregularities.
- Check vehicle alignment and wheel bearing adjustment.
 - 3.1 Check the vehicle service history for the last known alignment, and inspect tire wear for indications that an alignment needs to be completed.
 - 3.2 Check front axle caster and camber measurements.
 - 3.3 Ensure wheel bearings and rear axle are in good condition, and that toe is set correctly.
 - 3.4 Ensure the rear axle is properly aligned.
- 4. Check for loose and binding components. Check whether any steering components need maintenance or adjustment.
 - 4.1 Check for proper lubrication of the drag link, tie rods, and knuckle pins. Apply lubrication as needed.
 - 4.2 Check the COE steering column, if equipped. Chock the rearmost tires. With the engine shut down, turn the steering

- wheel and check for looseness or binding. Make sure all components are free to move, but are not excessively loose.
- 4.3 Check the steering driveline U-joints for looseness or binding. Lubricate them if needed.
- 4.4 Check the sector shaft adjustment.
 - With the vehicle on the ground, the engine idling, and the front tires pointed straight ahead, turn the steering wheel until slight motion is observed at the front wheels.
 - Align a reference mark on the steering wheel to a rule, then, with the engine running, slowly turn the steering wheel in the opposite direction until motion is again detected at the wheels.
 - Measure the lash (free play) at the rim of the steering wheel.
 - Excessive lash exists if steering wheel movement exceeds 2-1/2 inches (64 mm) with a 20-inch (508-mm) steering wheel, or 2-1/4 inches (57 mm) with an 18-inch (457-mm) steering wheel.
- 4.5 Check that the front wheels self-return without binding.
 - With the engine off, chock the rearmost tires and place the front tires on radius plates (turntables).
 - Disconnect the drag link from the steering arm.
 - By hand, pull one tire to the axle stop and release. The tire should self-return to almost straight ahead.
 - Repeat with the opposite tire.
 - If a tire does not return to near straight ahead, check for binding or lack of lubrication in the steering axle kingpin bushings or tie rod linkage.
 - Connect the drag link and tighten the castle nut, then install a new cotter pin.

- 4.6 Inspect all suspension fasteners and components for wear or looseness.
- 5. Check the steering system for leaks and restrictions, and test the system back pressure.
 - 5.1 Inspect hoses, fittings, and seals for damage or leaks.
 - With the engine idling, inspect for kinked or collapsed hoses. Repair or replace any collapsed or kinked hoses. If collapsed hoses are found, ensure the steering system is filled with the correct automatic transmission fluid.
 - Inspect fittings for leaks. Repair leaking fittings; replace parts as needed.
 - Inspect all external seals. Replace leaking seals.
 - Inspect the seal bores and sealing surfaces for scrapes or burrs. Make sure the seals are installed correctly using the recommended tools.
 - If you replaced the steering gear input shaft seal and found it to be excessively hard, test the system operating temperature in step 6.
 - 5.2 Inspect the steering gear for external leakage.
 - Clean the area around the input shaft and inspect the input shaft for signs of leakage after operating the vehicle under normal conditions through steering maneuvers.
 - Inspect the sector shaft for signs of leakage. A well greased or heavily used steering gear may weep oil from the grease seal, but a confirmed leak will be evidenced by fluid collecting while the vehicle is being operated under normal conditions.
 - Inspect the vent plug in the trunnion housing for signs of leakage. Any fluid in or around the rubber vent plug indicates leakage from an internal steering gear seal.

NOTICE —

Do not turn the steering wheel or allow system pressure to exceed the rating of the gauge during the following test. Damage to the gauge could

- 5.3 Check total steering system back pressure.
 - Install a low pressure gauge—300 psi (2068 kPa) maximum—between the steering pump and the steering gear.
 - Check for correct fluid level. If necessary, add fluid. If bubbles or foam appear in the reservoir, check hose fittings for looseness or leaks.
 - With the engine idling, read the total system back pressure on the pressure gauge.
 - If the total system back pressure is greater than 100 psi (689 kPa), or 140 psi (965 kPa) for a vehicle with hydraulic brakes, replace the steering fluid filter and re-test the system.
 If the system back pressure is still excessive, go to the next substep.

