

Installation Instructions



KNORR-BREMSE® IPS90™ AND IPS100™ (INTEGRAL POWER STEERING) HYDRAULIC POWER STEERING GEARS FOR COMMERCIAL VEHICLES



Figure 1 - Hydraulic Power Steering Gear

WARNING

Steering gears are heavy. When assembling and disassembling the steering gears, make sure to follow all safety protocols.

Steering fluid can get hot and reach temperatures up to 250° F (121° C). Use the appropriate PPE when servicing.

Comply with OSHA guidelines.

Avoid high-pressure hydraulic wash on steering gears and steering sub-systems.

Unless and otherwise mentioned, use of a hammer or heat to disassemble steering components is not permitted.

Use manufacturer-recommended steering fluid only. Mixing of fluids may cause internal damage to rubber or plastic components.

GENERAL SAFETY GUIDELINES

WARNING! PLEASE READ AND FOLLOW THESE INSTRUCTIONS

TO AVOID PERSONAL INJURY OR DEATH:

When working on or around a vehicle, the following guidelines should be observed AT ALL TIMES:

- ▲ Park the vehicle on a level surface, apply the parking brakes and always block the wheels. Always wear personal protection equipment.
- ▲ Stop the engine and remove the ignition key when working under or around the vehicle. When working in the engine compartment, the engine should be shut off and the ignition key should be removed. Where circumstances require that the engine be in operation, EXTREME CAUTION should be used to prevent personal injury resulting from contact with moving, rotating, leaking, heated or electrically-charged components.
- ▲ Do not attempt to install, remove, disassemble or assemble a component until you have read, and thoroughly understand, the recommended procedures. Use only the proper tools and observe all precautions pertaining to use of those tools.
- ▲ If the work is being performed on the vehicle's air brake system, or any auxiliary pressurized air systems, make certain to drain the air pressure from all reservoirs before beginning ANY work on the vehicle. If the vehicle is equipped with a Bendix® AD-IS® air dryer system, a Bendix® DRM™ dryer reservoir module, a Bendix® AD-9si®, AD-HF®, or AD-HFi™ air dryer, be sure to drain the purge reservoir.
- ▲ Following the vehicle manufacturer's recommended procedures, deactivate the electrical system in a manner that safely removes all electrical power from the vehicle.
- ▲ Never exceed manufacturer's recommended pressures.
- ▲ Never connect or disconnect a hose or line containing pressure; it may whip and/or cause hazardous airborne dust and dirt particles. Wear eye protection. Slowly open connections with care, and verify that no pressure is present. Never remove a component or plug unless you are certain all system pressure has been depleted.
- ▲ Use only genuine Bendix® brand replacement parts, components and kits. Replacement hardware, tubing, hose, fittings, wiring, etc. must be of equivalent size, type and strength as original equipment and be designed specifically for such applications and systems.
- ▲ Components with stripped threads or damaged parts should be replaced rather than repaired. Do not attempt repairs requiring machining or welding unless specifically stated and approved by the vehicle and component manufacturer.
- ▲ Prior to returning the vehicle to service, make certain all components and systems are restored to their proper operating condition.
- ▲ For vehicles with Automatic Traction Control (ATC), the ATC function must be disabled (ATC indicator lamp should be ON) prior to performing any vehicle maintenance where one or more wheels on a drive axle are lifted off the ground and moving.
- ▲ The power MUST be temporarily disconnected from the radar sensor whenever any tests USING A DYNAMOMETER are conducted on a vehicle equipped with a Bendix® Wingman® system.
- ▲ You should consult the vehicle manufacturer's operating and service manuals, and any related literature, in conjunction with the Guidelines above.

DESCRIPTION

The Knorr-Bremse® IPS90™ and IPS100™ (Integral Power Steering) hydraulic power steering gears are designed for heavy duty vehicles with front axle weight ratings of up to 16,000 lbs. It is an integral power steering gear incorporating the mechanical and hydraulic actuation and control components in a single cast housing which serves as the power cylinder.

The vehicle's steering column is coupled to the gear at the input shaft which transmits steering effort through a recirculating ball screw and piston nut. The piston nut is an integral part of the power assist piston and also acts as a steering damper. The direction and degree of power assist is controlled by a rotary hydraulic valve which is integral to the input shaft and supplied by an engine driven hydraulic pump.

This valve design ensures light, responsive steering while maintaining a mechanical connection between the steering column and the ball screw.

OPERATION

General

The hydraulic power steering gears are composed both of mechanical steering components and hydraulic power assist components. Actual steering is accomplished mechanically. Effort applied at the vehicle's steering wheel results in mechanical movement within the steering gear which causes the vehicle to change its direction of travel. The hydraulic power assist components function solely to reduce the effort required to turn the vehicle's steering wheel. Loss of hydraulic power will in no way prevent the vehicle from being maneuvered mechanically, however, greater effort will be required to turn the steering wheel.

