INTRODUCTION

All rear-wheel-drive (RWD) vehicles use a drive axle assembly to transfer power from the driveshaft to the drive wheels. Because it is powered, it is sometimes called a live axle.

The purpose and function of a drive axle assembly includes the following:

1. Changing the direction of engine torque—This is achieved using a ring and pinion gears. Figure 1.

2. Allowing the drive wheels to rotate at different speeds when turning— This is achieved using a differential assembly. Figure 2.

3. Support the weight of the vehicle—This is achieved by using a robust drive axle assembly.

4. Drive the wheels through axles—The drive axles are splined to the side gears of the differential and attached to the drive wheels at the outer end.

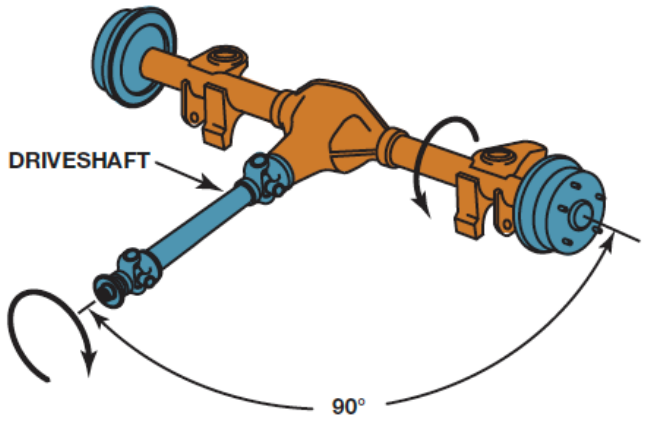


Figure 1. The drive axle assembly changes the direction of engine torque and increases the torque to the drive wheels.

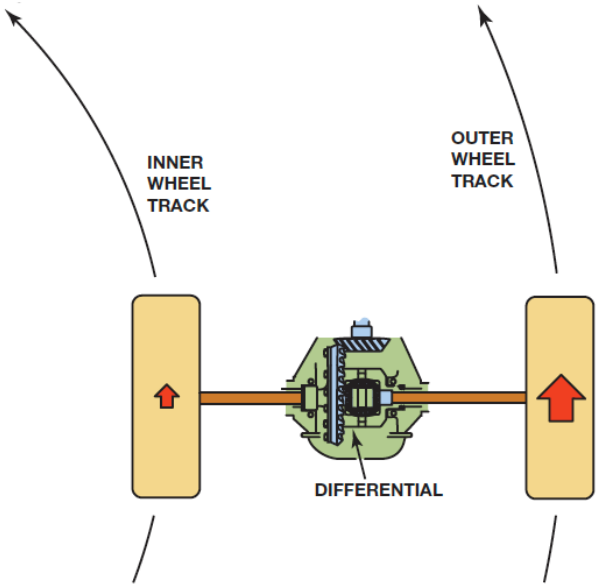


Figure 2. The differential allows the wheels to rotate at different speeds when cornering.

The axle shafts transfer the torque from the differential side gears to the drive wheels and support the weight of the vehicle. Figure 3. To give them the necessary strength to transfer the torque, axles are made of forged steel. The inner ends are splined to match the splines of the differential side gears.

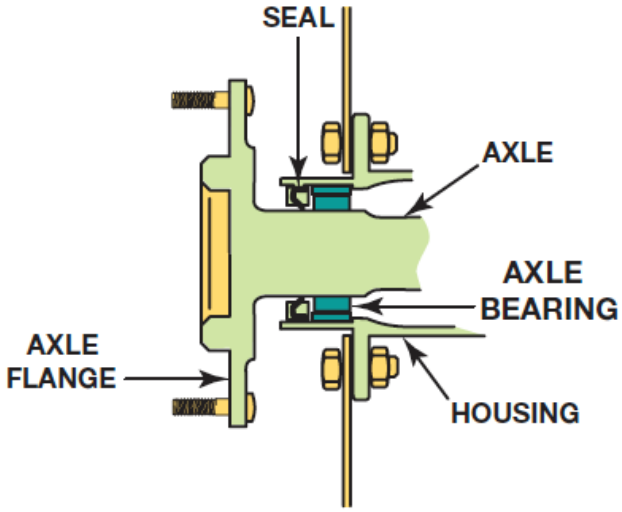


Figure 3. Axle housing and bearing.

The ring and pinion gears are the final drive reduction gears. The gear set is a hypoid type. A hypoid gear set uses a drive pinion that meshes with the ring gear below the center line of the ring gear. Figure 4.

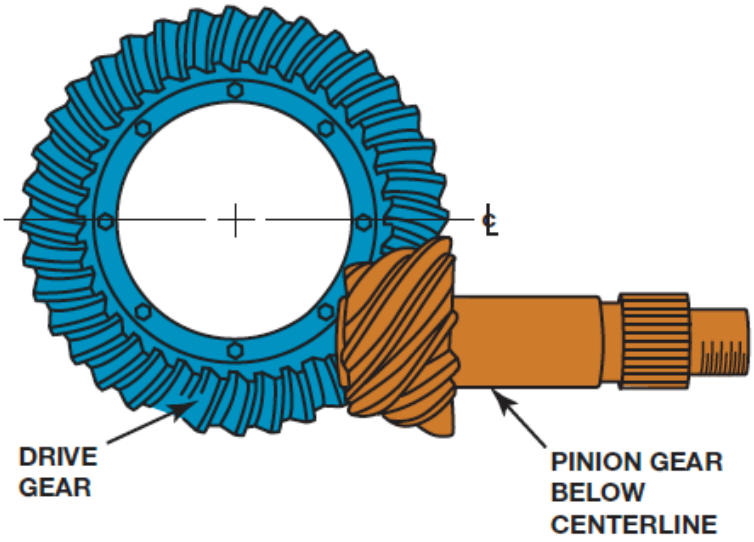


Figure 4. A hypoid gear set. The gears are a matched set and must be replaced as a set.

The ring gear is bolted or riveted to the differential case. The differential case is mounted on a pair of tapered roller bearings, which are commonly called carrier bearings or side bearings. Figure 5.

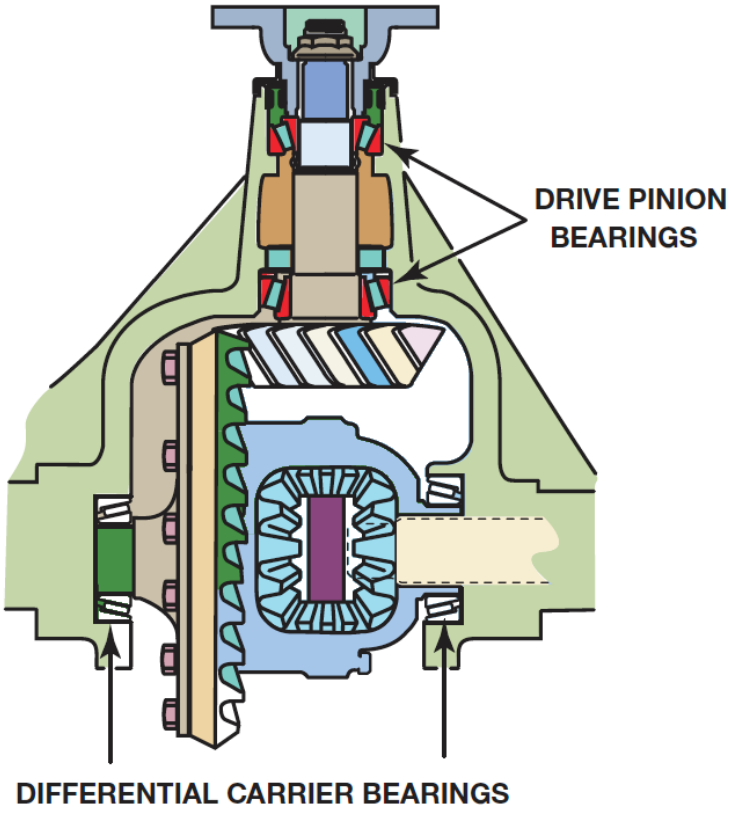


Figure 5. Ring gear, differential case, and carrier bearings.

