CHAPTER 12

DRIVE AXLE SERVICE

OBJECTIVES

After studying Chapter 12, the reader should be able to:

1. Perform the maintenance operations needed to keep a drive axle operating properly.
2. Diagnose the cause of the common drive axle problems.
3. Recommend the proper repair procedure.
4. Remove and replace an axle shaft, axle bearings, and axle seals.
5. Remove and replace a removable carrier.
6. Overhaul a drive axle, making all necessary adjustments and checks.
7. Complete the ASE tasks for content area E, Rear-Wheel-Drive Axle Diagnosis and Repair.

KEY TERMS

Backlash (p. 336)
Backlash variation (p. 359)
Bearing spacer (p. 372)
Carrier bearing preload (p. 375)
Collapsible spacer (p. 372)
Contact pattern (p. 371)
Crush sleeve (p. 372)
Gear marking compound (p. 371)
Pinion bearing preload (p. 357)
Pinion depth (p. 357)
Ring gear runout (p. 359)
Service spacer (p. 379)
Shim (p. 357)

INTRODUCTION

Drive axle service includes the following operations:

- Checking the gear oil level
- Diagnosing problems
- Removing and replacing axle shafts
- Removing and replacing the carrier or entire axle for repairs
- Overhauling and adjusting the carrier

GEAR OIL CHECKS

The gear oil used in most drive axles is 90-weight or 120-weight gear oil and should be hypoid quality GL-4 or GL-5. If the axle has a limited slip differential, the gear oil must meet the requirements for that differential type. A label is normally located near the filler opening on those axles to indicate the fluid required.

To check drive axle gear oil level:

1. Raise and securely support the vehicle on a hoist or jack stands so that you have access to the axle. The vehicle should be raised so that the drive axle is in its normal position relative to level.
2. Locate the gear oil-level plug, clean the area around it, and remove the plug (Figure 12-1). Be prepared for fluid to run out of the opening.
3. In most axles the gear oil level should be even with the bottom of the opening.

TECH TIP

If you cannot see the gear oil level, carefully insert your finger into the opening and bend it downward, using it as a level indicator (Figure 12-2).

TECH TIP

The fluid level on some Ford axles should be a specified distance below the opening and requires a special dipstick, which can be shop-made (Figure 12-3).

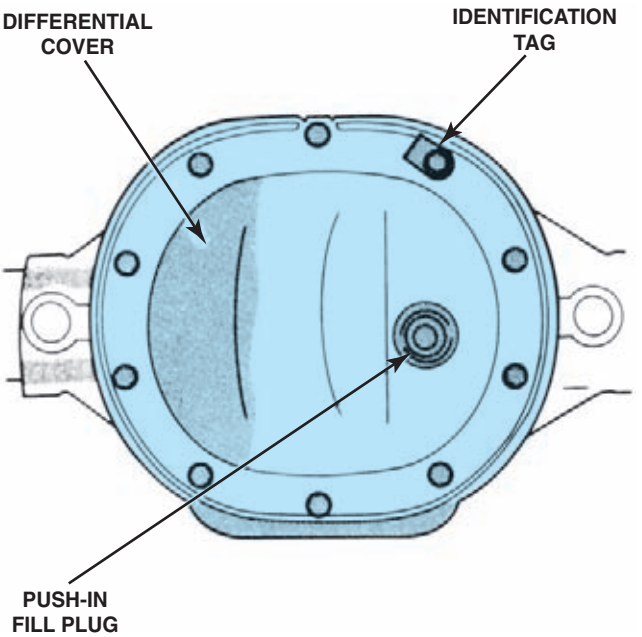


FIGURE 12-1 The oil level/fill plug is often in the rear cover; it can also be found in the carrier housing. This axle uses a rubber push-in plug; many use threaded plugs. *(Courtesy of DaimlerChrysler Corporation)*

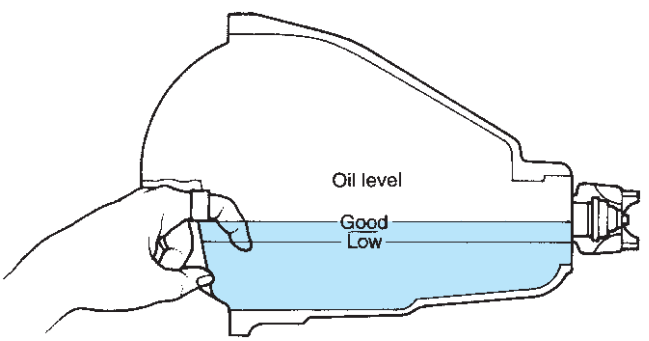


FIGURE 12-2 The oil level is usually even with the bottom of the fill opening; if necessary, your finger can be used as a dipstick to determine the level.

REAL WORLD FIX

A 1994 Dodge Caravan 4×4 (100,000 mil) had a leak in the rear drive axle, pinion shaft area. The seal was replaced using OEM parts, but the vehicle came back with a seal leak.

On the advice of other technicians, the fluid level was dropped 1 in. below the fill hole, and this stopped the leak. In a case like this, the technician should consult service information. Adjusting a fluid level to below the proper fill level should only be done with the owner's approval.

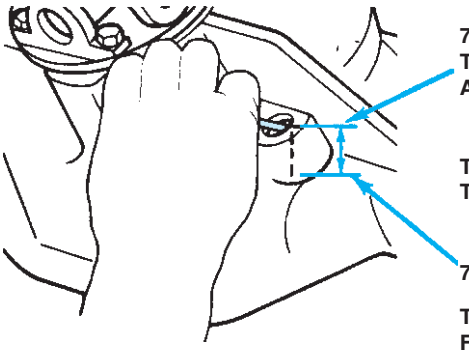


FIGURE 12-3 On this axle, the oil level should be 1 1/4 in. below the fill opening; a shop-made tool can be made to check it. *(Courtesy of Ford Motor Company)*

REAL WORLD FIX

A 2001 Honda CRV (130,000 mil) has an objectionable noise while turning. An inspection of the suspension, axles, driveshafts, and transmission show no problem. The gear oil levels were correct. On a road test, the noise seemed to be coming from the rear so the rear driveshaft was removed, and the noise was gone.

The fluid was drained from the rear drive axle and replaced using the recommended oil, and this almost cured the noise problem. A second gear oil change was done, and this fixed this noise problem.

TECH TIP

A high fluid level can flood the axle seals and can cause gear oil to leak into the brake drums. If the fluid level is too low, gear and bearing wear and overheating will occur.

TECH TIP

While checking gear oil level, be sure to note its condition. Gear oil normally has a mildly unpleasant smell because of the additive's sulfur compounds. Its color should be the same as that of new oil. Metal particles in the oil indicate internal problems.

REAL WORLD FIX

A 1997 Ford F150 (46,000 mil) had a binding condition in the rear end when starting off and making either a right or left turn. It had a stick/slip feeling.

The rear axle fluid was drained and replaced.This fixed the problem. It is assumed that the proper limited slip lubricant was used.

REAL WORLD FIX

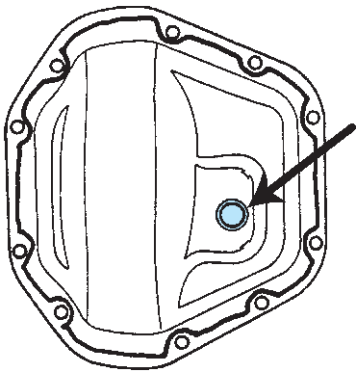
A 1997 5.9 L Dodge extended cab 4×4 had a vibration that felt like a clutch chatter that happened mostly on turns.The vehicle had an antispin rear axle.

A friction modifier additive was added to the rear axle, and the chatter was eliminated.

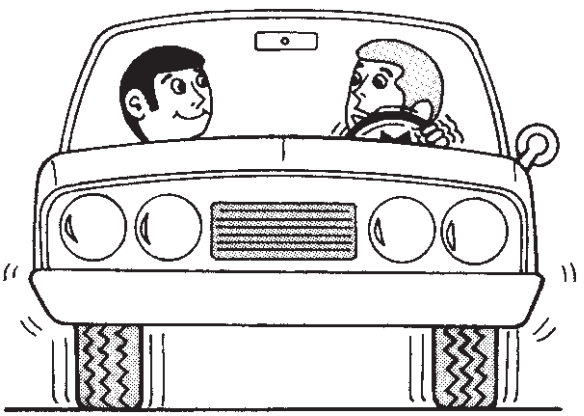
PROBLEM DIAGNOSIS

Most drive axle problems are related to noise, vibration, leaks, and failure to transmit power. One of the problems that a technician faces when diagnosing complaints of noise and vibration is isolating them to the drive axle or other driveline component. This can be done by conducting a road test and several in-shop tests. Leaks and no-drive problems can be diagnosed in the shop (Figure 12-4).

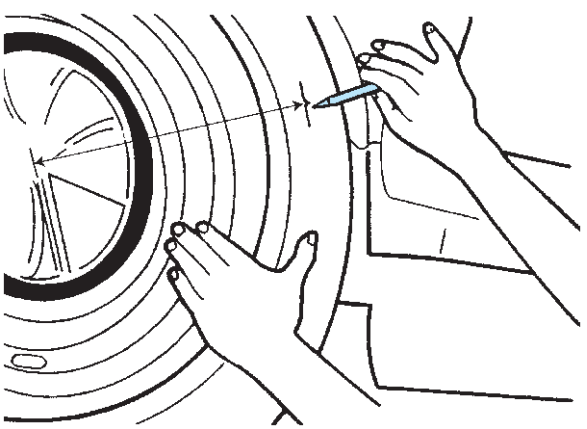
Problem diagnosis normally begins with the customer's complaint, which should include an exacting description of the type of noise or vibration and when it occurs. This is followed up by a road test over various types of road surfaces



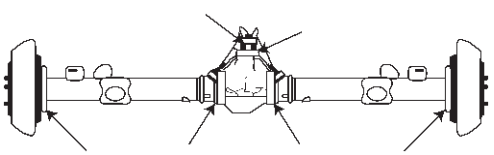
(a) Check Fluid Level



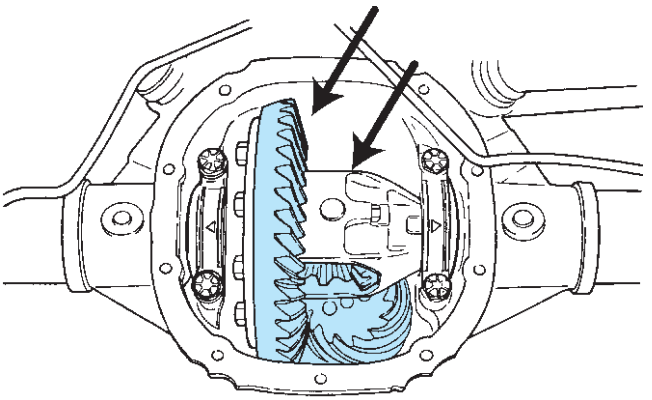
(b) Road Test



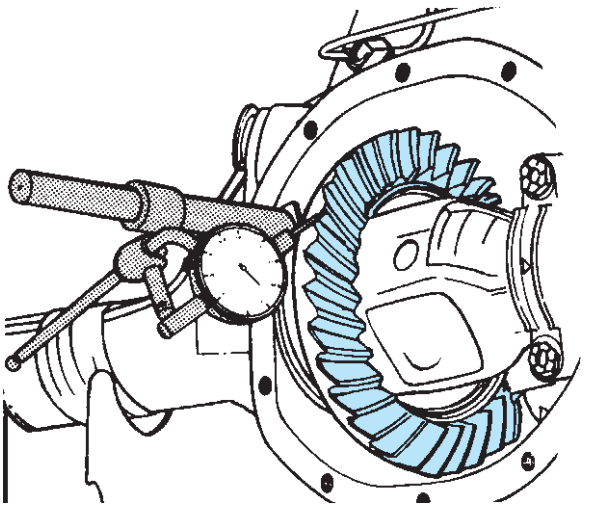
(c) Check Total Lash



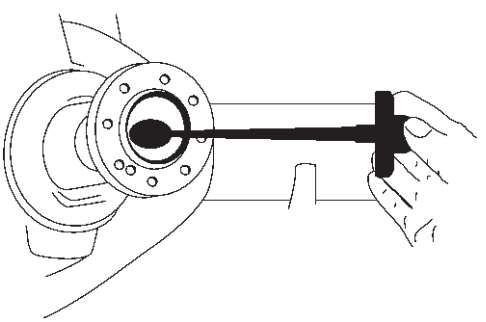
(d) Check Bearings



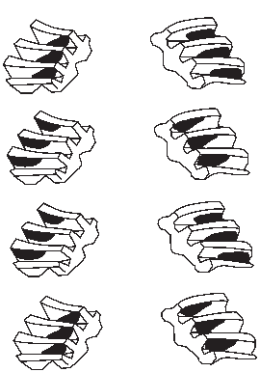
(e) Remove Cover and Inspect Gears



(f) Check Backlash



(g) Check Bearing Preload



(h) Check Contact Pattern

FIGURE 12-4 Drive axle problem diagnosis usually begins with a check of the gear oil level and a road test. Depending on the nature of the problem, it can include a check of the total lash in the axle, checks of the bearings and gears, and adjustments.

through the speeds where the complaint occurs. 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

If vibrations are the problem, the technician should note where the vibration is most noticeable—in the seat, steering wheel, instrument panel, floor pan, or hood and front fenders. Rear axle problems show up mostly in the seat or floor pan.