If the total system back pressure is less than 100 psi (689 kPa), or 140 psi (965 kPa) for a vehicle with hydraulic brakes, restriction is not a problem—go to step 6.

- 5.4 Leave the low pressure gauge in place and check individual steering system components for excessive restriction. See Fig. 1 for a plumbing diagram.
 - Bypass the steering gear by disconnecting the steering gear input and output lines from the gear and coupling them together. See Fig. 2 for an example.

If the drop in system pressure from the value found in substep 5.3 is greater than 55 psi (379 kPa), the steering gear has excessive restriction. If the drop in pressure is less than 55 psi (379 kPa), reconnect the

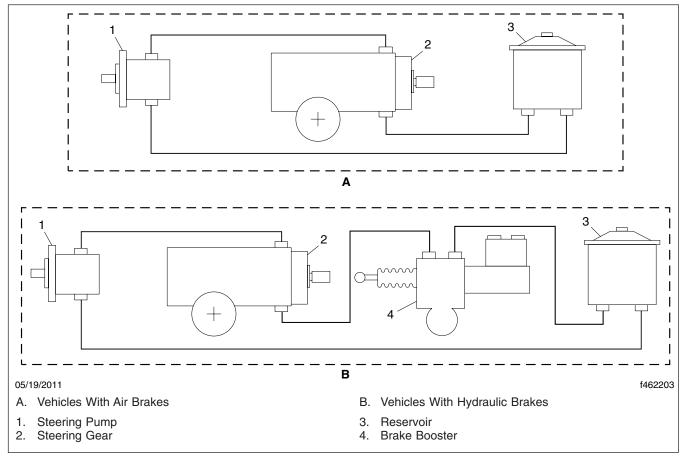


Fig. 1, Plumbing Diagrams

gear input and output lines to the gear and continue with this substep.

 If the vehicle is equipped with hydraulic brakes, bypass the brake booster by disconnecting the booster input and output lines and coupling them together.

If the drop in system pressure from the value found in substep 5.3 is greater than 40 psi (276 kPa), the brake booster has excessive restriction. If the drop in pressure is less than 40 psi (276 kPa), reconnect the booster input and output lines and continue with this substep.

 Test each hydraulic line in the power steering system individually by bypassing them one at a time, as was done with the steering gear and brake booster, if equipped.

If the drop in system pressure from the value found in substep 5.3 is greater than 12 psi (83 kPa) for any one line, replace the line and test total system back pressure again.

6. Check steering pump performance. Power steering fluid temperature should be approximately 180°F (82°C) to best replicate fluid temperatures under normal driving conditions.

If the system fails the tests in the following substeps, replace the pressure relief valve (PRV) and complete the tests in the substeps below again. If the system fails again, replace the pump.

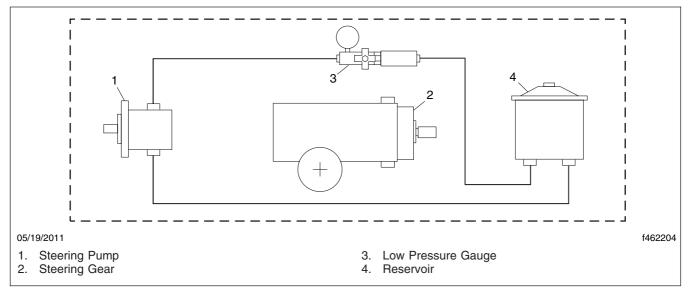


Fig. 2, Testing Steering Gear Restriction

Install the PSSA between the steering pump and the gear for the following substeps. See the following heading, **Power Steering System Analyzer Setup**, for instructions on PSSA installation.

NOTICE -

Do not leave the load valve closed for longer than five seconds during the following test. Doing so could damage the power steering system.

- 6.1 Check for erratic pump response.
 - Slowly close the load valve and watch the pressure and flow readings as the valve closes, then open the valve immediately.
 - If the pressure rises rapidly or appears uncontrolled, open the load valve immediately.
 - If the response was erratic, replace the PRV or pump, as required. If the response was smooth and controlled, go to the next substep.