The differential carrier is the heavy cast iron portion of the rear axle assembly that provides mounting points for the drive pinion shaft bearings and the carrier bearings. Figure 6.

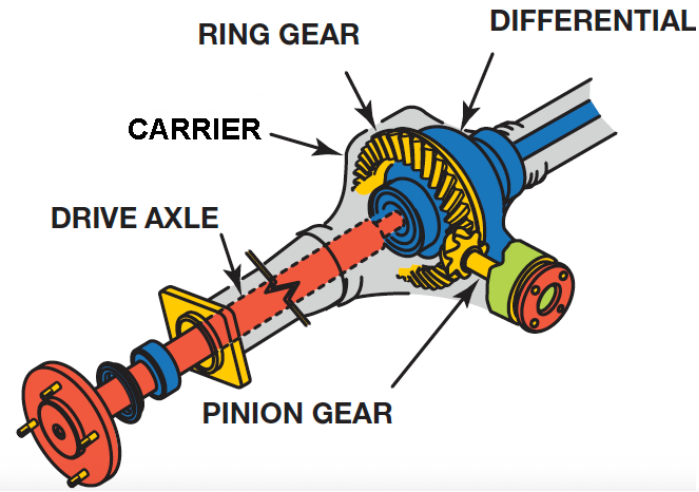


Figure 6. The cast iron center housing of the drive axle is called the differential carrier.

A drive axle assembly must include a differential to allow the drive wheels to rotate at different speeds on corners. The differential used in most drive axles includes:

- Two or more differential pinion gears mounted on a differential pinion shaft(s)

- Two side or axle gears which are splined to the axle shafts

The differential pinion shaft runs through the case and has the two differential pinion gears (sometimes called spider gears) floating on it. They are located between the differential case and the two side gears, which are also called axle gears. Figure 7.

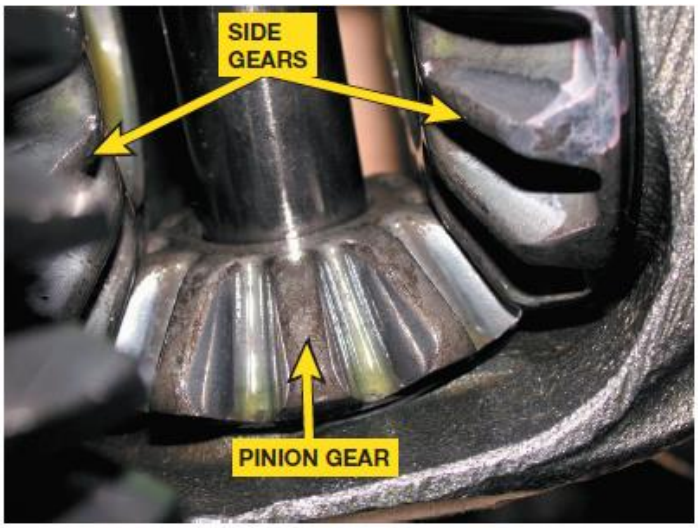


Figure 7. Differential gears and pinion shaft.

ASE TEST TOPICS

► Ring and Pinion Gears

1. Diagnose noise, vibration, and fluid leakage problems; determine needed repairs.

Most drive axle problems are related to noise, vibration, leaks, and failure to transmit power. The road test should include the following driving conditions:

- Drive: Light-to-moderate throttle acceleration
- Cruise: Enough throttle to maintain a constant speed
- Float: Just enough throttle to keep engine load off the drivetrain as the vehicle slows
- Coast: Closed throttle deceleration
- Coast while in neutral: Isolates transmission noises
- A summary of noise-related faults and their possible causes is shown in Figure 8.

WHEN NOISE OCCURS	POSSIBLE CAUSE
Under all driving conditions	Road and tires; wheel bearings; incorrect driveline angles
Changes with road surface	Tires
Noise becomes louder during cornering	Differential gears; axle bearings
Howling sound	Ring and pinion gears (incorrect adjustment, worn, or runout issues)
Growling sound	Bearing(s)
Whine noise concern	Check ring gear pattern for incorrect backlash or pinion depth
Clunk on speed change or going from forward to reverse or reverse to forward	Worn U-Joints, differential or driveshaft splines
Continuous low pitched whir	Worn U-joints
Low pitch rumble over 20 MPH (32 km/h)	Worn carrier bearings
Chatter during cornering	Incorrect gear oil or worn limited slip clutches

Figure 8. Drive axle noise diagnosis.

Most gear oil leaks will be found at the following locations.

- Axle shaft seals
- Drive pinion seals
- Rear cover Figure 9.
- Carrier-to-housing gasket (on removable carrier type).

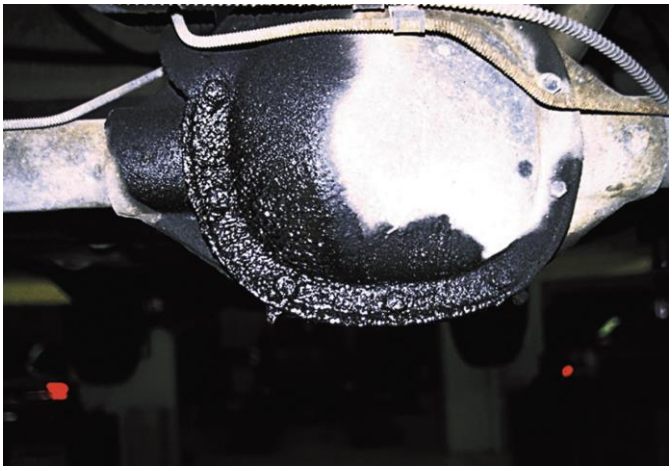


Figure 9. Rear cover gasket leak.

2. Inspect and replace companion flange, yoke, and pinion seal; measure companion flange runout.

The companion flange is splined to the rear axle pinion shaft and provides the mounting for the rear U-joint of the driveshaft. The companion flange should have a maximum runout of 0.006 inch (0.15 mm) while being rotated.

A leaking pinion shaft seal can be replaced in-vehicle without removing the pinion shaft from the carrier or drive axle/carrier from the vehicle. The driveshaft flange is removed and then the seal is removed and replaced. An important requirement while performing this operation is to not disturb the drive pinion bearing preload adjustment.

- After removing the wheels and eliminating any brake drag, use an inch-pound torque wrench to measure the pinion bearing preload. It should be between 17 and 22 inch-pounds or slightly lower in most applications. Figure 10.

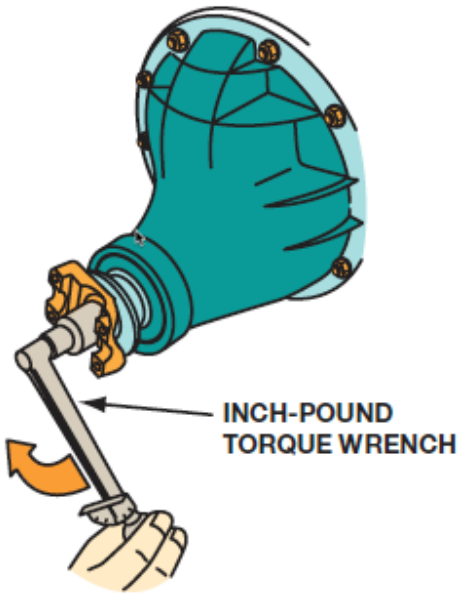


Figure 10. Measuring drive pinion preload.

- Mark the pinion flange, pinion nut, and the pinion shaft before removing the pinion nut. Figure 11.

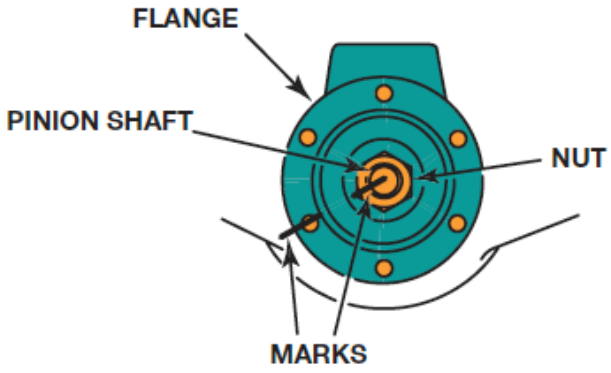


Figure 11. Reference marks.