It should be remembered that some sounds will telegraph and appear to come from locations other than the real source of the problem. Sounds in the driveshaft, exhaust system, and body floor pan can do this, making locating the problem source more difficult. Remember the following when diagnosing sound and vibration problems:

- Tire noise changes with road surfaces and is speed sensitive. It is not affected by torque.
- Drivetrain noise and vibrations are usually torque sensitive and will often change relative to speed or driving conditions.
- Wheel bearing noise and vibration are load sensitive and will often change due to weight transfer as a vehicle turns a corner.
- Driveshaft vibrations occur relative to engine speed in high gear (1:1 ratio), whereas axle vibrations are slower because of the gear ratio in the drive axle.

REAL WORLD FIX

A 1993 Jeep Wrangler (100,000 mil) felt like the brakes were applied when operated in either 4-High or 4-Low. 2WD operation was normal, but it would not go faster than 10 mph in 4-High. Removal of the rear driveshaft allowed normal operation from the front drive axle. All four tires were the same diameter, and a check showed a 4.10:1 ratio in the front axle and a 4.11 ratio in the rear.

A more careful inspection revealed a 3.73 ratio in the rear axle even though it had a tag showing 4.11. The technician had found “41” and “11” on the rear ring gear that he thought meant 4.11.This marking indicates a 41-tooth ring and 11-tooth pinion; “41” divided by “11” equals 3.73. Changing the rear gear set fixed this problem.

TECH TIP

Certain drive axles are noisy because of less than perfect machining. The noise type is often a whine that occurs during light throttle, medium speed, and deceleration. Although it is annoying, if the noise does not occur under heavy loads or does not increase with additional mileage, it is not an indication of failure.

REAL WORLD FIX

A 1988 Nissan Pathfinder came in for major service, and the transmission and drive axle were drained and refilled with new fluids.The tires were rotated, and the rear brake pads and rotors were replaced at the same time.The vehicle worked fine during the road test, but two days later, it returned with a shudder from the rear wheels. In an attempt to cure this problem, the tires were replaced to their original position and the rotors were replaced with new OEM rotors, but this did not help.

It was determined that the rear axle had a limited slip differential. A limited slip additive was put into the differential, and this cured the problem.

REAL WORLD FIX

A 1995 Ford Thunderbird (170,000 mil) came in with a complaint that something was loose in the rear end. The vechicle would pull left on acceleration and pull right on deceleration during a test drive. An inspection on the rack revealed no suspension or drive axle problems.

The technician was advised to carefully check the wheel bearings on this rear independent suspension vehicle, and the right rear tire was found to have 1/8 in. of side play. Tightening the wheel bearing fixed this problem.

REAL WORLD FIX

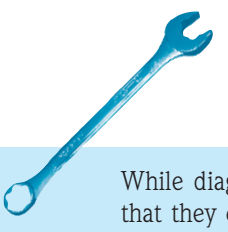
A 2000 BMW 740i (90,000 mil) was towed in and will not move in any gear. This was confirmed on the hoist by putting the vehicle in gear. The driveshaft would turn, but the wheels were not driven. With the vehicle back on the ground, it drove normally.

The technician was told that the drive axle output flanges are held in place by circlip that can let the shaft pop out. Replacement of the circlips and shaft seals fixed this problem.

Noise

Drive axle noise problems normally fall into one of these categories:

- **Gear noise:** howling or whining; often is torque sensitive but can be continuous.
- **Bearing noise:** can be a high-pitched, whistlelike sound but 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.
- **Clunk:** heavy metallic slapping noise during reversal of power flow or engagement of power from neutral. It is caused by excessive slack or lash in the drivetrain and can be felt in the drive axle.
- **Chuckle:** a rattling noise, similar to something against spinning bicycle spokes, during deceleration below 40 mph (64 kph). It is often caused by excessive clearance in the differential.
- **Chatter on corners:** a vibration or noise as the vehicle turns a corner, especially after prolonged straight driving. Often called a *chuckle,* commonly caused by a stick/slip condition at the clutch plates of a limited slip differential.



TECH TIP

While diagnosing noise problems, remember that they can come from the exhaust system (both normal air-transmitted noises and noises from metal-to-metal contact between the exhaust system and the vehicle body or frame), tires, and wind. Drivetrain noises can usually be heard while the vehicle is operated and being supported on a hoist or jack stands. Vehicle loads can be simulated by applying the brake for short periods of time.

TECH TIP

When changing the lubricant in a limited slip differential to cure a chatter problem, drive the vehicle through 10 to 12 figure-8 turns. This should work the new lubricant between the clutch plates.

TECH TIP

A diagnostic tool, Chassis Ear, consists of a headset and six sensors that can be attached to locations under the vehicle. The vehicle can be driven on a road test while the technician listens to six different locations underneath. This should help locate the noise source (Figure 12-5).

While diagnosing noise problems, a technician may use a chart like the one in Figure 12-6 as a guide to help locate the source of the problem. A complete road test and shop tests must also be performed to confirm that the problem is in the drive axle.

FIGURE 12-5 A Chassis Ear has a microphone attached to each of the six clamps that are connected to various locations under the vehicle. The technician makes a road test while wearing the headset, and turns the selector switch to locate the source of an under-car noise. *(Courtesy of Steelman)*

NOISE CONDITION	PROBABLE CAUSE
In all driving conditions	Road and tires, front wheel bearings, incorrect driveline angles
Changes with road surface	Road and tires
Louder on turns	Differential gears, axle bearings
Howl in one or more driving modes	Ring and pinion gears: adjustment or wear
Clunk on speed change or direction of power flow	Worn differential
Continuous low pitched whir	Worn U-joints
Whir while decelerating or accelerating	Worn pinion bearings
Low pitch rumble, over 20 mph	Worn carrier bearings
Chatter on corners	Wrong gear oil, worn limited slip clutches
While vehicle is stationary and moving	Engine, transmission
Vibration	Tire runout or balance, driveshaft problem, bent axle shaft

FIGURE 12-6 A technician will use a chart like this to help locate the cause of a drive axle problem.

REAL WORLD FIX

A 1992 Ford F350 4×4 (385,000 km) had a bucking condition under acceleration.The condition increased under load but was not speed related. It occurred to a lesser degree during deceleration.The driveline and springs were inspected, but no problems were found. A broken transmission mount was replaced, but this did not help.The shock absorbers were replaced. U-joints were checked for binding and angles; these were okay. The rear driveshaft was removed, and the problem went away when the vehicle was driven using only the front drive axle.

The rear axle cover was removed, and inspection revealed a cracked differential case. There was evidence that the case spread and contacted the drive pinion under load. Differential replacement fixed this problem.

REAL WORLD FIX

The 1995 Ford Ranger pickup (85,000 mil) came in with a fluid leak at the axles and a rubbing sound when making right turns. The axle seals were replaced. The technician found scoring in the bearing surface of the right axle so the right-side axle and bearing were replaced. The noise was still there on a road test, so the right axle was removed, and the bearing replaced using a repair type bearing, but this did not help.

The technician looked deeper in the axle assembly and found that the right-side carrier bearing was pitted. Replacement of the carrier bearings fixed this noise problem.

REAL WORLD FIX

A 2000 Honda CRV (89,000 mil) with AWD came in with a complaint of a high-pitched, growling sound, similar to a wheel bearing noise, that occurs only on sharp turns. The technician replaced the right rear wheel bearing, but this did not help. A listening device was not available to help narrow down the noise source. The technician asked for advice.

Following advice, the technician drained and replaced the rear drive axle oil, and this fixed the problem.

Drive Axle and Differential Total Backlash

A drivetrain clunk during a power change can be caused by too much internal **backlash**.

To check total drive axle backlash (Figure 12-7):

1. Raise and securely support the vehicle on a hoist or jack stands. You need access to the drive axle and the wheels must be free to turn.
2. Lock the driveshaft and drive pinion companion flange by clamping a bar to the companion flange and the body or rear suspension.
3. Block the left wheel so that it cannot turn.
4. Turn the right wheel slowly in one direction until it stops, loading all of the lash to one side. Using chalk,

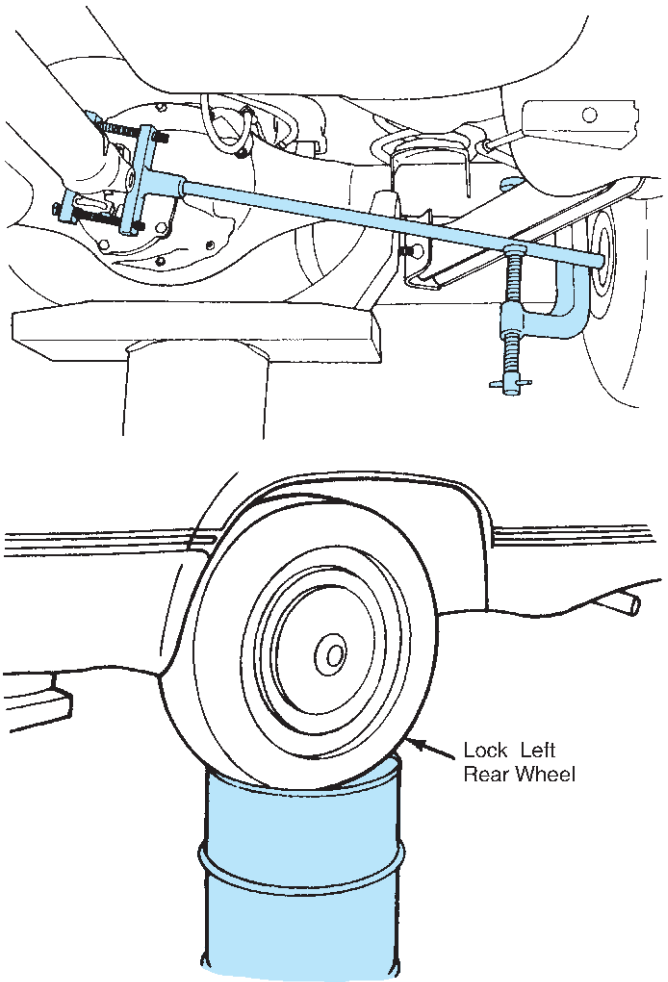


FIGURE 12-7 A drive axle can be checked for excessive play in the differential by blocking one drive wheel and the driveshaft (a) and then measuring the distance that the free tire rotates (12 in. out from the tire center) using a piece of chalk (b).The chalk mark should be 1 in. or shorter. *(Courtesy of Ford Motor Company)*

place a mark on the side of the tire 12 in. (305 mm) from the center of the wheel.

5. Hold the chalk steady and rotate the tire in the opposite direction until it stops.
6. Measure the length of the chalk mark; this is the amount of backlash in the drive axle. More than 1 in. (25.4 mm) of lash is excessive and indicates that something in the axle is worn. This is usually a differential problem. If the lash is less than 1 in., the clunk is being caused by another part in the drivetrain.

Bearing Noise Check

The road test may indicate faulty drive pinion or axle bearings. During part of this check, you will be working around a spinning tire and driveshaft. Make sure that you have no loose clothing, hair, or other body parts that could become entangled.