- 6.2 Check the pump relief pressure.
 - Slowly close the load valve. When the valve is completely closed, read the pressure gauge, then open the valve.
 - If the pump relief pressure does not exceed the relief pressure in
 Table 2 or Table 3, refer to the pump manufacturer's service literature to verify the exact relief pressure for the pump.
 - If the pump relief pressure does not exceed the relief pressure in
 Table 2, Table 3, or the pump manufacturer's specifications, replace the PRV or pump, as required.
 - If the pump relief pressure exceeds the relief pressure in Table 2 or Table 3, it is acceptable. Go to the next substep.
- 6.3 Test the pump relief valve reaction at idle.
 - Run the engine at idle and note the flow rate with the load valve open.

Minimum Measured	Pump Flow and Re	elief Pressure at E	ingine Idle	
Power Steering Gear	Flow at 1500 rpm, No Load: gpm (L/min)	Flow at 1000 psi (6900 kPa): gpm (L/min)	Flow at 1800 psi (12 400 kPa): gpm (L/min)	Typical Relief Pressure: psi (kPa)
Sheppard M100	3.7 (14.0)	2.8 (10.6)	2.3 (8.7)	
TRW TAS40	3.7 (14.0)	2.1 (7.9)†	1.6 (6.1)	
TRW TAS55		2.4 (9.1) [†]	1.9 (7.2)	
TRW TAS65		2.8 (10.6)†	2.3 (8.7)	2175 ± 100
TRW TAS85		3.3 (12.5)	2.8 (10.6)	
TRW TAS65 With C28 or C32 Linear Cylinder		4.0 (10.5)	4.4.(16.7)	$(15\ 000\ \pm\ 700)^*$
TRW TAS65 With RCS65	F 9 (00 0)	4.9 (18.5)	4.4 (16.7)	
TRW TAS85 With C28 or C32 Linear Cylinder	5.8 (22.0)	F 4 (00 4)†	4.0 (40.5)	
TRW TAS85 With RCS65		5.4 (20.4)†	4.9 (18.5)	
Thursdan Krunn L 705 Dook and Dinion	2.7 (14.0)	0.0 (10.5)	0.0 (10.6)	2300 ± 116
ThyssenKrupp LZS5 Rack and Pinion	3.7 (14.0)	3.3 (12.5)	2.8 (10.6)	(15 500 ± 800)

^{*} On vehicles with TRW TAS steering gears and hydraulic brakes, typical relief pressure is 2375 ± 100 psi (16 375 ± 690 kPa).

Table 2, Minimum Measured Pump Flow and Relief Pressure at Engine Idle

Minimum Measured Pump Flow and Relief Pressure for High-Pressure Gears at Engine Idle						
Power Steering Gear	Flow at 1500 rpm, No Load: gpm (L/min)	Flow at 1000 psi (6900 kPa): gpm (L/min)	Flow at 2300 psi (15 860 kPa): gpm (L/min)	Typical Relief Pressure: psi (kPa)		
Sheppard HD94		2.6 (9.8)	1.8 (6.8)			
TRW THP45	3.7 (14.0)	2.2 (8.3)	1.4 (5.3)	2683 ± 100		
TRW THP60 or PCF60		2.6 (9.8)	1.8 (6.8)			
TRW THP60 With Linear Cylinder	F 0 (00 0)	4 4 (45 5)	0.0 (40.5)	$(18\ 500\ \pm\ 700)$		
TRW THP60 With RCH45	5.8 (22.0)	4.1 (15.5)	3.3 (12.5)			

Table 3, Minimum Measured Pump Flow and Relief Pressure for High-Pressure Gears at Engine Idle

- Close the load valve until the pump relief pressure is reached. Smoothly and quickly open the load valve and note the flow rate. Repeat this action three times. The flow rate should return to the flow rate first noted with the load valve open.
- If the flow rate does not return smoothly and quickly, the pump relief valve is not working correctly.
 Replace the replace the PRV or pump, as required.