Power Steering Gear Identification

A nameplate is installed on the unit which indicates the part number, serial number, and build date.

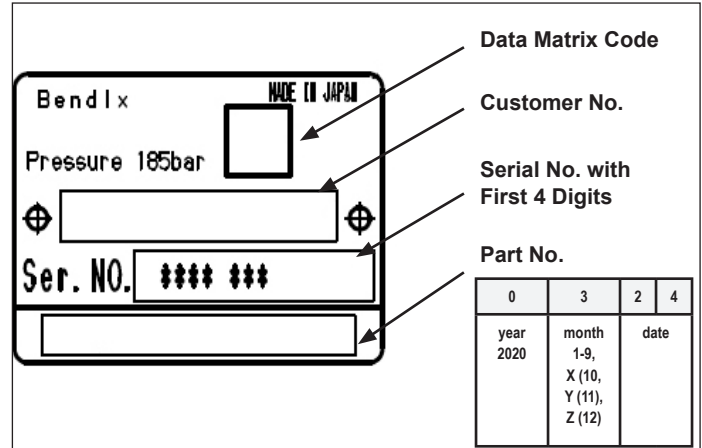


Figure 2 - Nameplate

Data Matrix Input Data:

- V + Bendix P/N + Supplier P/N: e.g. VK123456/123-45678
- P + Customer P/N: e.g. P12-34567-000
- S + Date + Serial Number: e.g. S0324123 (example for 2020/03/24 No. 123)

Arranging input data in a row and each data is delimited by # mark: VK123456/123-45678#P12-34567-00#S0324123

Description	IPS90	IPS100
Steering ratio	18.8 - 20.8	18.7 - 20.2
Turning angle output shaft w/o poppets	100° +4°	96° +4°
Adjustable turning angle output shaft	30° - 50°	34° - 48°
Output torque at 185 bar 90% efficiency	4523 - 5000 N•m / 3336 - 3688 ft-lbs	6174 - 6670 N•m / 4554 -4920 ft-lb
Maximum working temp	121° C / 249.8° F	121° C / 249.8° F
Minimum flow rate	8 l/min	11 l/min
Normal flow rate	16 l/min	16 l/min
Max. pressure	185 bar +/-3 bar	185 bar +/-3 bar

Table 1 - Technical Data

Dual Steering Gear System

Two or more steering gears (“master” and “slave” units) are sometimes used where front axle weights exceed 16,000 lbs. Dual steering gear systems balance the steering gear output across two or more steering arms and conserve space under the hood.

Pressure from the master gear on the vehicle’s left side powers the secondary, or slave unit, on the vehicle’s right side. Hydraulic pressure and flow move the slave gear in the opposite direction of the master gear. Another difference between the two units is that hydraulic relief plungers are not used in the slave gear. Master gear relief plungers will relieve hydraulic pressure for both gears when properly adjusted. See Figure 6 for an exploded view of a slave gear application.

The dual system is mechanically linked to the front-end components by a drag link and steer arm on the right-hand spindle on the axle. Only hydraulic connections with no physical mechanical components exist between the master and slave units.

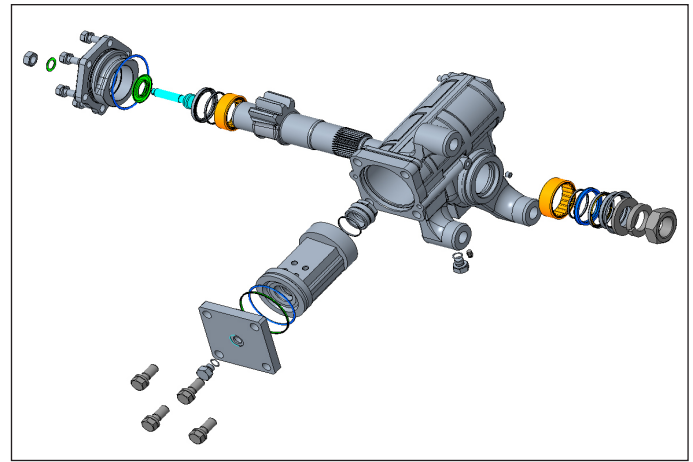


Figure 4 - Hydraulic Power Steering Gear - Exploded View

PREVENTIVE MAINTENANCE

Power Steering Oil



The vehicle manufacturer's recommendations is that an approved oil be used to ensure proper operation of the power steering unit.

Once an oil type is in use, it should never be mixed with any other type. If it should become necessary to change types of oil, the entire system must be drained following the procedure below.