To check drive pinion and axle bearings:

1. Raise and support the vehicle securely on a hoist or jack stands so that the wheels are free to turn. Release the parking brake.
2. Grip each wheel and attempt to move it up and down and in and out.
3. If axle shaft end play seems excessive, place index marks on the tire and the brake drum and remove them. Mount a dial indicator on the axle flange, position the stylus on the brake assembly, and move the axle shaft in and out

TECH TIP

A bearing-retained axle should have no movement in either direction. Any free play indicates a faulty bearing.

TECH TIP

A C-lock-retained axle should allow only a barely perceptible vertical motion and between 0.005 and 0.030 in. (0.13 and 0.7 mm) of in-and-out motion, or axle shaft end play. Excessive motion indicates faulty axle bearings or too thin a C-lock for the axle groove.

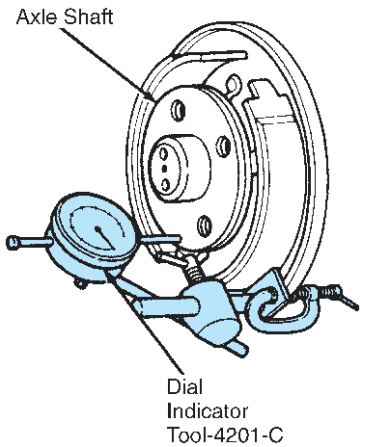


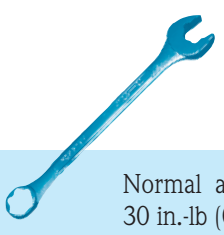
FIGURE 12-8 Axle shaft end play can be checked by mounting a dial indicator onto the brake assembly or axle housing with the indicator stylus on the axle.The indicator will measure the end play as the axle is moved in and out. *(Courtesy of Ford Motor Company)*

TECH TIP

You should feel smooth, irregular motions from the inside of the drive axle. A bad bearing will usually cause a harsh, rough feel and normally will make a rough growling noise.

while you read the amount of end play on the dial indicator (Figure 12-8).

4. With the tire and wheel in place, rotate the tire; it should rotate smoothly and quietly.
5. Start the engine and drive the wheels at idle speed in high gear. Carefully place your fingers lightly against the axle housing close to the brake assembly and under the drive pinion shaft close to the companion flange (Figure 12-9).



TECH TIP

Normal axle preload should be about 8 to 30 in.-lb (0.9 to 3.4 N-m) of torque. Brake drag can cause much higher readings. A low reading or any free play of the shaft indicates faulty drive pinion bearings.

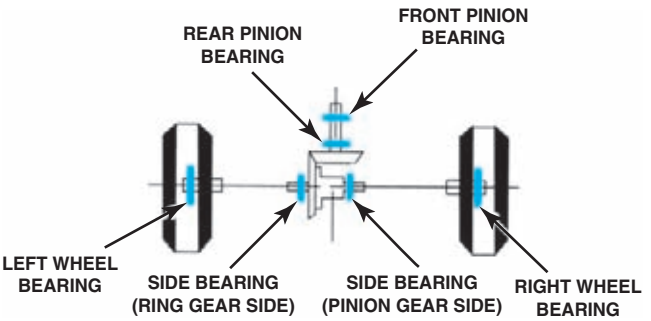


FIGURE 12-9 A faulty rear axle bearing can usually be located by listening and feeling next to the bearing as the vehicle is operated on a hoist or stands. Be careful when doing this because of the rotating shafts and wheels. *(Courtesy of DaimlerChrysler Corporation)*

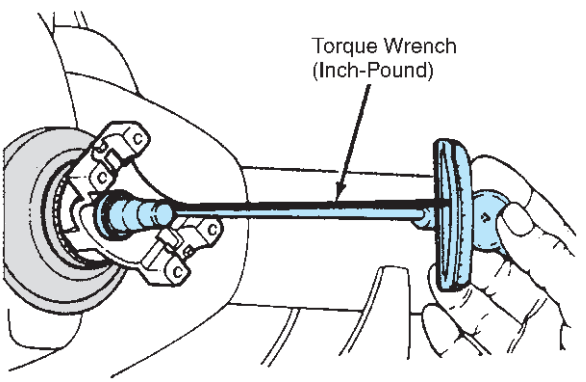


FIGURE 12-10 Drive pinion and axle preload is measured by disconnecting the driveshaft and using a torque wrench to measure the torque required to rotate the pinion shaft. *(Courtesy of Ford Motor Company)*

6. If roughness is noticed at the drive pinion, stop the engine and disconnect the driveshaft from the companion flange. Now check for end play and side play of the drive pinion shaft; there should be none. If there is no play, use a low-reading in.-lb torque wrench and measure the torque required to turn the pinion shaft (Figure 12-10).

REAL WORLD FIX

A 1995 Mustang (46,000 mil) had a rhythmic tirelike noise coming from the left rear that was only heard on smooth roads. All four tires were replaced with no change. A leaking left rear axle seal was replaced along with the bearing, but this did not help either.

Checking inside the axle housing showed galling of the axle gear and differential case. Replacement of these differential parts repaired this problem.

REAL WORLD FIX

A 2003 Buick Rendezvous (61,000 mil) came in with loud drivetrain howl and vibration that varied with speed and load. Running the vehicle on a hoist allowed the technician to narrow the problem down to the rear drive axle. The rear gear oil was clean and at the proper level.

A close inspection of the drive axle revealed rough pinion shaft bearings, possibly from too tight of an adjustment or poor lubrication. The technician was unable to get replacement bearings or a rebuilt assembly so a new axle was installed. With a cost of over $3,000, this fixed this noise problem.

REAL WORLD FIX

The rear wheel bearings on a 1992 Subaru SVX (113,000 mil) were replaced a year ago because they were very noisy. The vehicle returned after 19,000 miles with the same noise; the wheel bearings failed. The technician was concerned about the early failure.

The technician discovered that the new OEM bearings were filled with a Vaseline-like grease for shipping. This grease must be cleaned out and the bearing packed with the proper grease. Proper bearing service procedures must be followed to ensure long bearing life.

Vibration Check

The vibration checks for a drive pinion shaft and companion flange are a continuation of the driveshaft checks described in Chapter 10 on page 262. The companion flange runout is checked by placing the dial indicator stylus on the companion flange (Figure 12-11).

TECH TIP

More than 0.005 in. (0.1 mm) of runout indicates a faulty companion flange or bent drive pinion shaft.

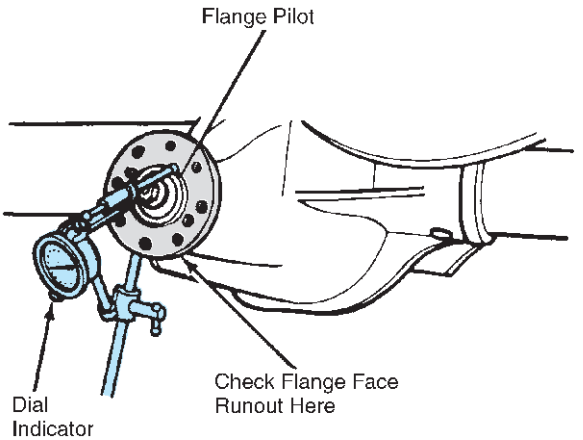


FIGURE 12-11 Runout of the companion flange is measured with a dial indicator, as shown here. *(Courtesy of Ford Motor Company)*

A bent axle shaft will cause runout at the wheel flange, which, in turn, produces wheel and tire runout.

To check wheel mounting flange runout:

1. Raise and securely support the vehicle on a hoist or jack stands.
2. Rotate the wheel while you observe the tire tread to determine if there is any lateral (side-to-side) or radial (vertical) runout.

TECH TIP

If there is more than 0.060 in. (1.5 mm) of runout in either direction, proceed to step 3.

3. Place an index mark on the wheel stud closest to the valve stem, and remove the tire and wheel. Place an index mark on the brake drum next to the marked stud and remove the brake drum.
4. Check flange lateral runout by mounting a dial indicator onto the axle housing or brake assembly and positioning the indicator stylus against the axle flange just outward of the wheel studs (Figure 12-12). The stylus should be positioned parallel to the axle.
5. Rotate the axle and note the dial indicator movement. This is the amount of axle lateral flange runout.
6. Check flange radial runout by moving the dial indicator 90° so that the stylus is parallel to the flange (Figure 12-13). The wheel studs usually interfere with this mounting, so an alternative is to check the runout of the wheel studs. To do this, position the stylus on

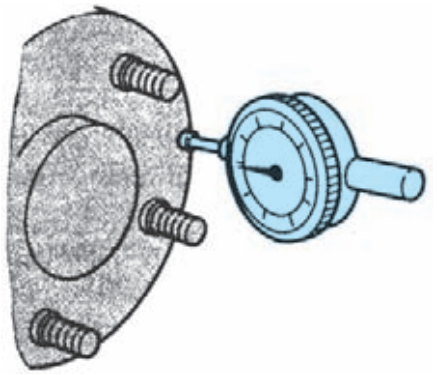


FIGURE 12-12 This dial indicator is set up to measure axle flange lateral runout, which can cause the wheel to wobble. *(Courtesy of Ford Motor Company)*

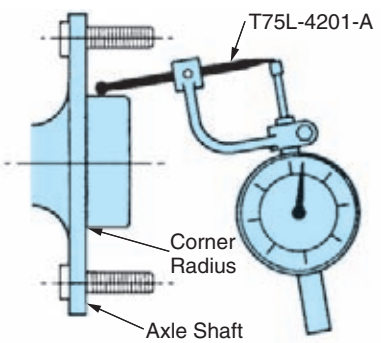


FIGURE 12-13 This dial indicator is set up to measure radial runout of the drum and wheel pilot, which can cause the wheel to run off-center. Note the wiggle bar (T75L-4201-A). *(Courtesy of Ford Motor Company)*

TECH TIP

A runout of 0.005 in. (0.1 mm) or less is acceptable; if the runout is more than this, the axle should be replaced.

the side of a wheel stud and rotate the axle so that the stylus is at the highest point. This is where the indicator needle reverses direction. Rotate the dial so that the zero aligns with the needle. Carefully pull the stylus back, rotate the axle to position a second stud under the stylus, and read the amount of runout between these two studs. Repeat this procedure on each of the studs and determine the difference between the readings at the lowest and the highest studs.

A vibration can also be caused by damage inside the axle assembly. This can be confirmed by operating the axle with the tires, wheels, and brake drums removed. Vibrating

TECH TIP

A runout of 0.030 in. (0.76 mm) or less is acceptable; if the runout is more than this, the axle should be replaced.

motion of the axle housing would confirm the source of the vibration.

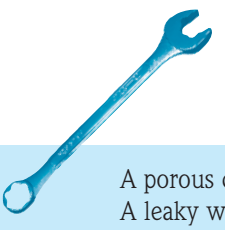
Leaks

Most gear oil leaks will be found at the axle shaft seals, drive pinion seals, rear cover, or carrier-to-housing gasket. The repairs for these are described in the service sections that follow. Occasionally, a leak is encountered in a porous casting or a faulty weld in the housing (Figure 12-14).

Limited Slip Differential Check. This check is used to confirm the differential's ability to drive both wheels (if a limited slip differential seems not to deliver power to both wheels while one has poor traction).

To check a limited slip differential:

1. Attach an adapter to one of the rear hubs (Figure 12-15). Some adapters require removal of the wheel and tire.
2. Either raise the wheel with the adapter off the floor, leave the other wheel on the floor and place the transmission

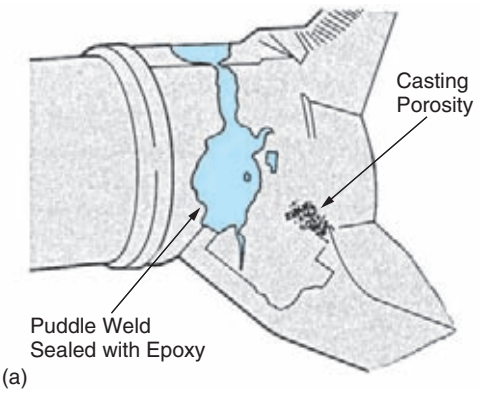


TECH TIP

A porous casting can be repaired using epoxy. A leaky weld is a sign of a potentially dangerous stress crack or fracture, and the housing should be replaced.