- If the flow rate returns smoothly and quickly, the pump relief valve is acceptable. Go to the next substep.
- 6.4 Test the pump relief valve reaction at 1500 rpm.
 - Run the engine at 1500 rpm and note the flow rate with the load valve open.
 - Close the load valve until the pump relief pressure is reached. Smoothly and quickly open the load valve and note the flow rate. Repeat this ac-

[†] Approximate value based on flow at 1800 psi (12 400 kPa).

tion three times. The flow rate should return to the flow rate first noted with the load valve open.

- If the flow rate does not return smoothly and quickly, replace the PRV or pump, as required.
- If the flow rate returns smoothly and quickly, the pump relief valve is acceptable. Go to the next substep.
- 6.5 Test the flow of the pump at idle with a load applied.

For vehicles with low-pressure steering gears, run the engine at idle and slowly close the load valve until the pressure gauge reads 1000 psi (6900 kPa). Read the flow rate on the gauge, then set the pressure to 1800 psi (12 400 kPa). Read the flow gauge, then open the load valve. Compare the values to those in **Table 2**.

For vehicles with high-pressure steering gears, use 1000 psi (6900 kPa) and 2300 psi (15 860 kPa) as the test load pressures. See **Table 3** for minimum flow rate.

- 6.6 Test the maximum flow of the pump with no load applied.
 - Run the engine at 1500 rpm, make sure the load valve is completely open, and read the flow gauge.
 - If the flow rate is below the minimum indicated in Table 2 or Table 3, replace the PRV or pump, as required.
 - If the flow rate is above 5.5 gpm (20.8 L/min) on a vehicle with a single steering gear, or 7.7 gpm (28.8 L/min) on a vehicle with an assist cylinder installed, replace the pump.
- 7. Test the steering gear internal leakage.

Select TRW integral steering gears and all ThyssenKrupp rack and pinion steering gears are equipped with an internal PRV that significantly limits maximum supply pressure to protect the steering gear. These gears, unlike gears on vehicles fitted with hydraulic brake boosters, cannot be tested for internal leakage by plugging the internal PRV in the gear. The pump output must

be limited to prevent excessive pressure from damaging the gear, and the internal PRV passage must be blocked to direct oil flow through the gear.

Use PartsPro® for the specific VIN to determine if the steering gear is equipped with an internal PRV, which will be listed as a serviceable part under module 536.

If a TRW steering gear has an internal PRV but no hydraulic brake booster, see the following heading, Internal Leakage Test Setup, TRW Steering Gears With an Internal PRV, for instructions on setting up the necessary test components before proceeding with the following substeps.

ThyssenKrupp rack and pinion steering gears are also equipped with an internal PRV, but cannot be tested for internal leakage.

IMPORTANT: Make sure the fluid temperature is approximately 180°F (82°C) and the vehicle is stationary with the front wheels pointing forward.

7.1 Run the engine at idle with the load valve open.

A WARNING

Keep fingers clear of the stop bolt and spacer block during the following test. Make sure that the spacer block contacts the axle stop squarely. Contact that is not square could break the stop bolts or eject the spacer block, which could cause serious personal injury.

7.2 Place an unhardened steel spacer, 1-inch (25-mm) thick, between the axle and the stop bolt on one side of the axle.

The spacer should have an extension or handle long enough to keep fingers clear of the axle stop area. A brazing rod or welding rod works well for this purpose.

NOTICE -

While running the following test, do not hold the steering wheel in the full-turn position for more than five seconds. Doing so could damage the pump.

7.3 Have someone turn the steering wheel, applying enough force to completely close the rotary valve.

Complete closure of the rotary valve requires approximately 20 lbf (27 N) pull on the steering wheel, and will be indicated by a pressure reading nearly equal to the system relief pressure (tested in substep 6.2).

- 7.4 Hold the steering wheel in the full-turn position. Note the steering gear internal leakage on the PSSA.
- 7.5 Repeat the previous substeps for the opposite turn.

The maximum permissible internal leakage for a single gear is 1.0 gpm (3.8 L/min). If leakage is greater in either turning direction, replace the steering gear components as needed.