Draining and Filling the System

1. Lift the front axle sufficiently to raise the wheels clear of the ground.
2. Disconnect the return line at the valve body outlet port. Turn the steering wheel to the left as far as it will go. Run the engine for up to ten (10) seconds until the oil is drained from the reservoir and pump. Switch off the engine and turn the steering wheel backwards and forwards from full lock to full lock until all the oil is drained out.
3. Clean the outside of the reservoir. Remove the old filter element. Replace with the new filter.
4. Connect the return line at the valve body outlet port and tighten the nut with the torque to be specified in the maker's manual.
5. Fill the reservoir full of oil.
6. Turn the engine over with the starter motor. (Must be done in a manner that the engine does not start.) Add oil as the level drops to avoid air being drawn into the system.
7. When the oil level reaches the full mark on the reservoir, start the engine and turn the steering wheel slowly from side to side until air bubbles cease to appear in the reservoir. Refill the reservoir to the full mark.
8. The oil level should be checked every 2,000 miles.

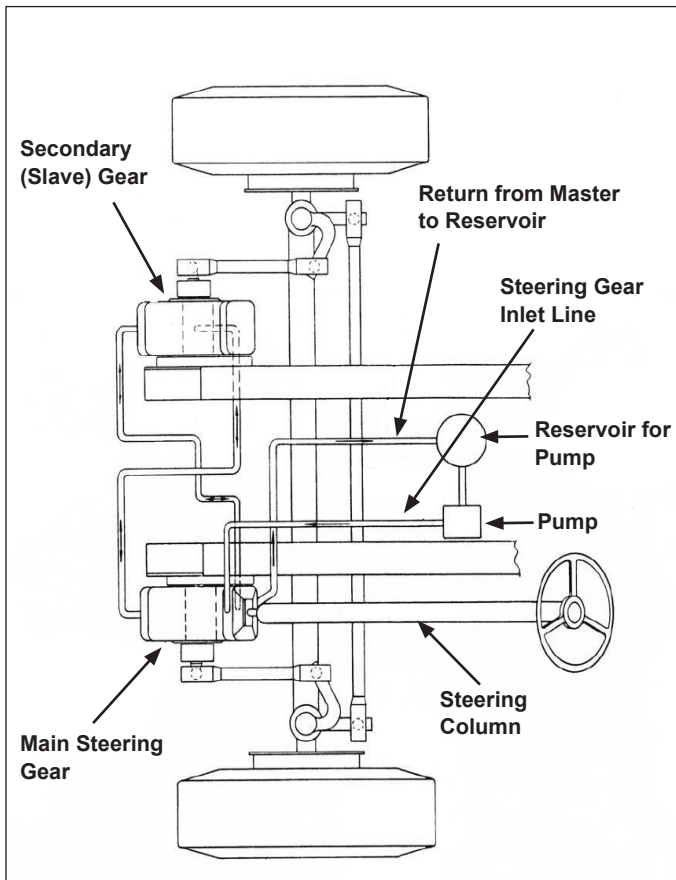


Figure 3 - Standard Slave System

Change Intervals

It is recommended that the oil be changed at 40,000-mile intervals and at the time of rebuild. Beyond its function as the medium for transmitting power, the oil also serves to lubricate and dissipate heat. Carefully clean, inspect, and replace if necessary, all filter elements in the pump system.

The gear lash between the piston teeth and sector gear should not require attention in normal service, however, a provision for an adjustment is provided.

Output Shaft Boot Seal

Inspect the integrity of the output shaft boot seal located between the pitman arm and the housing. This component prevents contamination from entering the output shaft bearing and retains grease on the bearing and output shaft to prevent corrosion. If deterioration or leakage is detected, it should be replaced.

Bill of Material for Service Kits

In order to identify the right service kit to solve a certain issue mentioned in the troubleshooting guide, the steering gear specific service kit specification needs to be viewed.

For direct personal technical support, call the Bendix Tech Team at 1-800-AIR-BRAKE (1-800-247-2725), Monday through Thursday, 8:00 a.m. to 6:00 p.m. ET, and Friday, 8:00 a.m. to 5:00 p.m. ET. The Tech Team is also available by email at techteam@bendix.com.

In general, there are four (4) different kinds of service kits available:

- A. Full seal kit that contains all the internal and external steering gear seals.
- B. Poppet kit that contains all the parts to change and reset the poppets.
- C. Pitman arm connection kit that contains the parts to disassemble and reassemble a pitman arm.
- D. Input shaft seal kit that contains the seals around the input shaft.