TECH TIP

If no specifications are available, some technicians will use a rule of thumb of 35 to 40 ft-lb (48 to 54 N-m) minimum. Readings lower than this indicate a badly worn clutch pack in the differential.



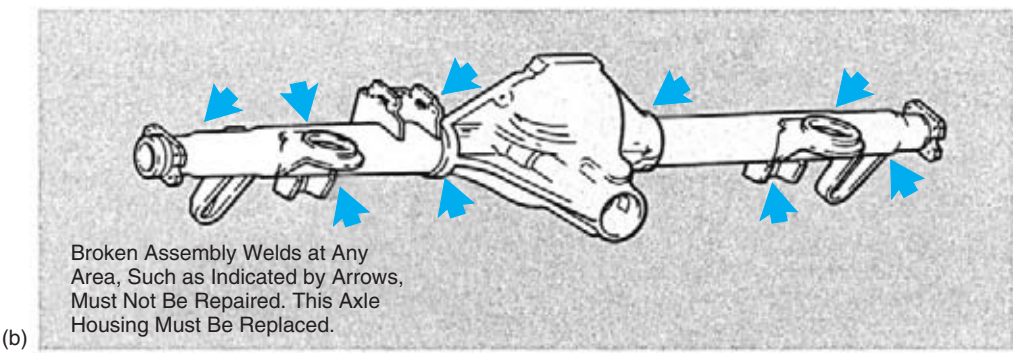


FIGURE 12-14 Some axle oil leaks can be caused by a porous casting or cracked welds. A casting problem can be repaired using epoxy sealant (a); a cracked weld requires housing replacement (b). *(Courtesy of Ford Motor Company)*

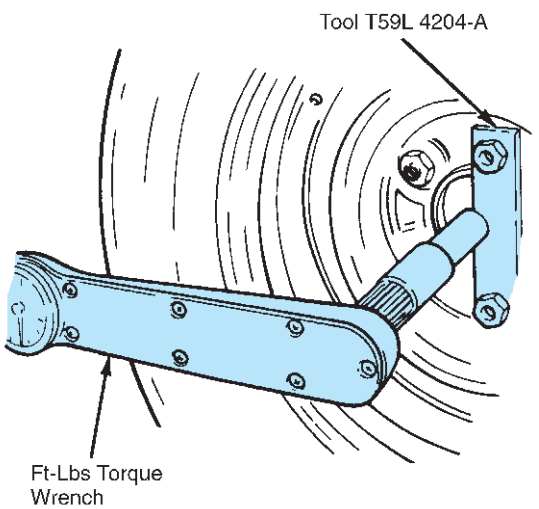


FIGURE 12-15 A special tool has been attached to two wheel studs, allowing a torque wrench to be used to measure the torque required to turn this wheel. The opposite wheel is on the ground with the transmission in neutral. A low reading indicates limited slip differential wear. *(Courtesy of Ford Motor Company)*

in neutral, or raise both wheels off the floor and place the transmission in park or in gear.

3. Connect a torque wrench to the adapter and measure the torque required to turn the wheel. Disregard the breakaway torque needed to get the wheel turning.
4. Compare your reading with the manufacturer's specifications.

REAL WORLD PROBLEM

Imagine that you are working in a general automotive repair shop and these problems are brought to you.

Case 1

A 10-year-old RWD vehicle has a clunk noise when shifted from neutral to drive or reverse. This was confirmed on a road test. When the vehicle is raised on a hoist, you find that both U-joints are good, but with the driveshaft and the left rear wheel locked, there is 1 1/2 in. of lash at the right tire. What do you think is the problem with this vehicle? How would you confirm your diagnosis?

Case 2

A vibration begins at about 35 mph with the pickup's transmission in either high or second and continues up to 55 mph. It seems to be coming from the back of the pickup. What should you do next to locate its cause? What possible rear axle problems could cause it?

ON-VEHICLE SERVICE OPERATIONS

On-vehicle operations include axle shaft, axle bearing, axle seal, and drive pinion seal replacement. Removal and replacement of a removable carrier and overhaul of an integral carrier can also be done on-vehicle.

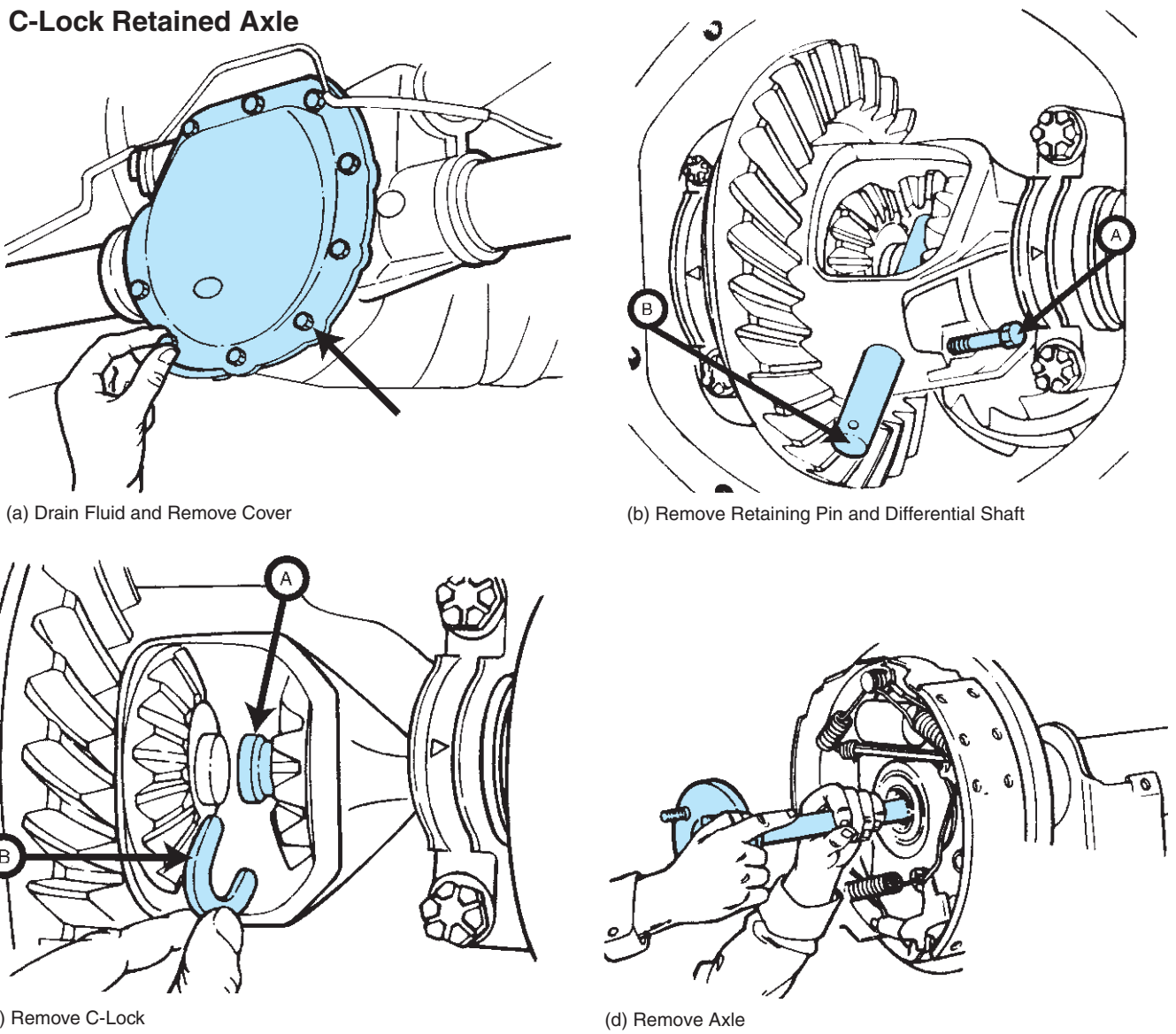
Passenger car and pickup axles are semi-floating and are retained in the housing by either a C-lock at the inner end of the axle or by the axle bearing retainer at the outer end. Axle service includes removing the axle for bearing or seal replacement and bent or broken axle replacement (Figures 12-16 and 12-17). Replacing damaged wheel studs can be done without removing the axle.

C-Lock Axle Shaft Removal and Replacement

Most modern integral carrier axle assemblies use a C-clip-type of axle shaft.

TECH TIP

The housing must have a removable cover to allow access to the C-lock.



(a) Drain Fluid and Remove Cover

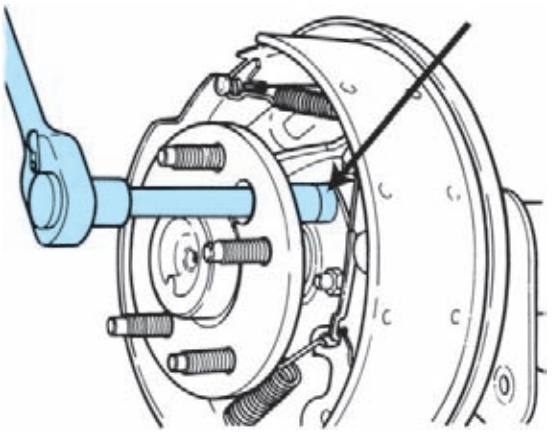
(b) Remove Retaining Pin and Differential Shaft

(c) Remove C-Lock

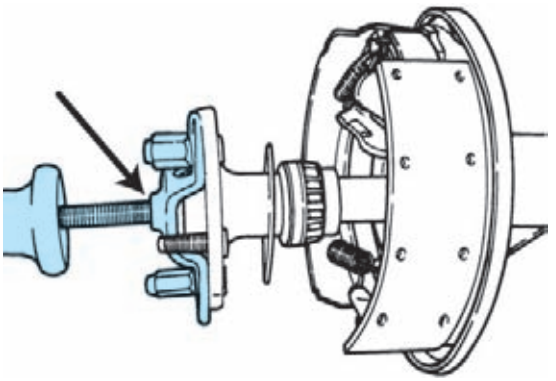
(d) Remove Axle

FIGURE 12-16 Procedure to remove a C-lock axle.

Bearing Retained Axle



(a) Remove Retainer Nuts/Bolts



(b) Attach Slide Hammer and Remove Axle

FIGURE 12-17 Procedure to remove a bearing retained axle.

To remove a C-lock axle:

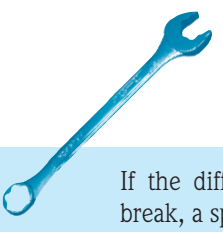
1. Raise and securely support the vehicle so that you have access to the axle housing.
2. Remove the tire and wheel and then the brake drum.
3. Place a drain pan under the axle housing to catch the gear oil. Remove the rear cover attaching bolts. Be sure to note the location of any special clips or tags for proper replacement.
4. Remove the differential shaft retaining pin (Figure 12-18).

TECH TIP

The differential shaft retaining pin is hardened and has a tendency to break.

TECH TIP

In some vehicles, the differential shaft retaining pin uses left-hand threads. Check the bolt head before trying to remove it.



TECH TIP

If the differential shaft retaining pin should break, a special tool is available that will force the pinion shaft out of the differential, shearing off the broken retaining pin (Figure 12-19). Some technicians remove a broken pin using carbide drill bits and left-hand easy-outs. Others use a reverse-direction drill and a reverse-spiral carbide drill bit.