For systems with two or more steering gears and/or linear cylinders, the total acceptable internal leakage is 1.0 gpm (3.8 L/min) for each steering gear/ram in the system. Maximum internal leakage on a dual-gear system is 2.0 gpm (7.6 L/min). If the leakage is more than 2.0 gpm (7.6 L/min) on a dual-gear system, isolate the auxiliary cylinder from the system using the substeps that follow.

- 7.6 Disconnect the auxiliary cylinder hydraulic lines at the main gear auxiliary ports.
- 7.7 Plug the main steering gear ports with suitable steel or high-pressure plugs or caps.
- 7.8 Repeat the internal leakage test.

If the internal leakage is less than 1 gpm (3.8 L/min), repair or replace the auxiliary gear or linear cylinder. If the internal leakage is greater than 1 gpm (3.8 L/min), repair or replace the main gear.

8. Check the steering gear poppet relief valve and stop bolt adjustment.

NOTE: Poppets limit the steering assist when the front wheels approach the stop bolts. Improper adjustment can apply excessive force to the steering linkage, or cause loss of assist, as the steering wheel approaches either full-left or full-right turn.

8.1 Check the steering system for stop bolt adjustment.

Make sure the stop bolt settings limit the steering travel so there is ½-inch (13-mm) clearance from all stationary components, and 3/4-inch (19-mm) clearance from all moving components.

8.2 Make sure the pitman arm is situated on the steering gear sector shaft correctly. Check that the pitman arm and sector shaft timing marks are aligned.

- NOTICE -

If power steering pump relief pressure is reached while the steering wheel is at full lock, release the steering wheel from this position. Do not allow the pump relief pressure to be maintained for longer than five seconds or damage to the pump may result.

- 8.3 Check the poppet relief pressure.
 - Install the PSSA between the steering pump and the steering gear. See the following heading, Power Steering System Analyzer Setup, for instructions on PSSA installation.
 - Run the engine at idle with the load valve open. Turn the steering wheel to either full-lock position. Note the pressure gauge reading, then repeat for the opposite turn.
 - The pressure should drop slightly before the stop bolts are contacted.
 If the pressure increases (from contact with the stop bolts), the poppets must be manually reset.

If the pressure is relieved and assist is lost when the wheel is too far from the axle stop bolts, refer to the applicable section in this manual for gear-specific information.

 After poppet replacement or adjustment, test again for correct poppet relief function and record the new pressure.

8.4 Check for normal hissing sound at full turn.

NOTE: Noise from the power steering system does not necessarily mean there is a problem. Some noises are normal and are the result of proper operation.

See **Table 4** for possible causes and remedies for common noises associated with the power steering system and power steering pump.

8.5 Check for abnormal power steering noise.

Listen for a hissing sound at less than full turn. If a hissing sound is heard, check the steering gear poppet and the axle stop adjustment.

- NOTICE —

If the temperature exceeds 250°F (121°C), damage to hoses, seals, and other components may result if the vehicle continues to operate at excessive steering system temperatures. If this temperature is exceeded, stop the test and record the last noted temperature on STI-492.

9. Test the system operating temperature.

- Run the engine at governed speed.
- Observe the power steering fluid temperature until it stabilizes.
- Record the power steering fluid temperature in 10-minute intervals until 40 minutes have passed.
- If the temperature does not exceed 250°F (121°C) during the test, excessive heat due to system components is probably not the cause of the complaint. The system may still experience overheating due to driving and load conditions.

If the temperature exceeds 250°F (121°C), excessive steering system back pressure or excessive pump flow may be the cause of the high temperature problem. If system back pressure or restriction values found in substeps 5.3 and 5.4 above were close to the maximum allowable, complete step 5 again. If steering pump flow and relief pressures found in step 6 above were close to the maximum allowable, complete step 6 again.

 If excessive heat continues to be a problem, a cooler may need to be added to the system.