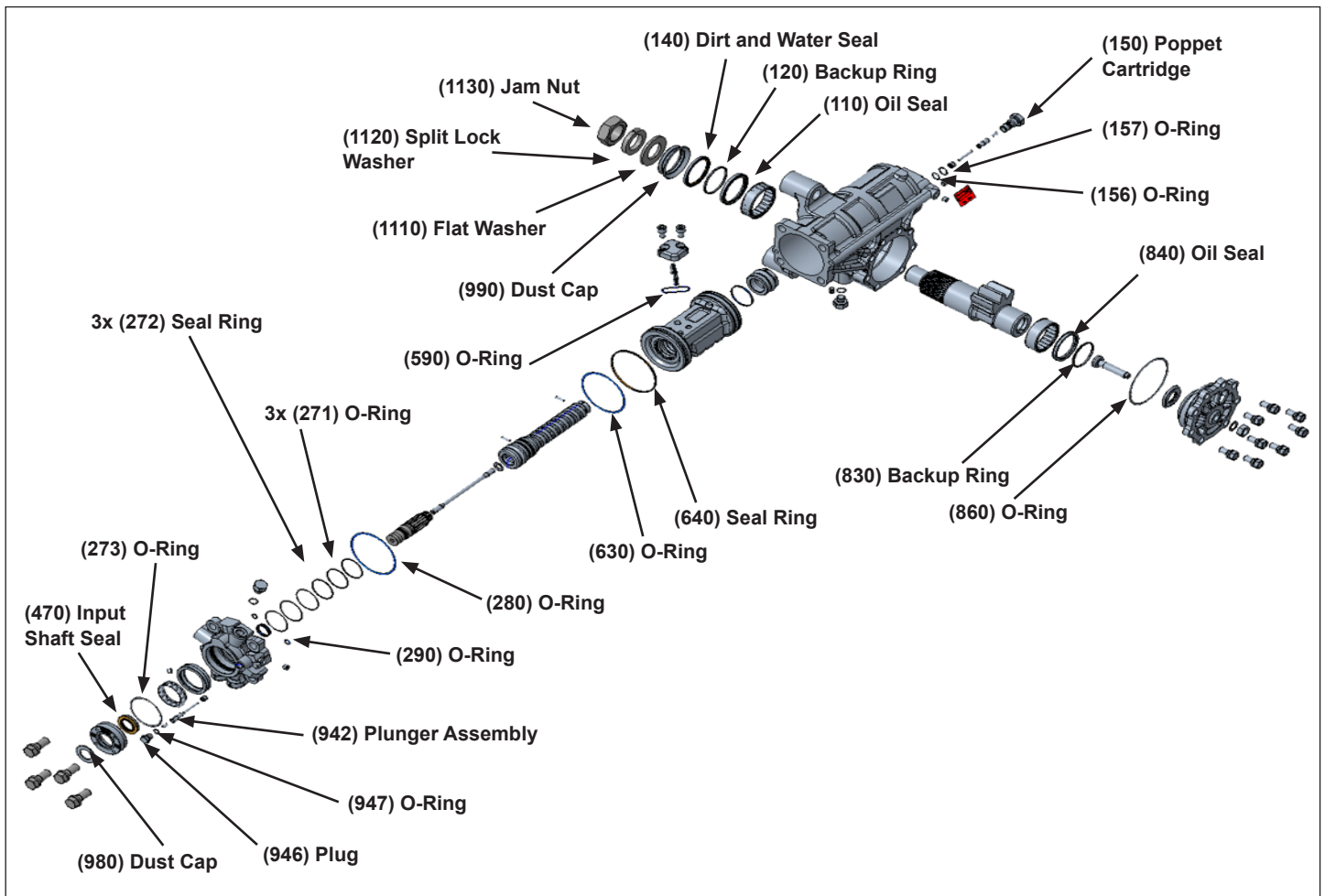


Figure 5 - Service Kit Components Exploded View

The following list gives an overview of all the steering gear seals:



Please notice that the slave gear application is missing some of the seals that are part of the master gear. This instruction is created to describe the replacement of all the master gear seals. When servicing a slave gear, please skip the steps referring to seals that are only part of the master gear.

Number	Part Name	QTY Master Gear	QTY Slave Gear
110	PACKING-Y	1	1
120	RING-BACK UP	1	1
140	OIL SEAL	1	1
271	O-RING	3	-
272	SEAL-RING	3	-
273	O-RING	1	-
280	O-RING	1	1
290	O-RING	2	-
470	OIL SEAL	1	-
630	O-RING	1	1
640	SEAL-RING	1	1
830	RING-BACK UP	1	1
840	PACKING-Y	1	1
860	O-RING	1	1
980	COVER-DUST	1	-
990	COVER-DUST	1	1
590	O-RING	1	-

Table 2 - List of Steering Gear Seals

AUTOMATIC POPPET SERVICE PROCEDURE

Poppets in the steering gear are used to reduce the pressure build-up during the end of travel in the steering gear. By decreasing the pressure build-up, poppets help in reducing system temperature and overloading other steering components. There are two poppets in a steering gear, one on the valve housing and the other on the main housing. See Figure 6. These poppets adjust automatically based on the wheel cut required in left and right turns.



Once the plunger in the poppet is pressed in, it cannot be repaired and reused in the steering gear.



Improper assembly of poppets can lead to damage in the steering system.

NOTE: Initial poppet setting should be done on new gears or on manufacturer's aftermarket gears. Also, if the poppets on a used gear are replaced with new sets, the poppet setting procedure must be followed.