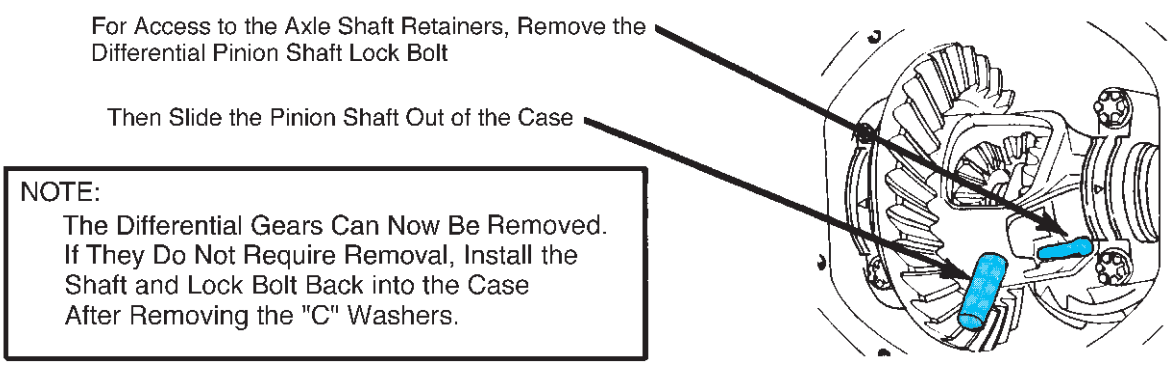
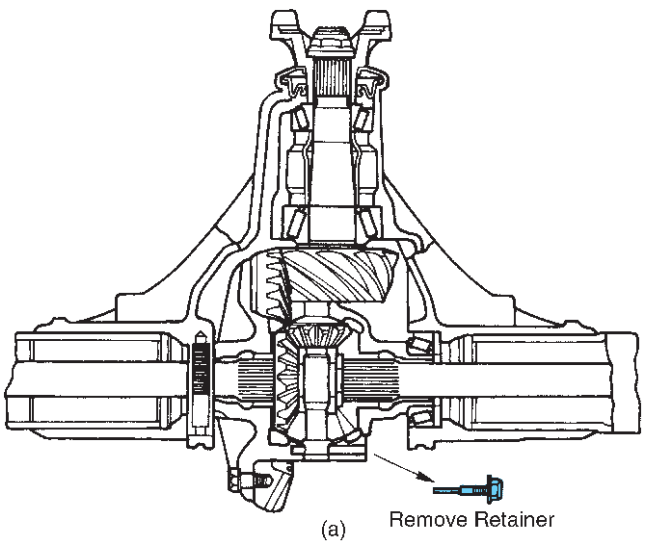


FIGURE 12-18 Removing the lock bolt allows removal of the differential pinion shaft. *(Courtesy of Ford Motor Company)*

FIGURE 12-19 In some differentials, the pinion shaft lock bolt tends to break during removal. This tool is used to force the differential pinion shaft out, shearing off a broken lock bolt without damaging the differential case. *(Courtesy of Borroughs)*



TECH TIP

Note that the differential pinions and thrust washers can rotate out of position while the pinion shaft is removed.

5. Remove the differential pinion shaft by rotating the differential one-half turn, tapping the pinion shaft inward an inch or so, rotating the differential back, inserting a punch into the retaining pin hole, and pulling the pinion shaft out of the differential (Figure 12-20).
6. Push the axle inward and remove the C-lock from its groove (Figure 12-21).
7. Pull the axle out of the housing, supporting it so that it does not drag across the seal.

TECH TIP

When the inner end strikes the carrier bearing, grip the axle flange so that you can lift the inner end to the center of the differential; push inward so that the axle splines will center the differential side gear (Figure 12-22).

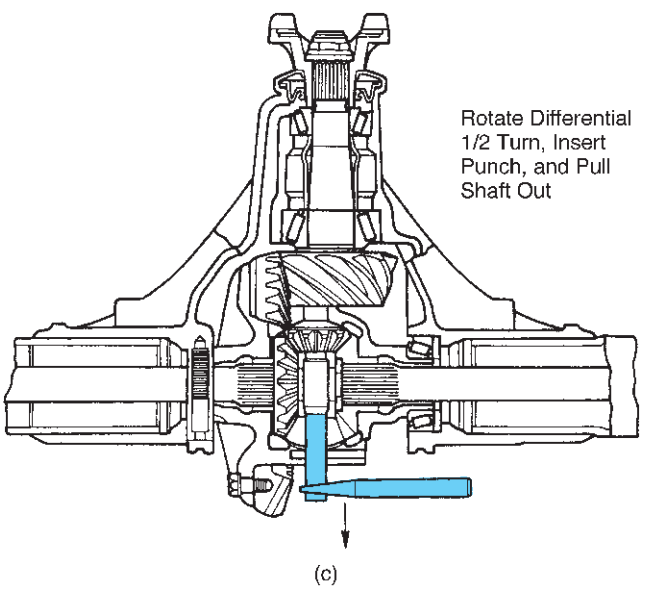


FIGURE 12-20 If the pinion shaft does not slide out easily (a), rotate the differential one-half turn, drive the pinion shaft inward enough to expose the lock pin hole (b), rotate the differential one-half turn, insert a punch into the lock pin hole, and pull the shaft out (c).

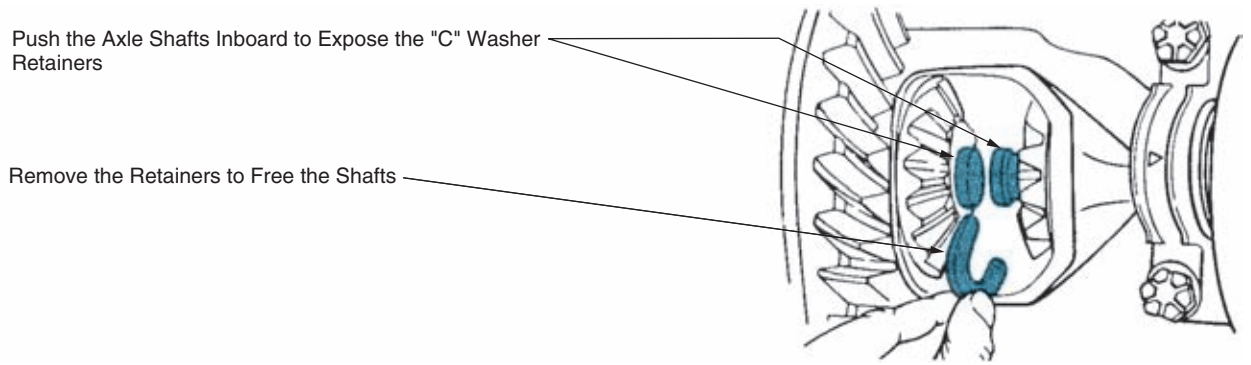
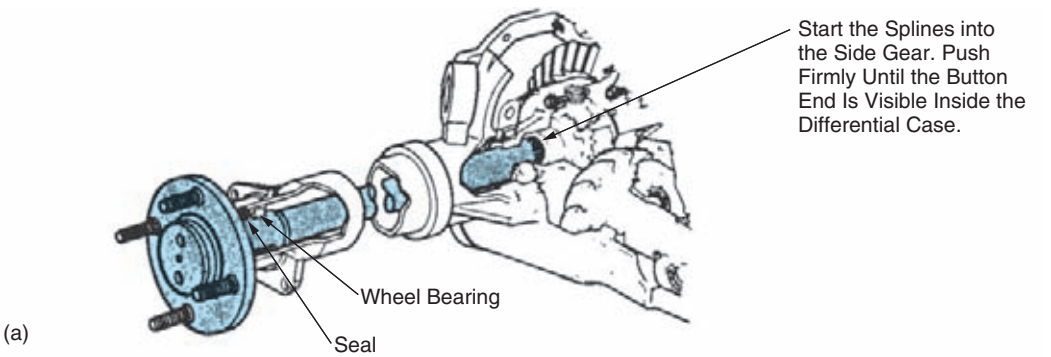


FIGURE 12-21 After the pinion shaft has been removed, the axle can be slid inward and the C-lock removed from its groove. *(Courtesy of Ford Motor Company)*



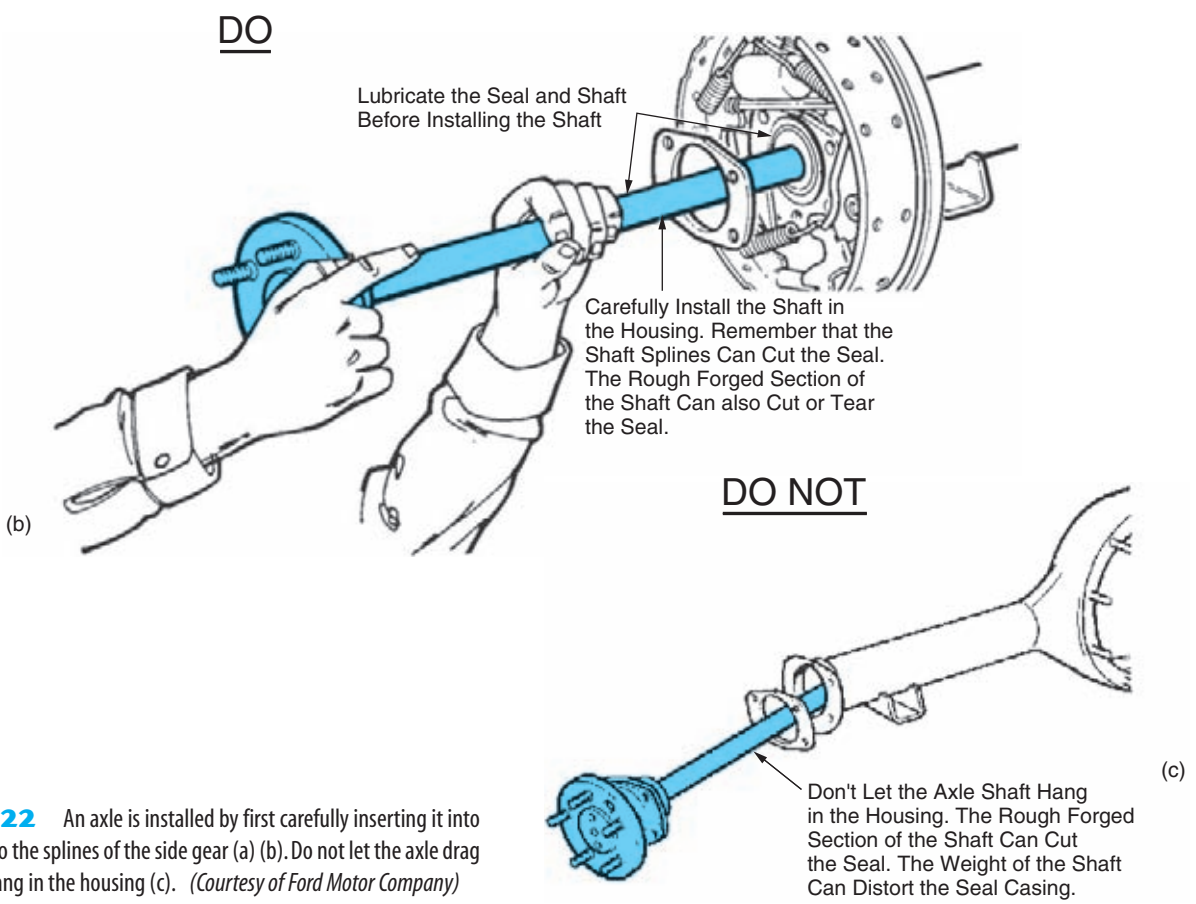


FIGURE 12-22 An axle is installed by first carefully inserting it into the housing and into the splines of the side gear (a) (b). Do not let the axle drag across the seal or hang in the housing (c). *(Courtesy of Ford Motor Company)*

TECH TIP

The axle shaft on larger pickups is heavy, long, and extremely difficult to keep level during installation. Some technicians are concerned that the inner end will push debris from the bottom of the axle tube into the differential. A length of 3-in. masking paper can be folded lengthwise and inserted into the tube. Now, the inner end of the axle can be slid along the paper path, and as the axle is almost in place, slide the paper out of the tube. Other technicians have made a long scraper using a large washer and small length of pipe; they use this scraper to pull debris out of the axle tube before axle installation.