	Power Steering System Noise				
Noise	Remedy				
Growling or other abnormal steering noise	Check the fluid level. Check for air bubbles and foam. Check for hose and fitting leaks. If there is air in the fluid, check for inlet tube and hose leaks. Correct all leaks.				
A change from the usual pump sound	Check the steering fluid reservoir for air bubbles and foam. If there is air in the fluid, check for inlet tube and hose leaks. Correct all leaks.				
Clicking noise during a turn	Check for loose steering components. Tighten any loose steering components. Check the front suspension for insufficient spring pin shims. Add front spring pin shims if needed.				
Hissing when the steering wheel is at or near full turn	This is normal; no action is needed.				
Steering Pump intake line is plugged	Drain the system. Clear the intake line if needed. Fill the system.				
Air leak at the pump or reservoir connections, fittings, or shaft seal	Check all the connections by pouring power steering fluid over them, and listening for a reduction in sound. Tighten all connections as needed.				
Pump input shaft is misaligned	Replace the pump.				

Table 4, Power Steering System Noise

Power Steering System Analyzer Setup

The hydraulic power steering system is tested with a Power Steering System Analyzer (PSSA), and with the hydraulic fluid at operating temperature. The PSSA and adaptor kit are available from SPX Kent-Moore.

A PSSA is a combination of a flow meter, a shutoff valve, and a high-pressure gauge. See **Fig. 3**. The PSSA will allow you to measure flow and pressure, and provide a load on the pump in the hydraulic lines of the steering system.

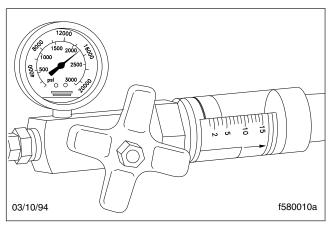


Fig. 3, Power Steering System Analyzer

- Install a PSSA between the pump high-pressure line and the steering gear.
- 2. Fill and bleed the steering system as needed.

- NOTICE -

Do not leave the load valve fully closed for longer than five seconds. Doing so could damage the power steering system.

- 3. Run the engine at idle.
- Partially close the load valve on the PSSA until the pressure gauge reads 1000 psi (6895 kPa).
- 5. Open the valve when the fluid temperature reaches about 180°F (82°C).

Internal Leakage Test Setup, TRW Steering Gears With an Internal PRV

Select TRW steering gears are equipped with an internal PRV that limits maximum supply pressure to protect the steering gear. These gears cannot be tested for internal leakage using the standard procedure. The pump output must be limited to prevent excessive pressure from damaging the gear, and the internal PRV passage must be blocked to direct oil flow through the gear.

Use PartsPro® to determine if a specific TRW steering gear is equipped with an internal PRV, which will be listed as a serviceable part under module 536.

If your TRW steering gear has an internal PRV, complete the following steps to set up the necessary internal leakage test components. See **Table 5** for a list of required leakage test components. The plumbing fittings and hose part numbers are recommended, but may be replaced with identical parts from other suppliers, if necessary.

The ThyssenKrupp rack and pinion steering gear is also equipped with an internal PRV, but cannot currently be tested for internal leakage.

IMPORTANT: The front wheels must be raised or on turnplates during this procedure.

- Turn the engine off. Remove the relief valve cap, O-ring, and relief valve from the steering gear. See Fig. 4.
- Install the relief valve plug, J-37130, in the internal PRV hole. Install the relief valve cap and O-ring over the plug.
- 3. Assemble the relief valve cartridge body, relief valve, and tee fittings as shown in Fig. 4.
- 4. Install the PSSA and other test components as shown in Fig. 4.
- 5. Open the external relief valve (**Fig. 4**, Item 15) on the relief valve cartridge. Ensure the PSSA shutoff valve is fully open.
- 6. Raise the front wheels off the ground and turn the steering wheel to the right and left full-lock positions five times to bleed air from the system.
- Start the engine and bleed the remaining air out of the system by continuing to turn the wheel from side to side.