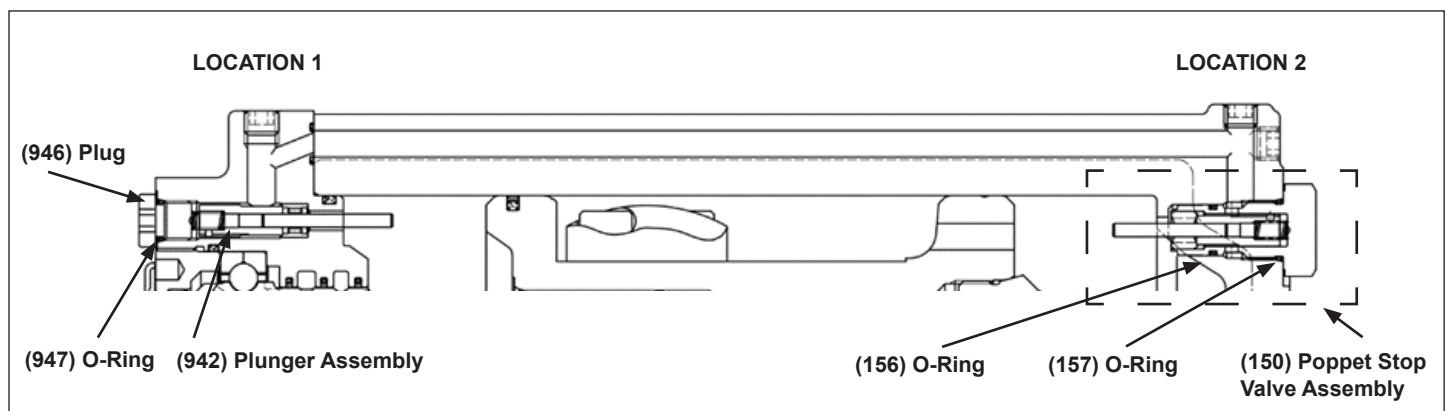


Figure 6 - Automatic Poppet Service Procedure



The axle stops and all steering linkage must be set according to the vehicle manufacturer's specifications, and the pitman arm must be correctly aligned on the sector shaft for poppets to be set correctly.

1. Set the vehicle parking brake. Jack up the vehicle at the front axle. Make sure the tires are not touching the ground.
2. With the engine at idle and vehicle unloaded, turn the steering wheel slowly from the center position a full turn in either the left or right direction until the axle stop contact is made. Pull hard on the steering wheel after the axle stop is in contact.
3. After the axle contact is made, return to center and turn the steering wheel to other direction until the axle contact is made. Pull hard on the steering wheel after the axle stop is in contact.
4. Lower the jack. The front axle is now loaded. Turn the steering wheel from left to right until the axle contact is made during both turns. Make sure the chassis is not flexing when the axle stops contact.



Poppets should not be disassembled while the engine is running. Do not turn the steering wheel with poppets disassembled. Make sure the vehicle tires are straight ahead while replacing the poppet.



There is no need to disassemble the poppets if the steering gear needs poppet adjustments. Never reuse a poppet that was removed from the steering gear.



Do not turn the output shaft more than +/- 30° from the center position until the pitman arm and drag link are assembled.

REMOVING THE POWER STEERING GEAR FROM THE VEHICLE

1. Mark or identify the inlet and return lines at the valve body ports. For slave gear applications, mark the pressure lines that go to the upper and lower pressure chamber of the main housing.
2. Turn off the engine.
3. Lift the front axle sufficiently to raise the wheels clear of the ground or put turntables below the wheels.
4. Disconnect the batteries and open the hood.
5. Remove all dirt from all the fittings and hose connections on the steering gear.
6. Disconnect the return line at the valve body outlet port and place a drain pan below it.
7. Turn the steering wheel to the left as far as it will go. Run the engine for ten (10) seconds at the most until the oil is drained from the reservoir and pump. Switch off the engine and turn the steering wheel back and forth from full lock to full lock until all the oil is drained out.
8. Remove both the inlet and return lines. For slave gear applications, put a drain pan below the slave gear before removing the two pressure lines from the slave gear.

NOTE: It is recommended to plug the inlet and return lines after the hydraulic lines are removed.

9. Put the vehicle back on the ground.
10. Place the front tires in the straight-ahead position, apply the parking brakes, and chock the tires.
11. Disconnect the steering column at the input shaft following the vehicle manufacturer's instructions (this step is not necessary for a slave gear).
12. Disconnect the drag link joint from the pitman arm. Make sure to follow the drag link manufacturer service procedure.

NOTE: Mask the input and output shaft splines to avoid any damage while handling, or during the removal process.



Steering gears are heavy and awkward to handle. It is easy to get fingers pinched or drop the gear when handling it. Maintain a clean work area and plan how to remove and store the old gear and install the new gear.

13. On vehicles with set-forward axle types, the steering gear is assembled inside the frame rail. See *Figure 7*. The pitman arm needs to be disassembled before removing the gear from the frame rail. Refer to the section titled *Removing the Pitman Arm* to disassemble the pitman arm.