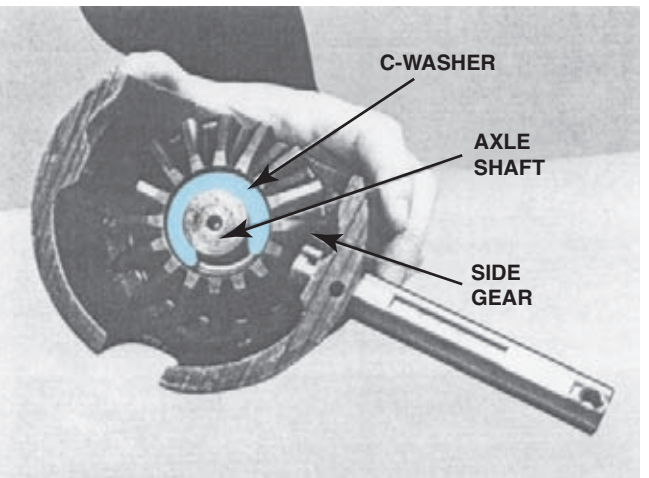


FIGURE 12-23 When the C-lock is in the axle groove and the axle is pulled back outward, the C-lock becomes locked in place in the side gear. *(Courtesy of Ford Motor Company)*

To replace a C-lock axle:

1. Oil the axle bearing in the housing and the seal area on the axle.
2. Insert the axle into the housing, supporting it so that it does not drag across the seal.
3. Place the C-lock into its groove in the axle and slide the axle outward so that the C-lock becomes captured in its recess in the side gear (Figure 12-23).
4. Slide the differential pinion shaft in place, making sure to align the hole for the retainer pin.
5. Replace the retainer pin and tighten threaded pins to the correct torque (Figure 12-24).
6. Test your installation by moving the axle in and out. It should have about 0.005 to 0.030 in. (0.12 to 0.76 mm) of end play.
7. On rear covers using gaskets, clean off the old gasket, install the cover using a new gasket, and tighten the bolts to the correct torque. On covers using formed-in-place gaskets, clean all of the old sealant and oil from the housing and cover surfaces. Run a bead of sealant on the housing surface circling each bolt hole (Figure 12-26). Replace the cover and tighten the bolts to the correct torque.
8. Fill the axle to the proper level with the correct lubricant.
9. Replace the brake drum and then the wheel and tire.

TECH TIP

Some manufacturers have C-locks of various thicknesses available to correct axle end play; others recommend adding a shim to correct excess end play (Figure 12-25).

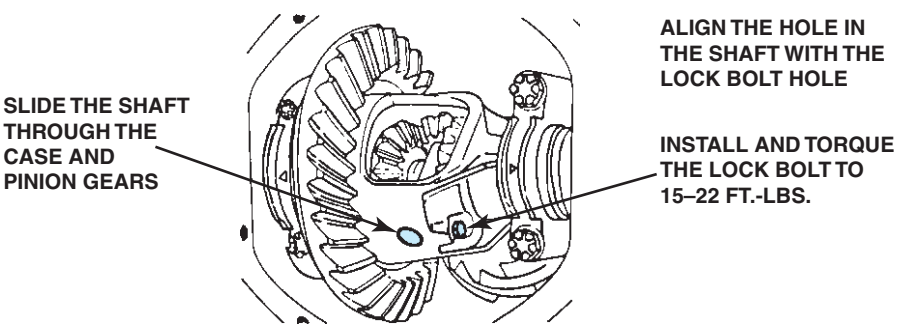


FIGURE 12-24 Installation of the differential pinion shaft locks the axle and C-lock in place. Be sure to tighten the lock pin to the correct torque. *(Courtesy of Ford Motor Company)*

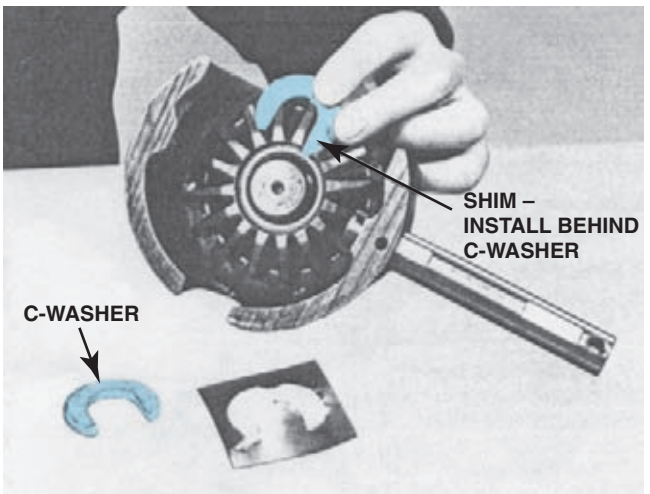


FIGURE 12-25 A shim has been cut and is being installed behind the C-lock to reduce the amount of axle end play. *(Courtesy of Ford Motor Company)*

Bearing-Retained Axle Shaft Removal and Replacement

A bearing-retained axle is used in most axle assemblies with a removable carrier; it is also used in some integral carrier axles.

To remove a bearing-retained axle:

1. Raise and support the vehicle securely on a hoist or jack stands.
2. Remove the tire and wheel. Remove the brake drum.
3. Remove the nuts that secure the axle bearing retainer to the axle housing (Figure 12-27).
4. Attach an adapter and slide hammer to the axle flange. Using the slide hammer, pull the axle and bearing loose from the housing (Figure 12-28).

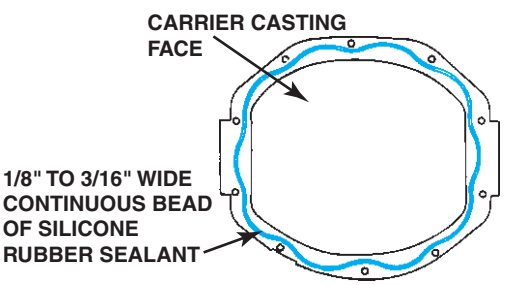
TECH TIP

Most axle flanges include a hole so that a socket and extension bar can be used to remove and replace the retainer bolts.

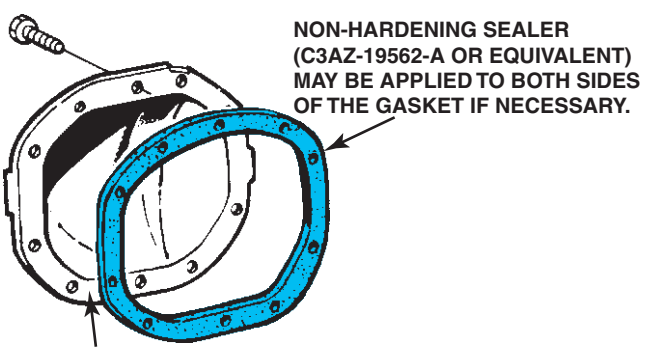
Pull the axle out of the housing, supporting it so that it does not drag on the seal.

To replace a bearing-retained axle:

1. Oil the seal area of the axle. On some axles the seal is inside the axle bearing and needs no oil.
2. Insert the axle into the housing, supporting it so that it does not drag across the seal. When the inner end strikes the carrier bearing, grip the axle flange so that you can lift the inner end to the center of the differential; push inward so the axle splines engage the differential side gear.

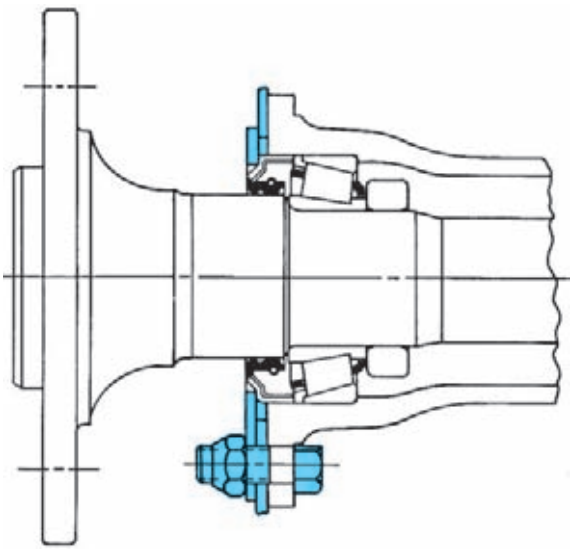


TYPICAL BEAD INSTALLATION. PARTS MUST BE ASSEMBLED WITHIN 15 MINUTES AFTER THE APPLICATION OF SEALANT. GASKET SURFACE OF HOUSING AND CARRIER MUST BE FREE OF OIL.



BE SURE THE MATING SURFACES ARE FREE OF NICKS, BUMPS OR CREASES. USE A TORQUE WRENCH TO BE SURE OF EVEN PRESSURE.

FIGURE 12-26 To seal the rear cover, axle housings use either a gasket or a formed-in-place gasket of sealant. *(Courtesy of Ford Motor Company)*



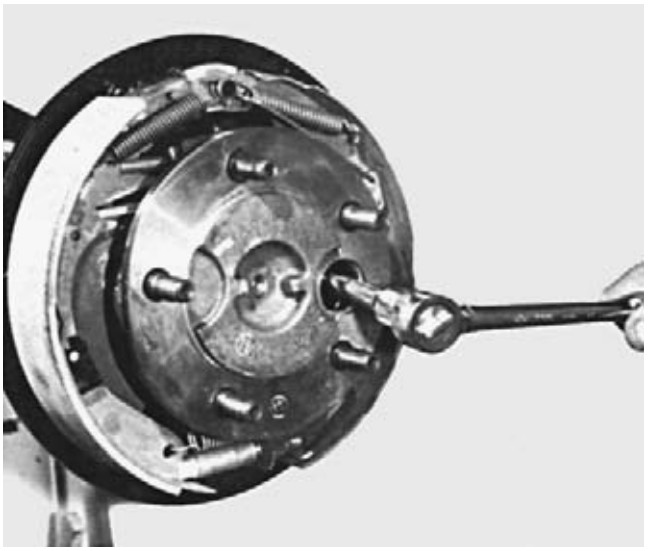


FIGURE 12-27 The bearing retainer bolts are being removed to allow removal of a bearing retained axle. The hole in the axle flange allows the use of a socket and extension. *(Courtesy of Dana Corporation)*

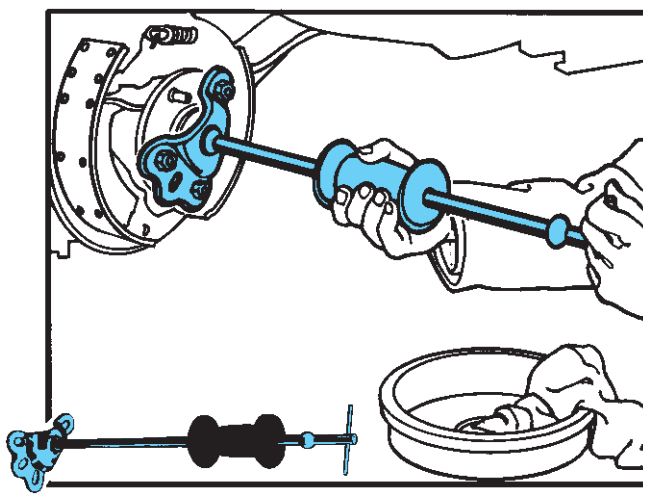


FIGURE 12-28 A slide hammer with an adapter for the wheel flange is used to pull a bearing retained axle from the housing. *(Courtesy of OTC Tools)*

3. Tap the outer end of the axle, if necessary, to move the axle bearing into its recess in the housing. As it enters, align the retainer with its bolts and install and tighten the nuts to pull the bearing and axle into place.
4. Tighten the retainer nuts to the correct torque (Figure 12-29).
5. Replace the brake drum and then the wheel and tire.

Full-Floating Axle Shaft Removal and Replacement

The full-floating axle is used in medium- and heavy-duty trucks and in many larger pickups and vans. Axles are removed to replace the shaft, gain access to the wheel bearings, allow removal of the hub and brake drum and the carrier.

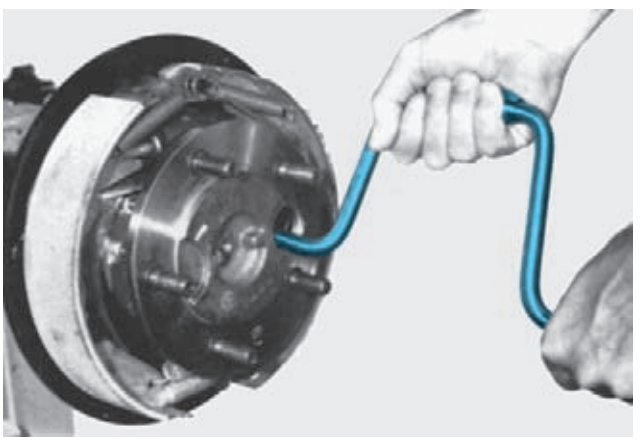


FIGURE 12-29 After the axle has been replaced, tighten the retainer nuts to the correct torque. *(Courtesy of Dana Corporation)*

To remove a full-floating axle shaft:

1. Remove the bolts that attach the axle shaft flange to the hub (Figure 12-30).
2. Using a soft hammer, strike the axle flange to break the gasket loose.
3. Slide the axle out of the housing.