- A companion flange holding tool is used to keep the companion flange from rotating as the pinion nut is loosened. Use hand tools, not an impact gun. Figure 12. After the pinion nut has been removed, a puller is used to remove the companion flange.

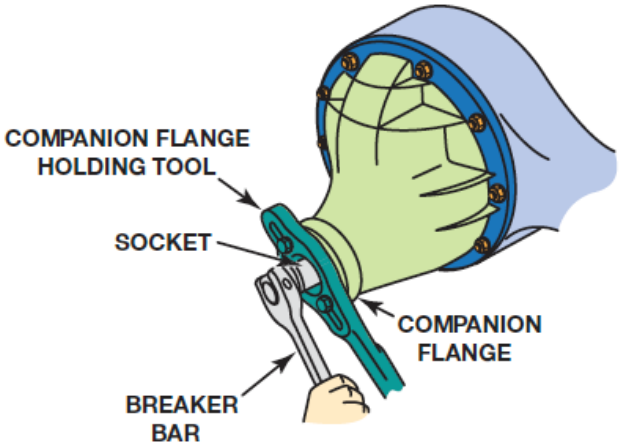


Figure 12. Use a holding tool and breaker bar to remove the pinion nut.

- After replacing the seal install the companion flange and install a new pinion nut with a washer and tighten the nut until the parts align as per the marks that were made earlier. Check that the bearing preload is slightly greater than what was recorded The pinion nut should be very tight.

3. Measure ring gear runout; determine needed repairs.

Ring gear runout is checked if there is evidence of damage to the ring gear. Runout is usually caused by a faulty or bent differential case or an improper mounting of the ring gear onto the case. Figure 13.

Figure 13. Ring gear runout should be less than 0.002 inch (0.05 mm) as measured by a dial indicator.

4. Inspect and replace ring and pinion gear set, collapsible spacers/crush sleeves, shims, and bearings.

The drive pinion gear and ring gear are manufactured as a matched set and must be installed as a set. When installing the ring gear to the differential case, perform the following steps to insure that the gear is firmly seated:

- Sometimes heat from a torch is needed to expand the ring gear slightly so it fits over the case.
- Use guide pins to help align the ring gear fastener holes while installing the ring gear.
- Use new retaining bolts and torque them to factory specifications. Figure 14.

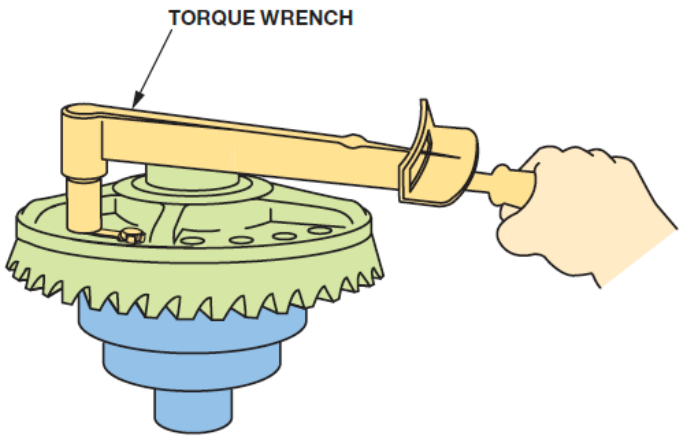


Figure 14. Tightening the ring gear mounting bolts.

If new pinion bearings are required, then the old bearing cups must also be replaced. Worn drive pinion bearing cups are normally removed from the carrier using a punch and hammer. Figure 15. New pinion bearing cups are installed by driving them into place using a bearing cup driver and hammer.

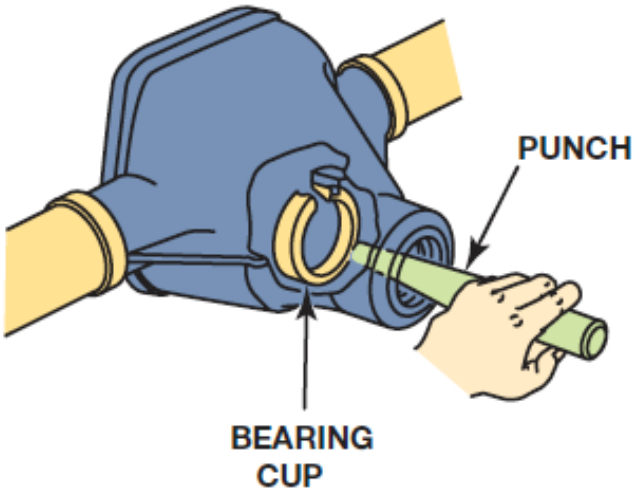


Figure 15. Removing pinion bearing cups.

5. Measure and adjust drive pinion depth.

All pinion gears use a depth shim to adjust for minor manufacturing tolerances of the gear and carrier. Pinion depth is affected by the machining of the gear and carrier, as well as by the rear bearing. The pinion depth shim is usually located between the rear bearing and the pinion gear head. Figure 16.

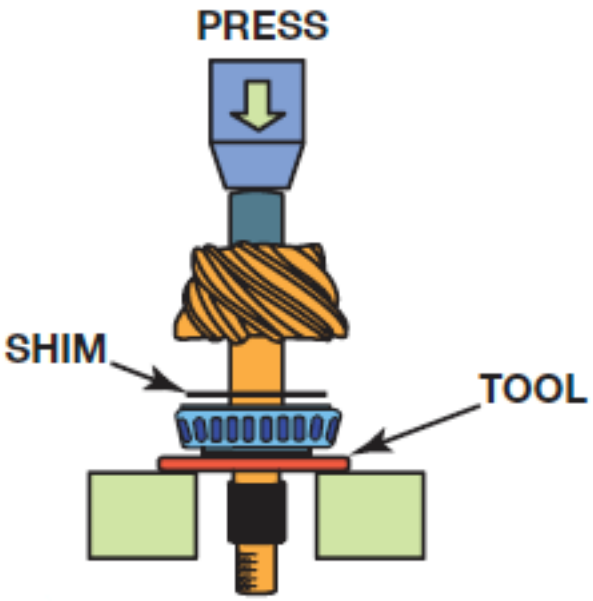


Figure 16. Pinion depth adjusting shim.

Most vehicle manufacturers use a set of pinion depth gauge blocks to select the correct depth shim. These gauges are installed in the carrier, usually using the rear drive pinion bearing. Universal pinion depth measuring tools are available that can be used to determine the pinion depth. Figure 17.

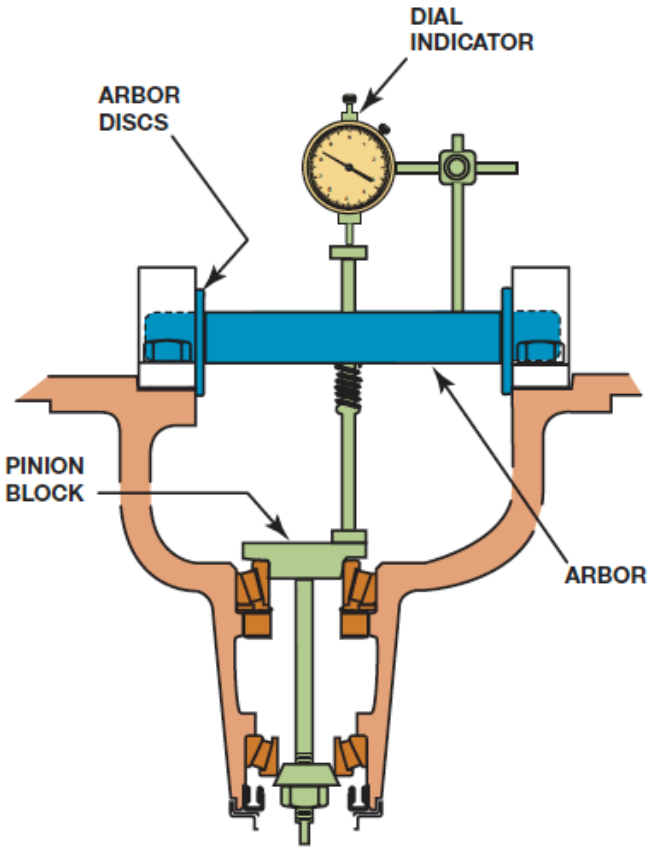


Figure 17. Special tool setup for measuring pinion depth.