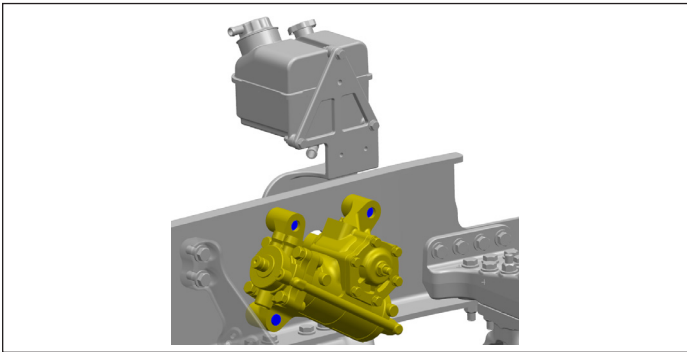


Figure 7 - Set-Forward Axle Type

14. After the pitman arm is disassembled, remove the fasteners that secure the steering gear to the mounting structure. Remove the steering gear from the vehicle per the vehicle manufacturer's instruction.
15. On vehicles with set-back axle types, the steering gear is assembled on the frame rail. See *Figure 8*. The steering gear should be removed with the pitman arm attached to it.

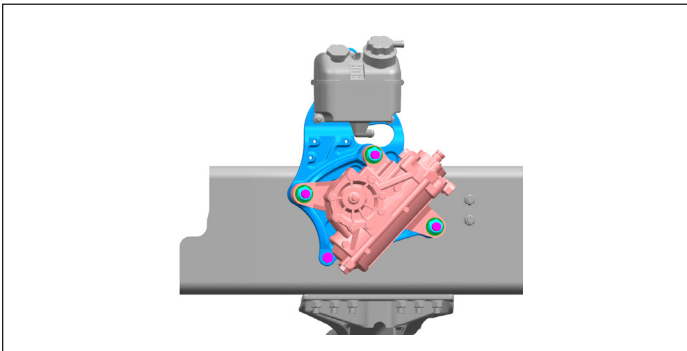


Figure 8 - Set-Back Axle Type

16. Secure the gear with the pitman arm on a vise. Refer to the section titled *Removing the Pitman Arm* to disassemble the pitman arm.

NOTE: For slave gear configurations, repeat the previous steps to remove the slave gear.

REMOVING THE PITMAN ARM

Required Tools

- Breaker bar with M55 socket
- Pitman arm puller



While disassembling the pitman arm, make sure to have all Personal Protective Equipment (PPE). Mask the threads on the steering gear sector shaft. Do not damage the threads on the steering gear sector shaft while disassembling the pitman arm.



After the disassembly of the jam nut and washers, the pitman arm will not come off easily. In order to remove the pitman arm, do not apply hammer blows or heat the pitman arm sector shaft assembly. Heat can damage or melt the seals and the dust cover on the steering gear sector shaft.

NOTE: It is recommended to use new washers and a new nut for reassembling the pitman arm. The service kit contains the necessary components.

1. Secure the steering gear onto a fixture or bench vise.
2. Loosen the jam nut using a breaker bar with an M55 socket.
3. The disassembly sequence is as follows:
 - A. Jam nut (1130)
 - B. Split lock washer (1120)
 - C. Flat washer (1110)
 - D. Pitman arm
4. To disengage the pitman arm from the sector shaft, use a pitman arm puller.

NOTE: It is recommended to wear ear protection headphones or ear plugs when an impact torque wrench is used.

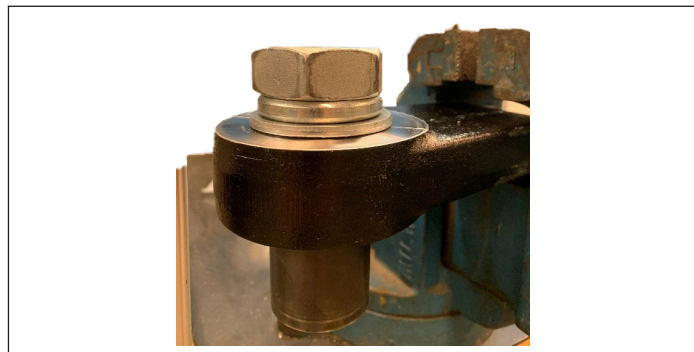


Figure 9 - Removing the Pitman Arm

INSTALLING THE PITMAN ARM

Required Tools

- Impact torque wrench with M55 socket



The pitman arm should be properly installed. Failure to torque the jam nut to the correct installation torque values may affect the safe operation of the vehicle.



Improper pitman arm installation may lead to accidents. If the pitman arm is found loose or the spline on the pitman arm is damaged, replace the pitman arm. If the thread on the steering gear sector shaft is damaged, replace the steering gear.