To replace a full-floating axle shaft:

1. Thoroughly clean the hub and axle flange surface, and place a new gasket in position.
2. Slide the axle into the housing. When the inner end meets the carrier, grip the axle flange and lift the inner

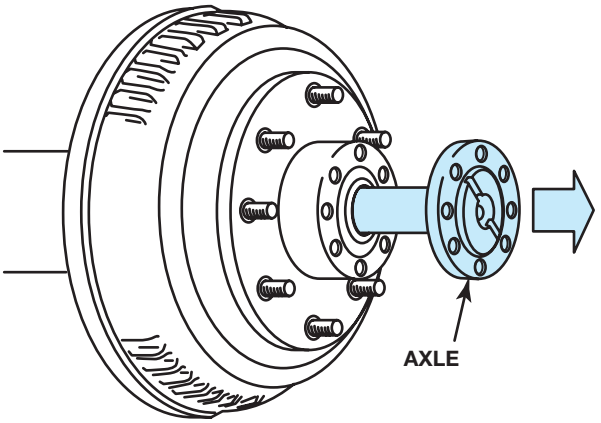


FIGURE 12-30 After removing the axle flange bolts, a full-floating axle can be slid out of the housing. This permits access to the axle, wheel bearings, and brakes.

TECH TIP

An offset bearing is available from aftermarket sources to run on an unworn portion of the shaft (Figure 12-31).

end as you push inward so the axle splines engage the differential side gear.

3. Replace the axle flange-to-hub retaining bolts and tighten them to the correct torque.

C-Lock Axle Bearing and Seal Removal and Replacement

The C-lock axle uses a roller bearing with a snug-fitting case and outer race in the axle housing. A smooth section of the axle shaft serves as the inner race for the bearing. When replacing a bearing or seal, the bearing race area of the axle should be checked for wear, roughness, and damage. If the bearing surface is damaged, the axle should be replaced.

The axle seal is located next to the bearing and seals against a smooth area of the axle shaft.

Both the bearing and the seal are removed from the housing using a slide hammer and special adapter (Figure 12-32). Pull the seal first and then, if desired, the bearing (Figure 12-33). After they are removed, the recesses where they fit should be checked for scratches or gouges that might let gear oil past the seal.

Another special tool is required to install the bearing. It should be slightly smaller than the diameter of the bearing and have a face that meets almost all of the face of the bearing so as

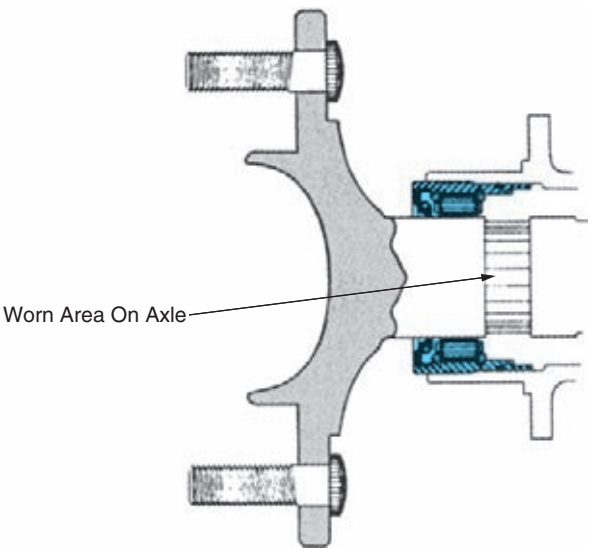


FIGURE 12-31 Axle bearing failure on a C-lock axle can ruin the axle. This bearing and seal assembly moves the bearing sideways, allowing an unworn portion of the axle to be used as the inner race. *(Courtesy of CR Services)*

TECH TIP

The axle seal surface can become worn and should be checked during seal replacement.

TECH TIP

If the new axle seal does not have a coating on its outer shell, it is recommended that the outer edge of the shell be coated with RTV or nonhardening gasket sealant.

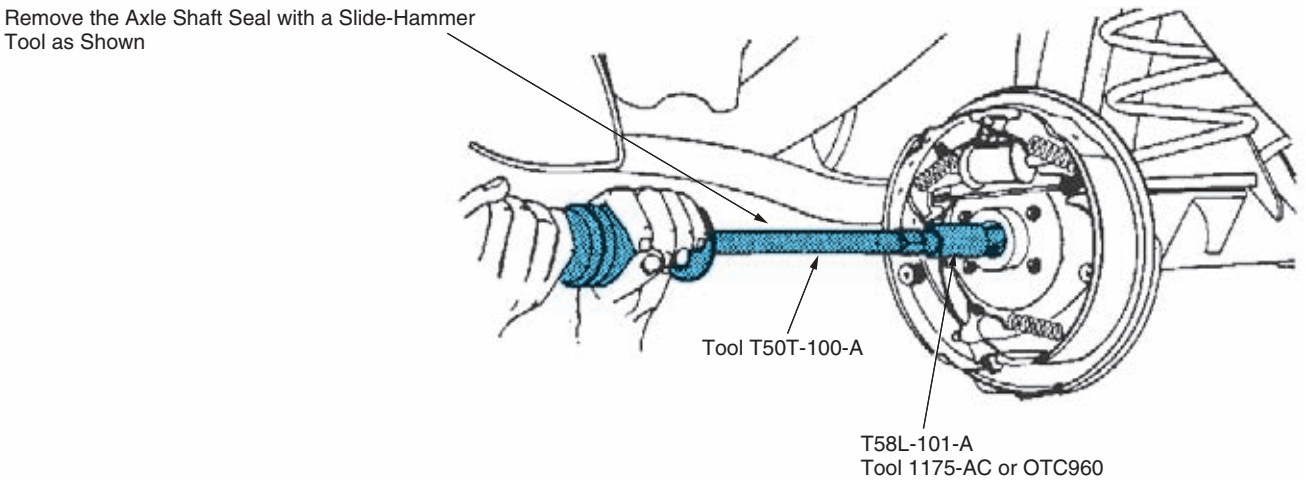


FIGURE 12-32 The bearing and seal are removed from the housing with a slide hammer and adapter. *(Courtesy of Ford Motor Company)*

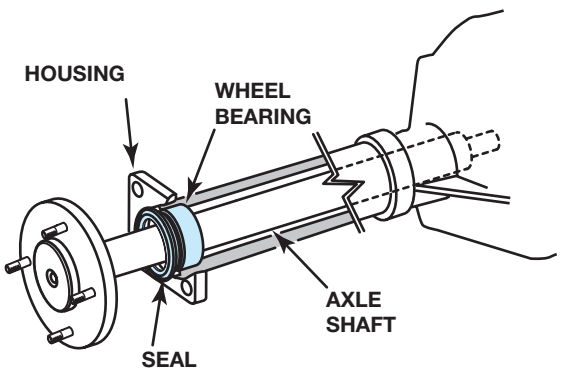


FIGURE 12-33 The axle seal is just inside the end of the housing and the bearing is inside it.

not to damage the bearing during installation (Figure 12-34). The new bearing is driven straight into the housing to the end of its recess. The same installation procedure and type of tool is used to install the new seal (Figure 12-35).

Bearing Retained Axle Bearing and Seal Removal and Replacement

The bearing retained axle bearing is press fit onto the axle shaft and should be removed carefully to prevent injury from possible bearing explosion. Most axle bearing removal tools enclose the bearing completely and thus will contain an exploding bearing.

On some axles, the seal is mounted alongside the bearing and is removed and replaced using the procedure described on page 349. Other axles use a seal that is part of the bearing.

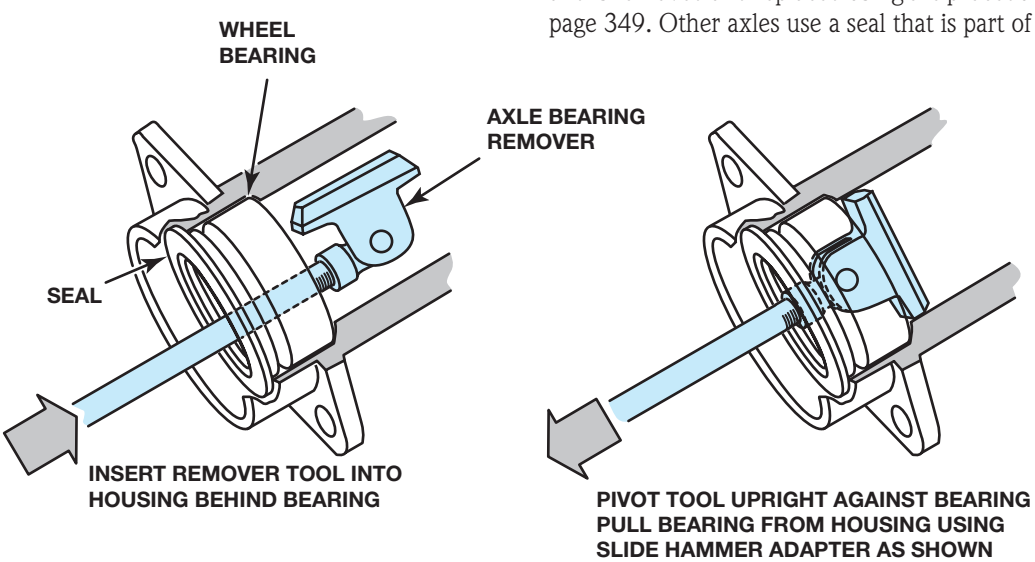


FIGURE 12-34 This axle bearing remover is attached to a slide hammer, and it is slid through the bearing and pivoted to catch the bearing and seal.

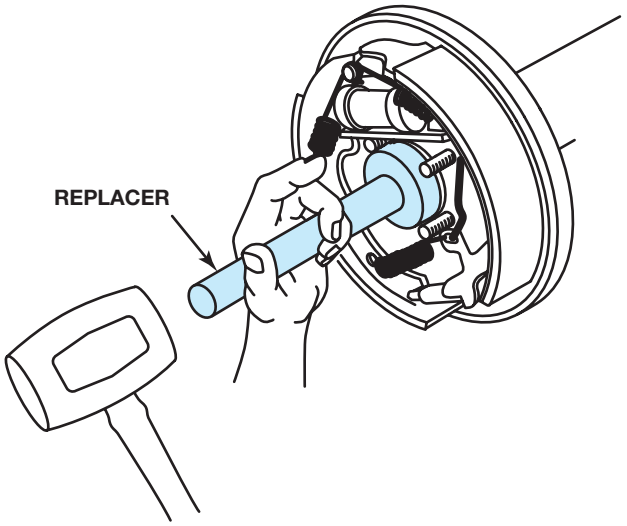
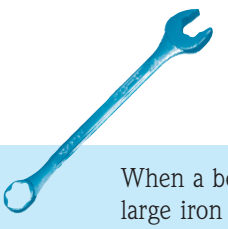


FIGURE 12-35 A new axle bearing is installed using a special driver and hammer.

FIGURE 12-36 A bearing could explode as it is being pressed off the axle. An old starter housing can be placed over the bearing as a scatter shield when a bearing separator is used under the bearing.This assembly can be used in a press with relative safety.



TECH TIP

When a bearing is being pressed, a section of large iron pipe or a used starter or generator housing can be placed over the bearing to enclose it (Figure 12-36).