6. Measure and adjust drive pinion bearing preload (collapsible spacer/crush sleeves or shim type).

After installation of the pinion depth shim, pinion seal, and rear bearing, the bearing spacer is placed on the pinion shaft and the pinion gear is installed in the carrier. The bearing spacer will be either a collapsible crush sleeve or a fixed-length solid spacer. Figure 18.

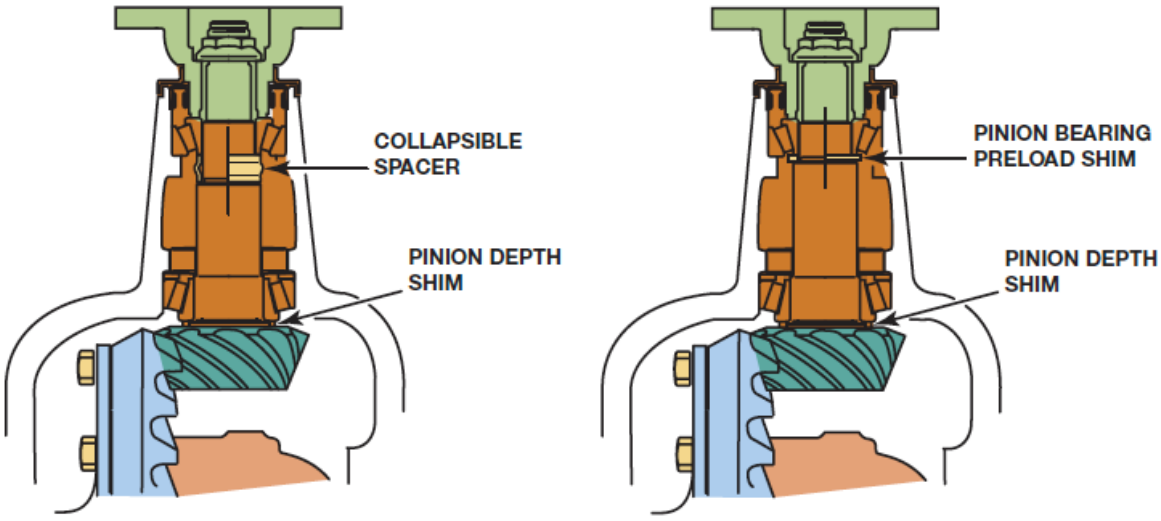


Figure 18. Two types of bearing spacer. The crush-type is the most common.

This spacer keeps the two tapered roller bearings apart as the companion flange nut is tightened. The spacer allows the bearings to be squeezed against their races just tight enough to obtain the proper preload. The length of a fixed spacer is adjusted by adding or removing thin selective-size shims. A crush sleeve starts out too long and is collapsed to the proper length as the drive pinion nut is tightened.

Crush sleeve. The drive pinion nut is gradually tightened and the rotating torque checked to prevent over-tightening the nut. If the rotating torque becomes higher than specifications, the collapsible spacer will require replacement, and the installation procedure must be repeated. Figure 19.

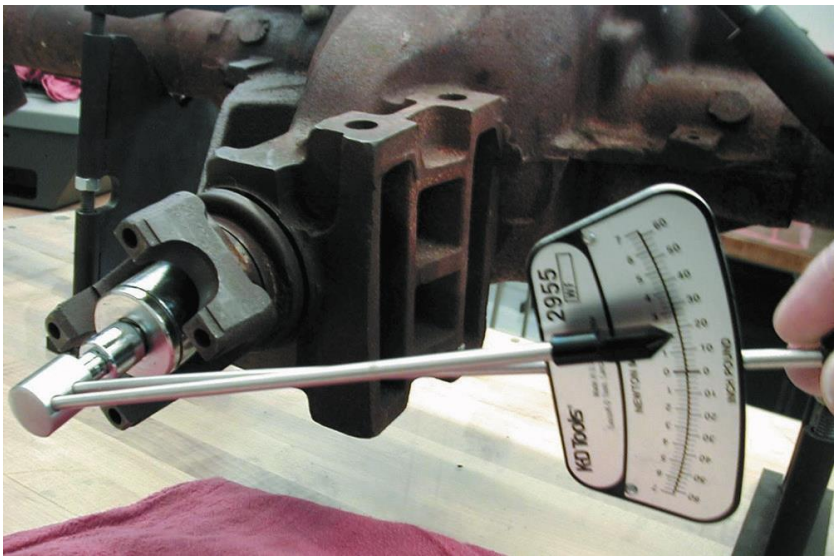


Figure 19. The rotating torque is checked after each small tightening of the pinon nut.

Shim-type adjustment.

- Install the solid spacer onto the pinion shaft with a starting shim that should be thicker than needed.

- Using a dial indicator, move the pinion shaft through its free play and read the dial indicator needle movement to determine the free play.
- Determine the shim change by subtracting a factor specified by the manufacturer and the free play from the size of the starting shim.
- Remove the pinion gear and replace the starting shim with the size just determined.
- Tighten the pinion nut to the correct torque and check pinion bearing preload.

7. Measure and adjust differential (side) bearing preload, and ring and pinion backlash (threaded adjuster or shim type).

Backlash and carrier side bearing preload adjustments are made as the ring gear and differential are installed into the carrier. Backlash is the operating clearance between the ring and pinion gears. It is adjusted by moving the ring gear toward the pinion gear to reduce backlash, or away from the pinion to increase backlash. Figure 20.

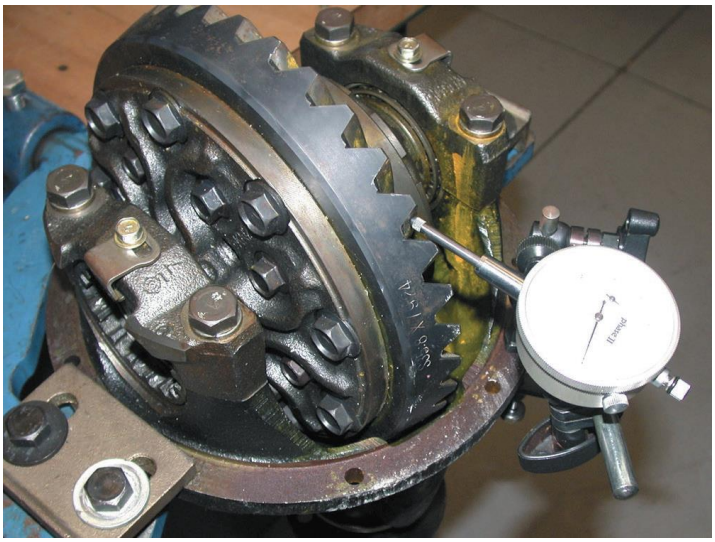


Figure 20. Measuring backlash.

Carrier bearing preload places enough pressure on the carrier bearings to hold the ring gear in proper mesh with the pinion gear without putting unnecessary load and drag on the bearings. These adjustments are made using threaded adjusters or by changing shims. Figures 21 and 22.