NOTE: Mask the splines and threads on the steering gear sector shaft to avoid any damage during servicing. Mask the splines and tapered hole on the pitman arm to avoid any damage during servicing.



While assembling the pitman arm or while torquing the jam nut, make sure to not rotate the steering gear sector shaft. Rotating the steering gear sector shaft may press in the poppets more than required. Doing so will eventually damage the steering system.

1. The pitman arm on set-forward axle vehicles (See Figure 7) should only be assembled after the steering gear is installed on the frame rail.
2. The pitman arm on set-back axle vehicles (See Figure 8) should be assembled before installing the steering gear on the frame rail.
3. Install the pitman arm to the steering gear sector shaft. Make sure that the timing mark on the steering gear sector shaft and the pitman arm align (See Figure 10).
4. The assembly sequence while installing the pitman arm to the steering gear is as follows:
 - A. Pitman arm to the sector shaft of the steering gear
 - B. Flat washer (1110)
 - C. Split lock washer (1120)
 - D. Jam nut (1130)



Failure to follow the above assembly sequence may lead to loss of torque retention on the pitman arm sector shaft assembly. This may eventually affect the safe operation of vehicle.

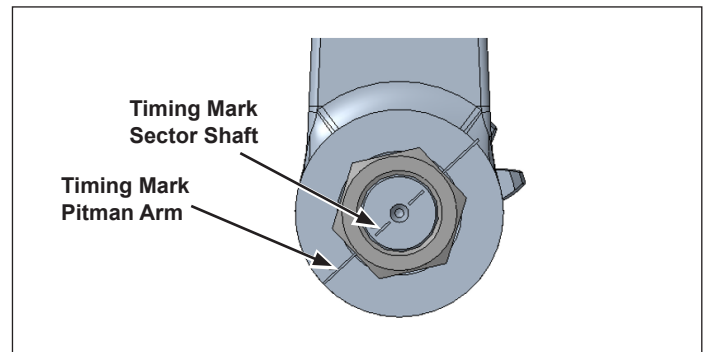


Figure 10 - Installing the Pitman Arm

5. Torque the jam nut to $440 \pm 49 \text{ N}\cdot\text{m}$ ($325 \pm 36 \text{ ft}\cdot\text{lbs}$). Make sure to torque the jam nut until the "click" sound on the torque wrench is heard.
6. Apply a witness paint mark after the assembly is complete. The witness paint mark will serve as an indicator if the jam nut starts to move or starts to lose torque retention.
7. For lash adjustment, loosen the adjustment screw nut if it is already assembled to the steering gear.
8. Wiggle the pitman arm while fastening the adjustment screw clockwise until no lash is felt on the pitman arm.
9. Turn the steering gear sector shaft adjusting screw an additional $1/8 - 1/4$ of a turn.
10. If not yet assembled, assemble the adjustment screw nut.
11. Tighten the nut to $117.7 - 127.5 \text{ N}\cdot\text{m}$ ($86.6 - 94 \text{ ft}\cdot\text{lbs}$) while holding the adjustment screw in place.



If only the pitman arm moves and the sector shaft stays rigid or fixed, disassemble the pitman arm and inspect if the splines are fractured. Refer to the section titled *Removing the Pitman Arm*.

INSTALLING THE STEERING GEAR TO THE VEHICLE

1. Install the steering gear to the vehicle frame following the vehicle manufacturer's specifications and reconnect the oil lines (repeat this step for the slave gear if present).
2. Reconnect the steering gear pitman arm taper hole with the drag link (except slave gears) following the vehicle manufacturer's specifications (slave gears should not have the drag link installed until the bleeding procedure is performed).
3. Reinstall the steering column lower yoke (not necessary for the slave gear). Torque the pinch bolt to the lower yoke to the vehicle manufacturer's specifications. Fill the power steering reservoir to the proper level.
4. Refer to the section titled *Single Gear Bleeding Procedure*.

SINGLE GEAR BLEEDING PROCEDURE

Required Tools

- Hex 8 wrench
- Drain pan

If the gear is mounted with the bulge in the housing for the sector shaft hanging below the piston cylinder, shown in *Figure 6*, perform the following procedure:

1. With the weight of the vehicle on the ground, start the engine and let it run at idle speed.
2. Turn the steering wheel back and forth from full lock to full lock three (3) times. Hold the steering wheel in pressure for about five (5) seconds when you reach the end of travel in each direction.
3. Center the steering wheel. The bleeding procedure is complete.