- NOTICE ----

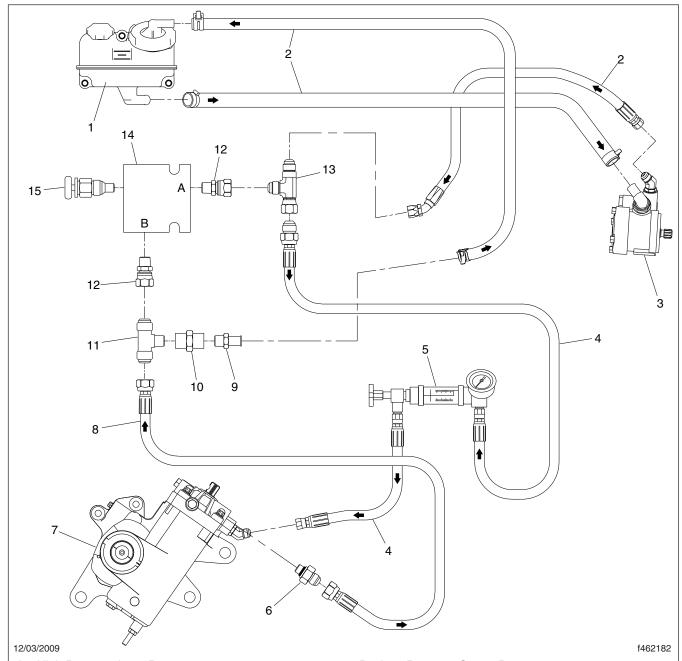
Do not leave the PSSA shutoff valve fully closed for longer than five seconds. Doing so could damage the power steering system.

- 8. With the engine on, close the shutoff valve on the PSSA.
- 9. Set the system relief pressure by closing the external relief valve (Fig. 4, Item 15) until the
- gauge on the PSSA reaches 2,000 psi (13 790 kPa), then fully open the shutoff valve on the PSSA.
- Continue with the steering gear internal leakage test (step 9 of the **Troubleshooting Steps** heading above).

Internal Leakage Test Components					
Part	Available From	Part Number (Vendor P/N)	Item #, Fig. 4		
Power Steering System Analyzer (PSSA)	SPX Kent-Moore	J-26487	5		
PSSA Adaptor Kit	SPX Kent-Moore	J-28593	_		
Relief Valve Plug	SPX Kent-Moore	J-37130	_		
Connector, Straight Thread with O-Ring	Daimler Trucks PDC	23-11470-088	6		
Power Steering Hose, 42"	Daimler Trucks PDC	14-12694-042	8		
Connector, 3/8" Male NPT to 5/8" Beaded Hose Barb	Daimler Trucks PDC	23-11321-001	9		
D: O II O/OII AIDT	B 1 11 '6	PH 3/8 GG S	10		
Pipe Coupling, 3/8" NPT	Parker Hannifin	(3/8 GG-S)			
T. M. IIO :: M. I. NDT D. I.	Davis a Harritia	PH 8STXS	11		
Tee, Male JIC with Male NPT Branch*	Parker Hannifin	(8 STX-S)			
		WH 9100X8X6			
Swivel Adaptor, 3/8" Male NPT to Female 37 degree JIC (qty 2)	Weatherhead	(9100x8x6)	12		
		PH 8 R6X S			
Swivel Nut Run Tee	Parker Hannifin	(8 R6X-S)	13		
		B10-2-A6P			
3/8" Female NPT Aluminum Relief Valve Threaded Cartridge Body	Parker Hannifin	(PH B102A6P)	14		
		PH RAH101K30			
Aluminum Hydraulic Threaded Cartridge Relief Valve with Knob	Parker Hannifin	(RAH101K30)	15		

^{*} Use steel 37 degree JIC fittings only.

Table 5, Internal Leakage Test Components



- A. High-Pressure Input Port
- Power Steering Fluid Reservoir
- Existing Power Steering Fluid Lines (Qty 3)
- Power Steering Pump
- PSSA Fluid Lines (Qty 2)
- 5. PSSA
- Connector, Straight Thread with O-Ring 6.
- Power Steering Gear (TAS85 shown) Power Steering Hose, 42" 7.

- B. Low-Pressure Output Port
- Connector, Male NPT to Beaded Hose Barb
- 10. Pipe Coupling11. Tee, Male JIC with Male NPT Branch
- 12. Swivel Adaptor (Qty 2)
- 13. Swivel Nut Run Tee
- 14. Relief Valve Threaded Cartridge Body
- 15. External Relief Valve, Threaded Cartridge Type

Fig. 4, Internal Leakage Test Component Installation