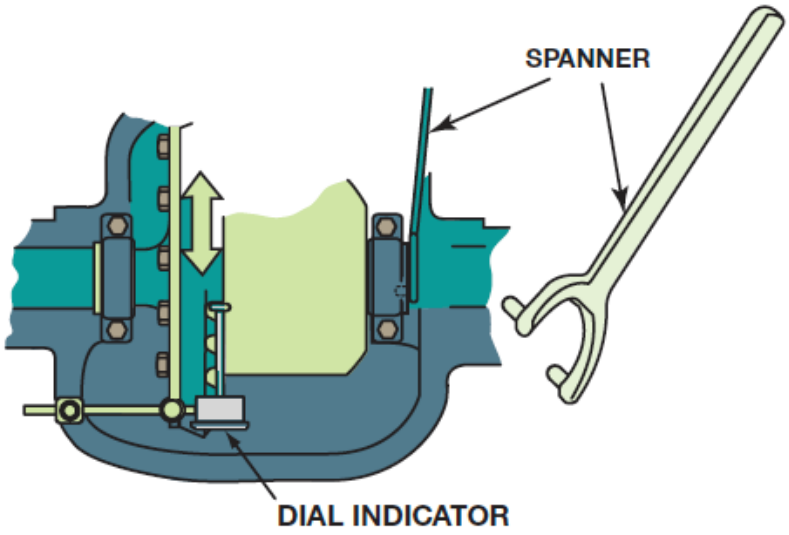


Figure 21. Threaded adjusters used to set backlash and carrier preload.

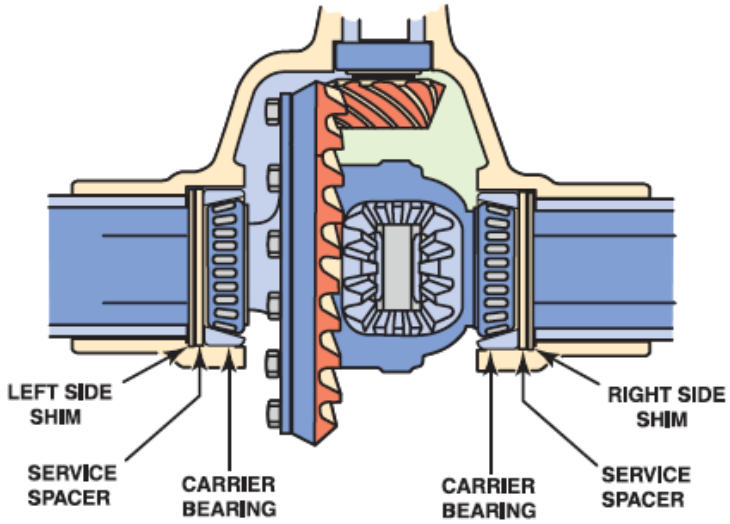


Figure 22. Backlash and preload adjusted using shims.

After carrier bearing preload has been adjusted, the overall preload of the carrier should increase by a noticeable amount, about 5 to 10 inch-pounds, from the pinion bearing preload.

On many axles, it is necessary to use a special tool to install steel spacers (shims) to achieve the specified backlash and side bearing preload. Figure 23.

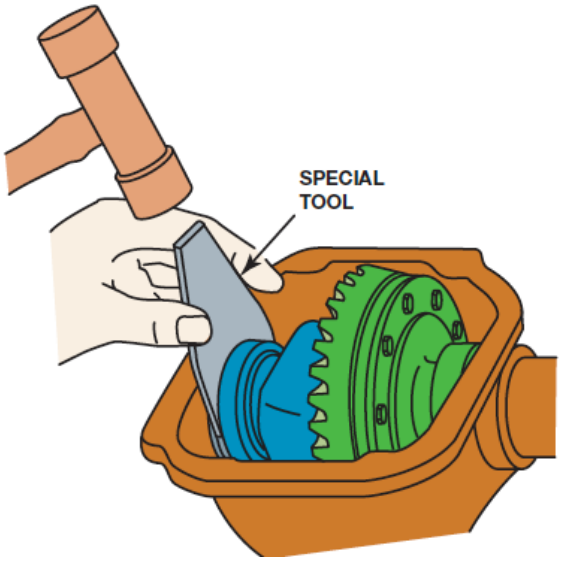


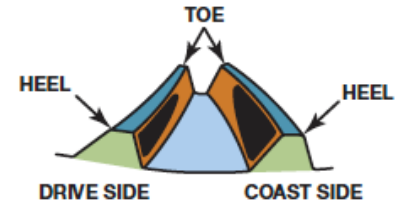
Figure 23. Installing the shim to achieve the proper preload.

8. Perform ring and pinion tooth contact pattern checks; determine needed adjustments.

After adjusting backlash and setting the proper side bearing preload, a tooth contact pattern test is an excellent method for checking proper drive pinion depth as well as proper backlash. Gear marking compound is available for this purpose from some gear or vehicle manufacturers.

- Using a small brush, apply a light coating of gear marking compound.
- Rotate the drive pinion until the ring gear turns one revolution (about three revolutions of the drive pinion gear).
- Repeat rotating the drive pinion in the opposite direction. This will create a contact pattern on both the drive side and the coast side of the ring gear.

Sample gear patterns Figure 24.



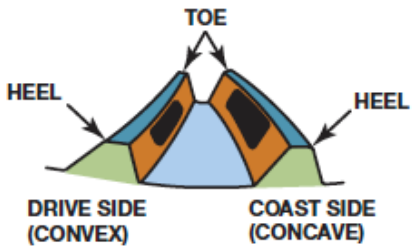
CONDITION

PINION DEPTH CORRECT.

BACKLASH INCORRECT - TOO MUCH CLEARANCE BETWEEN THE PINION AND RING GEARS.

CORRECTION

INCREASE THE THICKNESS OF THE LEFT (RING GEAR SIDE) SHIM AND DECREASE THE THICKNESS OF THE RIGHT SHIM AN EQUAL AMOUNT.



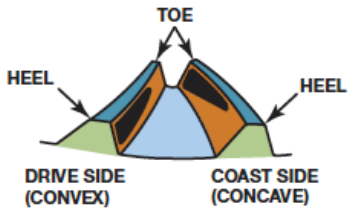
CONDITION

PINION DEPTH CORRECT.

BACKLASH CORRECT.

CORRECTION

NONE.



CONDITION

PINION DEPTH INCORRECT - PINION GEAR IS TOO FAR AWAY FROM THE RING GEAR.

BACKLASH CORRECT

CORRECTION

INCREASE THE PINION SHIM THICKNESS.

Figure 24. Sample gear contact patterns, conditions and corrections.

► Differential Case/Carrier Assembly

9. Diagnose differential assembly noise and vibration problems; determine needed repairs.

A noise that becomes louder during cornering could be caused by damaged differential gears or worn axle bearings. Excessive clearance in the differential gear set can cause a clunk as the lash is taken up when either the manual transmission clutch or automatic transmission is engaged. This is especially noticeable when changing direction, low to reverse, or reverse to low.

10. Remove and replace differential assembly.

After removing the bearing cap mounting bolts and the bearing caps the preload at the shims should be too tight to allow easy removal of the differential. Most differentials can be pried out of the carrier, but care must be taken to not damage the gasket surface on the carrier. Figure 25.

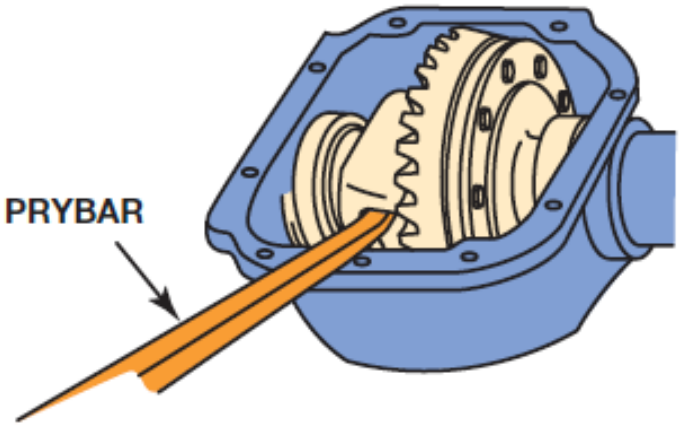


Figure 25. Removing the differential carrier.

11. Inspect, measure, adjust, and replace differential pinion (spider) gears, shaft, side gears, thrust washers, side bearings, and case/carrier.

Differential case clearance is usually checked by using a dial indicator with the stylus on a side gear tooth. Hold the other side gear stationary as the first gear is moved back and forth. Figure 26.