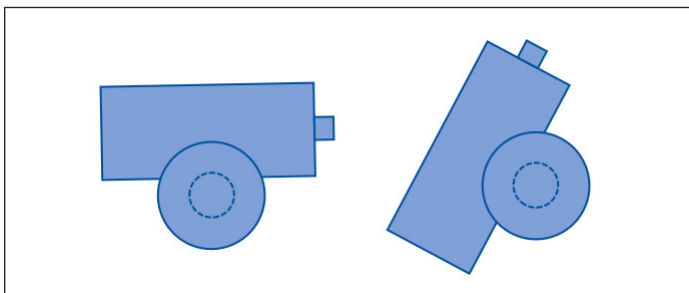


Figure 11 - Single Gear Bleeding Procedure - Shaft Below Piston Cylinder

If the gear is mounted with the bulge in the housing for the sector shaft sitting above the piston cylinder, shown in *Figure 12*, perform the following procedure:

1. Locate the bleeder plug on the steering gear sector shaft housing.
2. Many newer model gears do not have the bleeder plug, even if they are mounted in this manner. Instead, there is a bleed passage cast into the housing which allows the air to be carried to the bearing cap. Bleed this type of gear using steps 1 and 2 for gears mounted with the bulge in the housing for the sector shaft hanging below the piston cylinder.
3. With the weight of the vehicle on the ground, start the engine and let it run at idle speed.

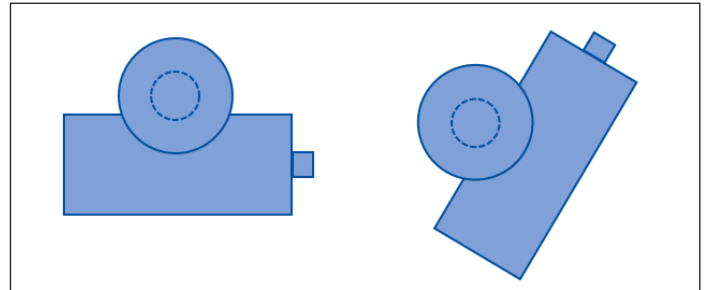


Figure 12 - Single Gear Bleeding Procedure - Shaft Above Piston Cylinder

For the following steps, identify if a left- or right-hand truck gear is installed.

Left-Hand Truck Gears

- A. With assistance, turn the steering wheel all the way to the left. Open the bleeder plug one half turn to one (1) turn using a Hex 8 wrench. With the bleeder still open, turn the wheels all the way to the right. Confirm the air bubbles drain through the tube. When you get all the way to the right, shut the bleeder and torque it to 6.9 - 12.7 N•m (5.1 - 9.4 ft-lbs). Turn the wheels all the way back to the left and repeat the procedure four (4) or more times until no air bubbles can be seen through the tube.

NOTE: THE BLEEDER SHOULD ONLY BE OPEN AS YOU ARE TURNING RIGHT! If it is open when turning left, air will be forced back into the system.

Right-Hand Truck Gears

- B. With a helper, turn the steering wheel to full right. Open the bleeder plug one half turn to one (1) turn using a Hex 8 wrench. With the bleeder still open, turn the wheels all the way to the left. Confirm the air bubbles drain through the tube. When you get all the way to the left, shut the bleeder and torque it to 6.9 - 12.7 N•m (5.1 - 9.4 ft-lbs). Turn the wheels all the way back to the right and repeat the procedure four (4) or more times until no air bubbles can be seen through the tube.

NOTE: THE BLEEDER SHOULD ONLY BE OPEN AS YOU ARE TURNING LEFT! If it is open when turning right, air will be forced back into the system.

4. Center the steering wheel. The bleeding procedure is complete.
5. After the air drains completely, fill the power steering reservoir to the proper level.

MASTER AND SLAVE GEAR BLEEDING PROCEDURE

1. With the weight of the vehicle on the ground, start the engine and let it run at idle speed. The drag link should be connected to the pitman arm on the main gear, but not connected to the slave gear.
2. Turn the steering wheel all the way to the left until the axle stop contacts the axle, and hold pressure on the steering wheel until the pitman arm on the slave gear moves its full travel. The slave gear should move in the opposite direction of the pitman arm on the main gear. A jack may be needed under the axle to take some weight off the steer tires for them to turn. Keep holding pressure on the steering wheel for 15 seconds after the slave gear stops moving.
3. Turn the steering wheel all the way to the right until the axle stop contacts the axle, and hold pressure on the steering wheel until the pitman arm on the slave gear moves its full travel. Keep holding pressure on the steering wheel for 15 seconds after the slave gear stops moving.
4. Repeat the procedure three (3) more times or until there is no air in the system and the slave gear moves freely.

NOTE: Pressure must be kept on the steering wheel to keep the valve open, sending fluid to the slave gear. When pressure is released, the valve returns to neutral and no pump pressure is sent to the steering gears.

5. Turn the steering wheel until the pitman arm on the slave gear lines up with the drag link and install the drag link. Do not move the pitman arm on the slave gear by hand as air may be drawn into the system.
6. Cycle the steering wheel from stop to stop. If a catch is noted, look for bleeder plugs on the steering gears. Depending on whether the steering gear is mounted with the bulge in the housing for the sector shaft sitting above or below the piston cylinder, *refer to the section titled Single Gear Bleeding Procedure.*

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