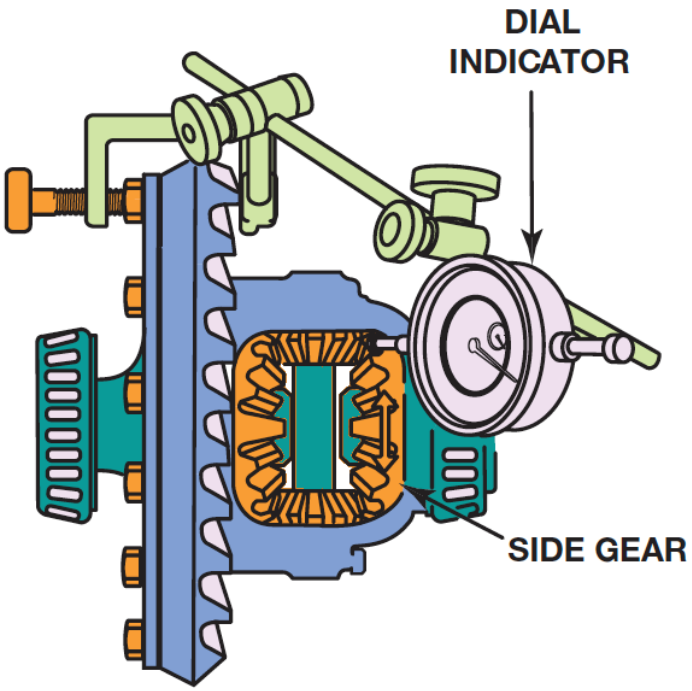


Figure 26. Measuring differential gear clearance.

A puller is normally required to remove the side bearings. Some manufacturers recommend the use of a special puller while others use a sturdy two-jaw bearing puller and a step-plate adapter. The new bearing is installed using a special bearing installer. Figure 27.

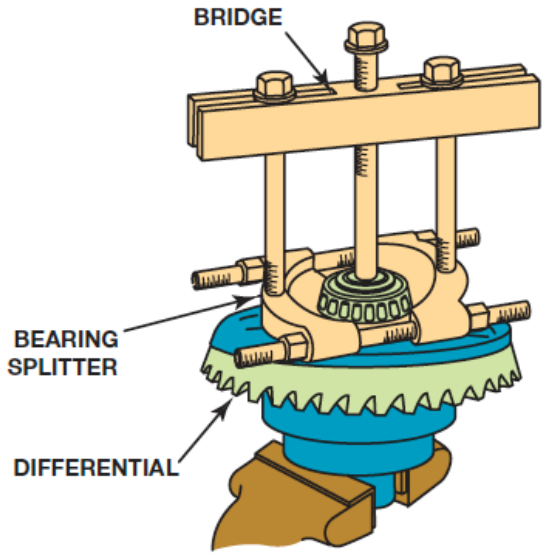


Figure 27. A puller and bearing splitter are set up to remove the differential side bearing.

To disassemble the differential case assembly, perform the following steps:

STEP 1 Remove the pinion shaft lock pin.

STEP 2 Slide the pinion shaft out of the case and check it for step wear.

STEP 3 Roll the pinion gears to the case window(s) and remove the pinion gears and thrust washers and the axle side gears and their thrust washers. Figure 28.

STEP 4 Inspect the gears, thrust washers, and case surfaces for scoring and wear. Reverse this procedure to reassemble the differential.

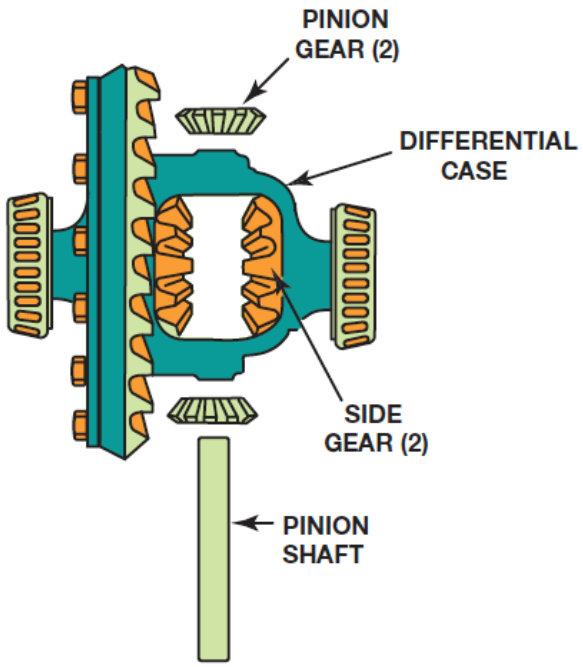


Figure 28. With the pinion shaft removed, the pinion gears can be rolled to the case windows and removed; then the side gears can be lifted out of the case.

12. Measure differential case/carrier runout; determine needed repairs.

Ring gear runout is checked if there is evidence of damage to the ring gear. Runout is usually caused by a faulty or bent differential case or an improper mounting of the ring gear onto the case. Figure 29.

Figure 29. Ring gear runout should be less than 0.002 inch (0.05 mm) as measured by a dial indicator.

► Limited Slip/Locking Differential

13. Diagnose limited slip differential noise, slippage, and chatter problems; determine needed repairs.

Chatter on corners is a vibration or noise as the vehicle turns a corner, especially after prolonged straight driving. This noise is often called chatter, commonly caused by a stick/slip condition at the clutch plates of a limited slip differential.

After changing the lubricant in a limited slip differential to cure a chatter problem, drive the vehicle through 10 to 12 figure-eight turns. This procedure will force the new lubricant between the clutch plates. Figure 30.

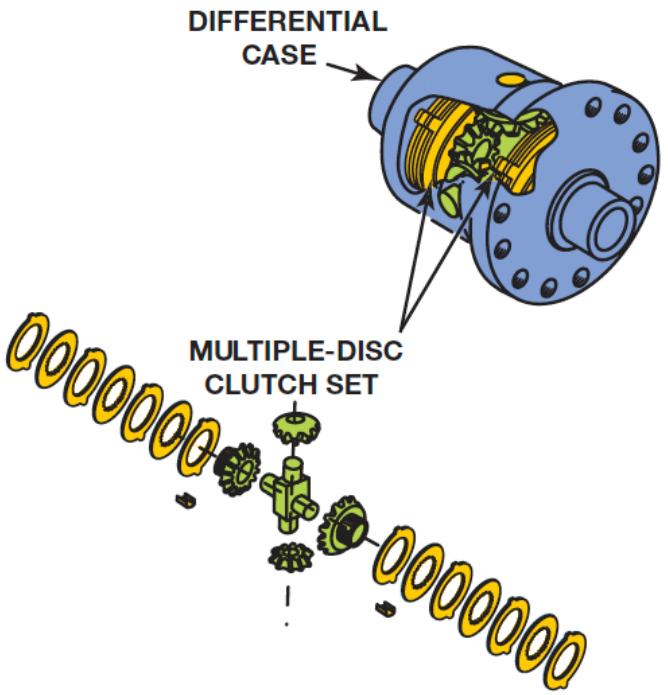


Figure 30. Limited slip differential clutch plates.

14. Inspect, drain, and refill with proper lubricant.

The lubricant (oil) level is usually even with the bottom of the fill opening. If necessary, a finger can be used as a dipstick to determine the level. Figure 31.

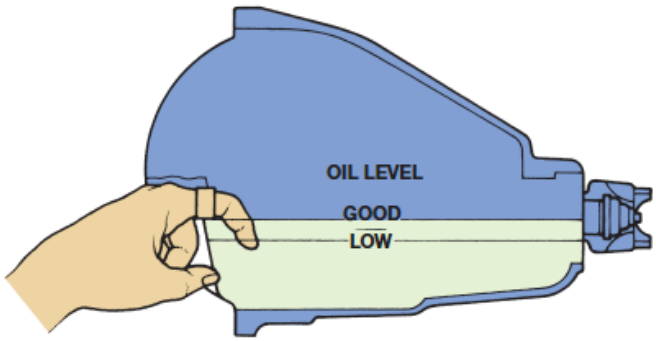


Figure 31. Checking lubricant level.

Lubrication of the clutch plates is critical because the plates have to slip across each other every time the vehicle turns a corner or rounds a curve. A special friction modifier additive is required in the gear oil to make it slippery enough for these differentials.

15. Inspect, adjust, repair or replace limited slip or locking assembly components.

In most cases, this operation involves disassembly and reassembly of the differential with replacement of worn parts.

STEP 1 Carefully remove the S-shaped preload spring by tapping it through the window.

STEP 2 Roll the differential pinions around the case windows and remove them.

STEP 3 Remove the side gear and clutch packs as a group, and tag or mark them so that they can be reassembled on the same side of the differential.

STEP 4 The clutch plates or cones should be checked for scores, grooves, or galling. Reassembly of most limited slip differentials is the reverse of the disassembly procedure. The clutch pack surfaces must be thoroughly lubricated with the proper lubricant during assembly.

16. Inspect, test, replace, and calibrate sensors, control modules, actuators, and switches.

Electric locking differentials use an electric motor or magnetic clutch assembly to lock the differential. When the axle shaft or side gear is connected to the differential case, the differential becomes locked. Current flow to the motor can be electronically controlled by the powertrain control module (PCM). Locking differentials are used in both rear and front axles. These systems will set diagnostic trouble codes (DTCs) when there is a fault. System testing is through the use of a scan tool.

► Axle Shafts and Housing

17. Diagnose rear axle shaft noise, vibration, and fluid leakage problems; determine needed repairs.

Rear wheel bearing noise is usually a rough growl or rumble. Bearings will often make a “wow-wow” type of sound at the speed frequency of the spinning shaft. The axle tube has a seal that keeps the axle fluid from leaking onto the brake shoes. Figure 32.

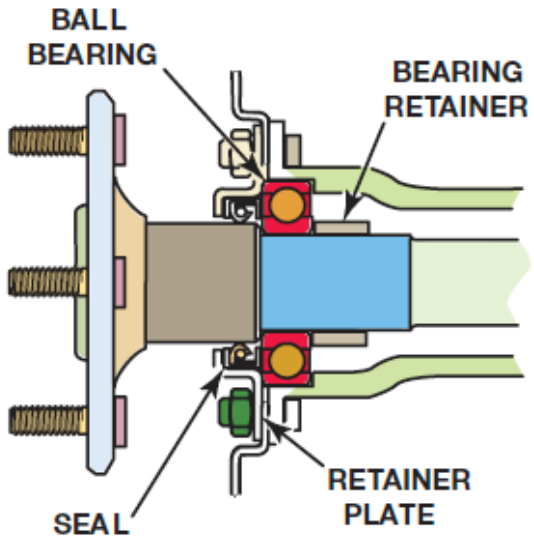


Figure 32. Rear axle outer section, showing the seal.

18. Inspect and replace rear axle shaft wheel studs.

Wheel studs are held in the axle flange by an interference fit between a serrated portion of the stud and the hole in the flange. Damaged wheel studs can be replaced without removing the axle. Figure 33.

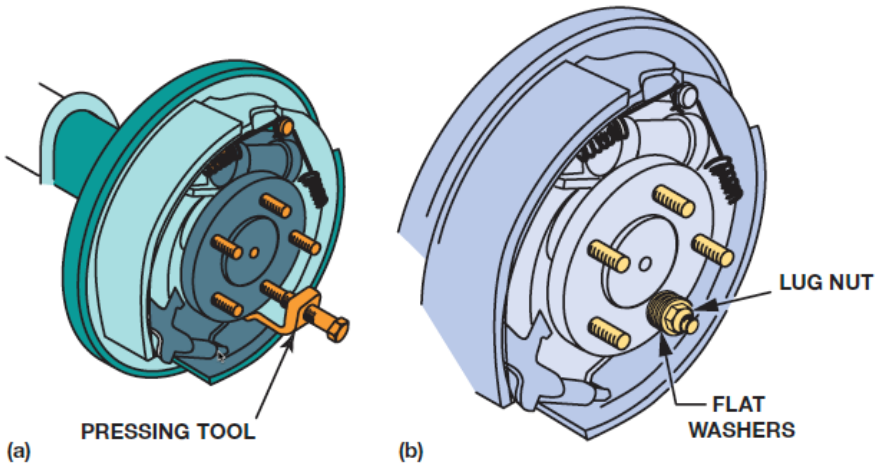


Figure 33. (a) A wheel stud should be removed using a pressing tool so as not to bend the axle flange. (b) A new wheel stud is installed by tightening the lug nut against a stack of flat washers.

19. Remove, inspect, adjust, and/or replace rear axle shafts, splines, seals, bearings, and retainers.

Passenger car and light pickup axles are semi-floating and are retained in the housing by either a C-lock at the inner end of the axle or by the axle bearing retainer at the outer end. Axle service includes removing the axle for bearing or seal replacement and bent or broken axle replacement.

Axle removal, C-lock axle.

- Drain the fluid and remove the rear cover.
- Remove the differential pinion shaft. Figure 34.
- Push the axle in and remove the C-lock. Figure 35.
- Remove the axle.

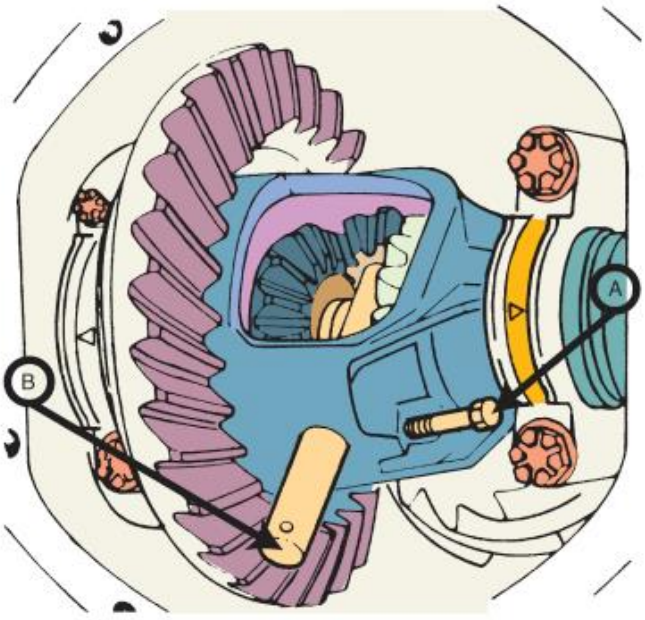


Figure 34. Remove the pinion shaft.

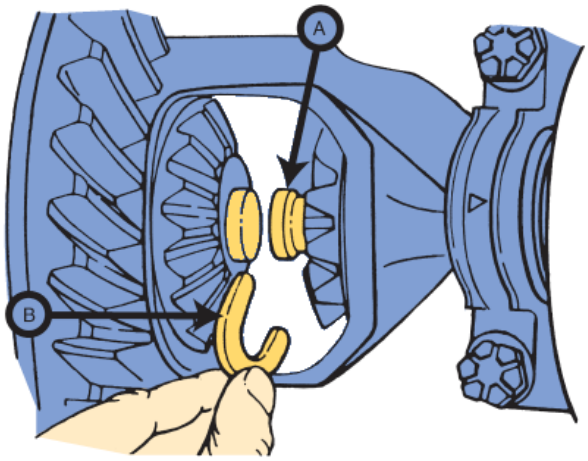


Figure 35. Push the axle in and remove the C-lock.

Axle removal, retainer plate-type.

- Remove the retainer plate nuts/bolts. Figure 36.
- Use a slide hammer to remove the axle. Figure 37.

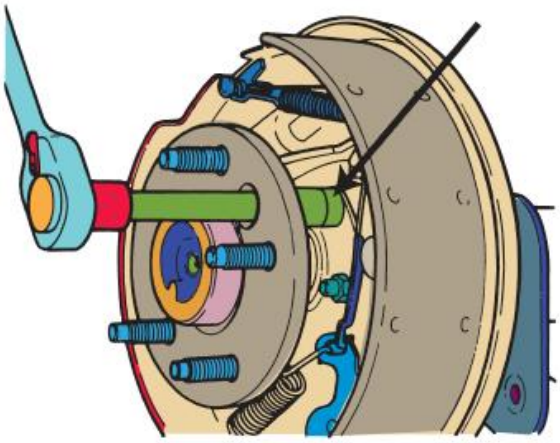


Figure 36. Remove retainer plate fasteners.

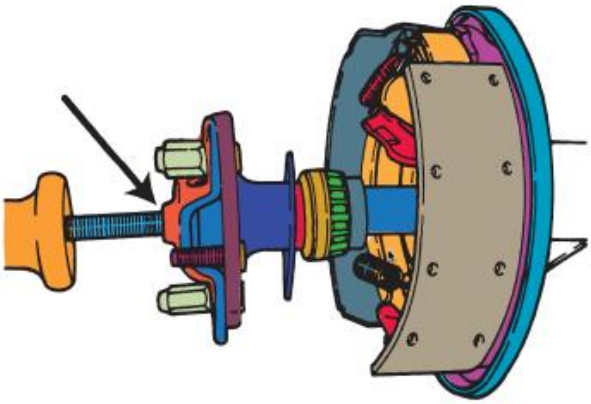


Figure 37. Remove the axle using a slide hammer.

Bearing and seal replacement C-lock type. Both the bearing and the seal are removed from the housing using a slide hammer and special adapter. The new bearing is driven straight into the housing to the end of its recess. The same installation procedure and tool is used to install the new seal. Figure 38.

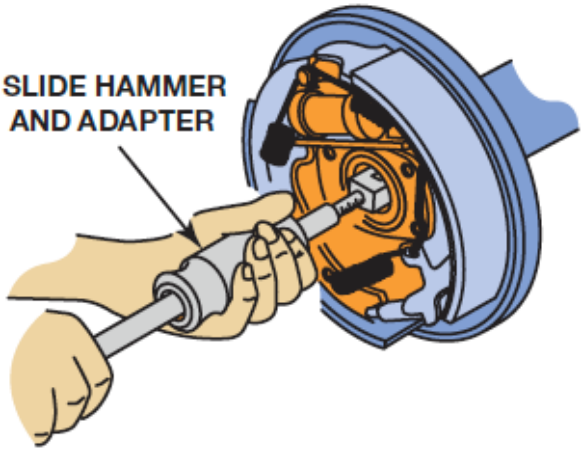


Figure 38. Removing the bearing and seal.

Bearing replacement retainer plate-type. The retainer bearing type axle bearing is press fit on the axle and requires a hydraulic press and special adapters to remove and install. The axle bearing retainer ring should be cut or stretched using a drill and a chisel before trying to press the bearing off the axle. Figure 39.

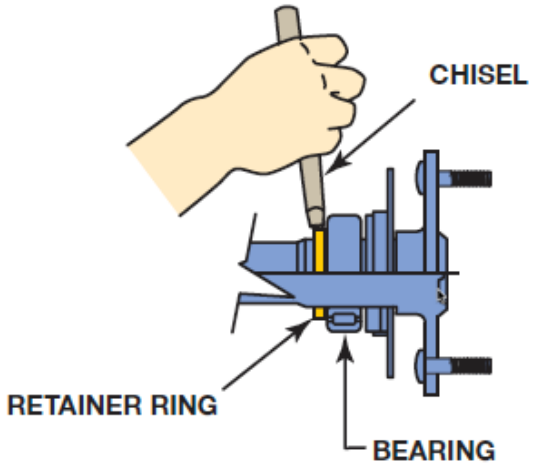


Figure 39. Cutting the retainer ring.

The new bearing is pressed on and then the retainer is pressed on, not both at the same time. Figure 40.

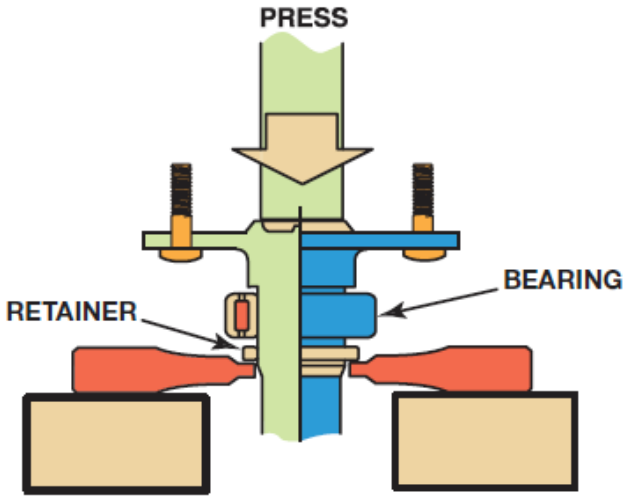


Figure 40. Pressing on the bearing retainer ring.

20. Measure rear axle flange runout and shaft endplay; determine needed repairs.

Axle shaft endplay can be checked by mounting a dial indicator on the brake assembly or axle housing with the indicator stylus on the axle. The indicator will measure the endplay as the axle is moved in and out. The same setup can be used to measure axle flange runout. Lateral runout of 0.005 inch (0.1 mm) or less is acceptable. Excessive endplay can mean a worn axle groove for the C-lock or a worn axle bearing. Figure 41.

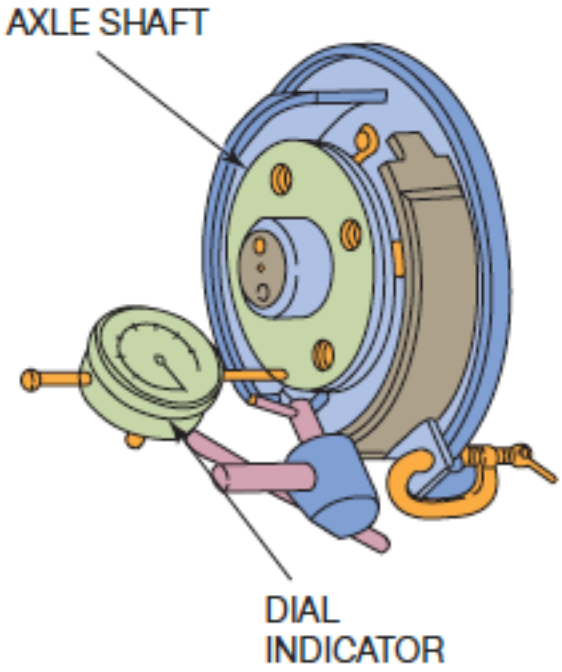


Figure 41. Measuring end play and runout.

21. Inspect axle housing and vent.

All differentials use a vent so make sure it is clear. A clogged vent can cause excessive pressure to build up inside the differential and cause the rear axle seals to leak. Figure 42.

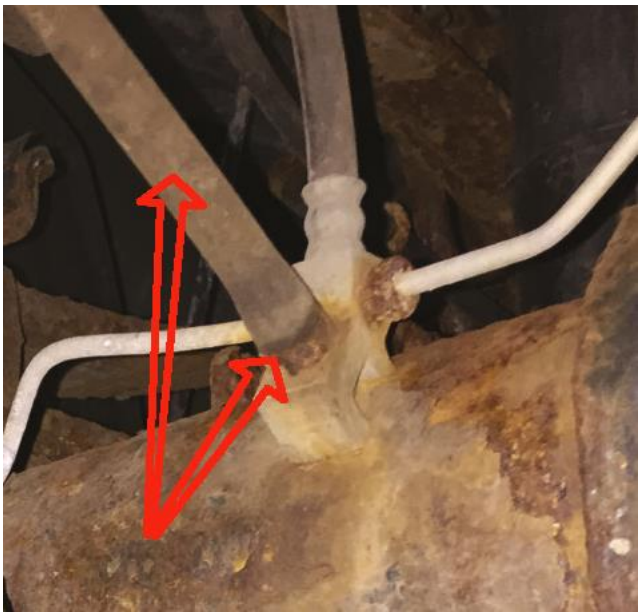


Figure 42. The axle vent and hose are often used as a mount for the rear brake lines.