To remove and replace a bearing pressed on an axle shaft:

1. Position the axle so that the lock ring rests on the edge of the anvil portion of a vise or a sturdy bench-top. Using a hammer and cold chisel, make a series of six or eight cuts into the ring (Figure 12-37). Strike each location

FIGURE 12-37 The axle bearing retainer ring should be cut or stretched using a drill and chisel to make six to eight chisel blows before trying to press the bearing off the axle. *(Courtesy of Dana Corporation)*

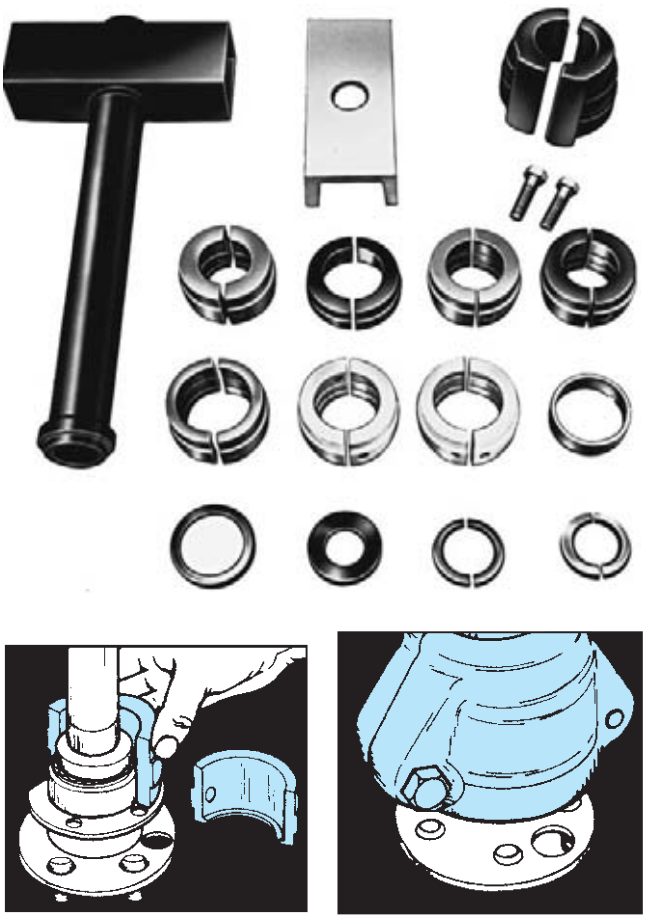


FIGURE 12-38 This tool set encloses the bearing in a collet as it attaches the bearing to the press fixture to allow the safe removal of the bearing. *(Courtesy of OTC Tools)*

once or twice using fairly strong blows to expand the ring slightly so that it will relax its grip on the axle.
2. Select an adapter of the correct size to fit the bearing, and install the adapter and fixture on the axle (Figure 12-38).
3. Place the fixture in the bed of a press and press the axle out of the bearing and lock ring (Figure 12-39).

Some axles use tapered roller bearings, which require a slightly different removal procedure because the rollers prevent the attachment of an adapter to the inner race. To remove these bearings, cut the bearing cage so that it and the rollers can be removed, and then attach an adapter or bearing separator to the inner race (Figure 12-40).

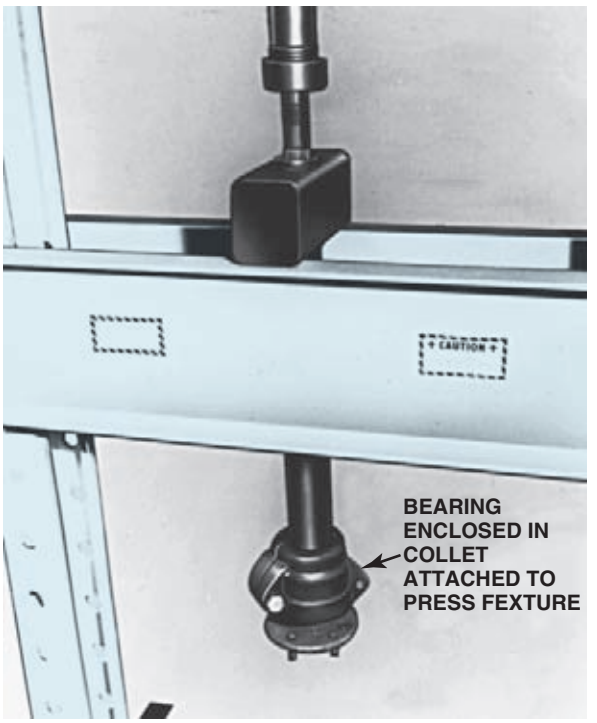


FIGURE 12-39 The fixture shown in Figure 12-38 has been placed in a press, and the axle is being forced from the bearing. *(Courtesy of OTC Tools)*

To press a bearing onto an axle:

1. Clean the bearing retainer and the end of the axle, and place the bearing retainer onto the axle.
2. Place the bearing on the axle and press the axle into the bearing to the correct position (Figure 12-41).
3. Place the lock ring on the axle and press the axle into the ring until the ring contacts the bearing.

TECH TIP

Be ready to catch the axle as it moves through the bearing as it will fall freely after moving an inch or so.

Lug Bolt/Wheel Stud Removal and Replacement

Lug bolts are held in the axle flange by an interference fit between a serrated portion of the bolt and the hole in the flange. Replacement lug bolts are sized using several dimensions, as shown in Figure 12-42. A lug bolt can often be removed using a hammer to give the lug bolt a firm tap on its end (Figure 12-43a); however, it is possible to bend the axle flange this way.

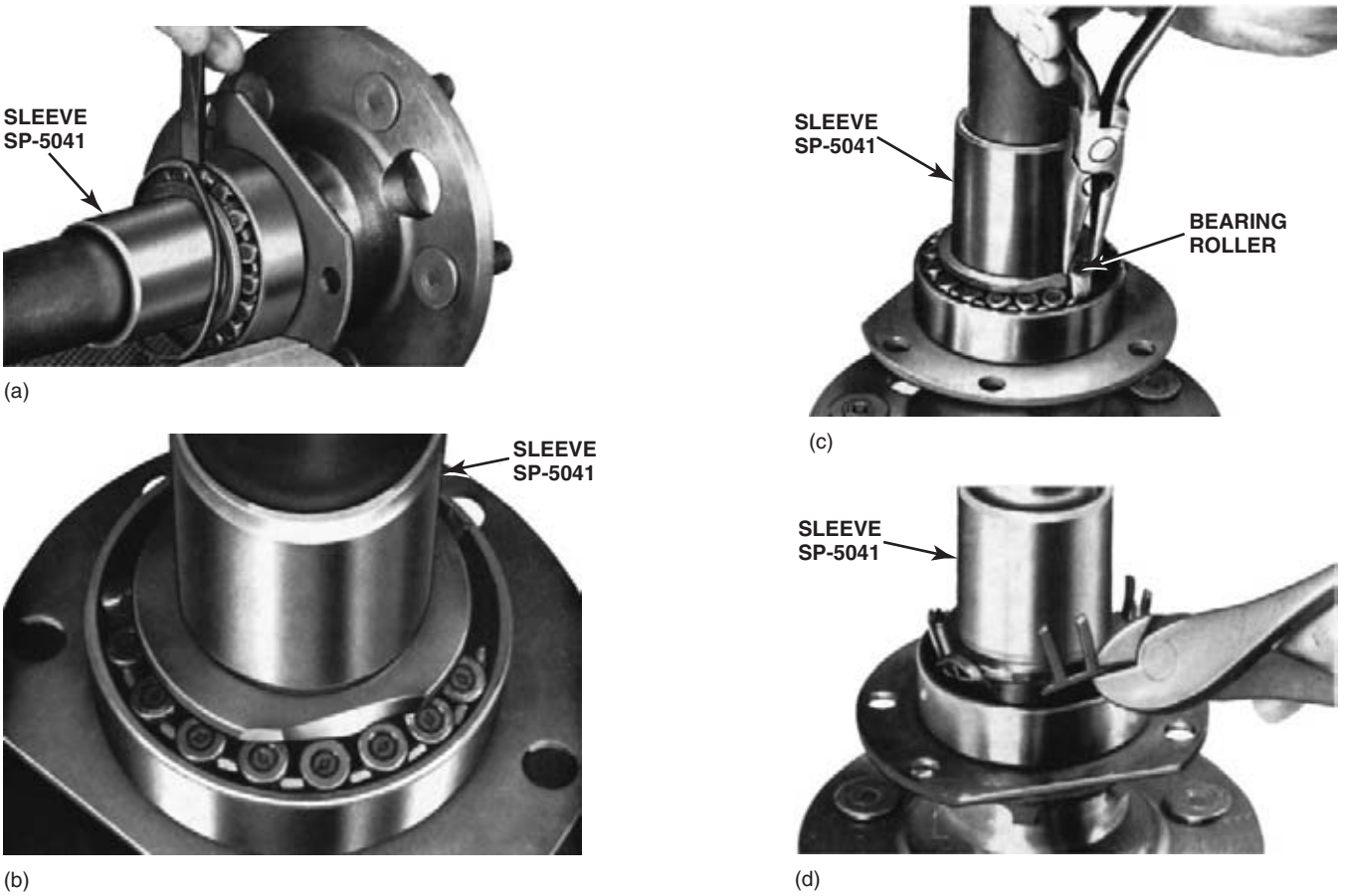


FIGURE 12-40 A safe procedure to remove a tapered roller bearing from the axle is to cut the bearing cage (a), grind a notch in the inner race (b), lift out the rollers (c) and remaining part of the cage (d), and attach an adapter to the inner race. Note the use of a sleeve to protect the seal area on this axle. *(Courtesy of DaimlerChrysler Corporation)*

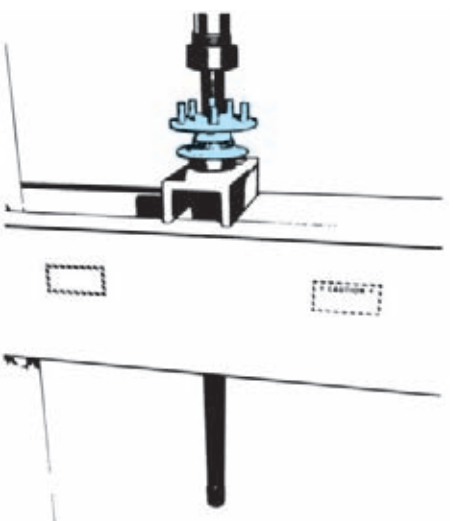


FIGURE 12-41 The axle is being pressed into the bearing and retainer plate. *(Courtesy of OTC Tools)*

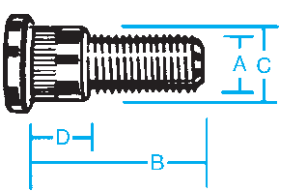
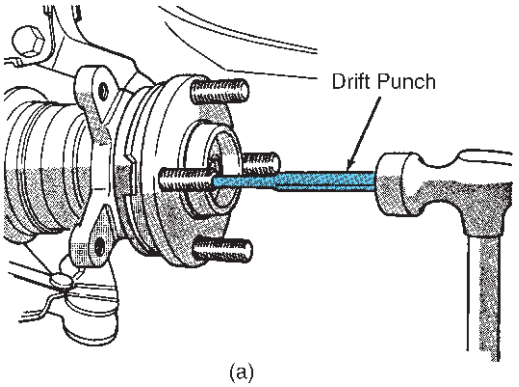


FIGURE 12-42 Critical dimensions for a wheel stud. *(Courtesy of Dorman Products)*

TECH TIP

If the bolt is too tight, fit a U-joint press, some suspension bushing presses, or a C-clamp and short pipe section over the axle flange and damaged bolt, and tighten the press/clamp to push the bolt inward (Figure 12-43b).



(a)

(b)

FIGURE 12-43 Sometimes a damaged wheel stud can be removed with a punch and firm tap from a hammer (a). A tight stud should be removed using a pressing tool so as not to bend the axle flange (b). *(a is courtesy of DaimlerChrysler Corporation).*

The new bolt is installed by placing it in position, setting a stack of flat washers over the threads, and tightening the lug nut to pull the bolt in place using socket wrench (Figure 12-44).

TECH TIP

Do not use an impact wrench to install a wheel stud. The impact wrench's pounding action can strip the wheel stud serrations.

FIGURE 12-44 A new wheel stud is installed by tightening the lug nut against a stack of flat washers.

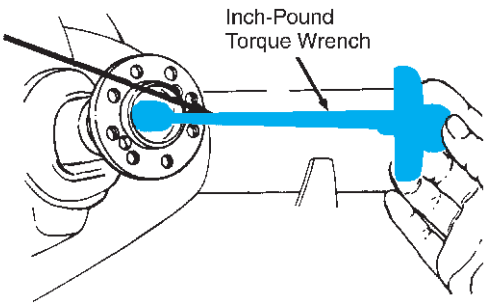
Pinion Shaft Seal Replacement

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. Measuring the drive axle preload in step 2 provides the information for tightening the pinion nut in step 7.

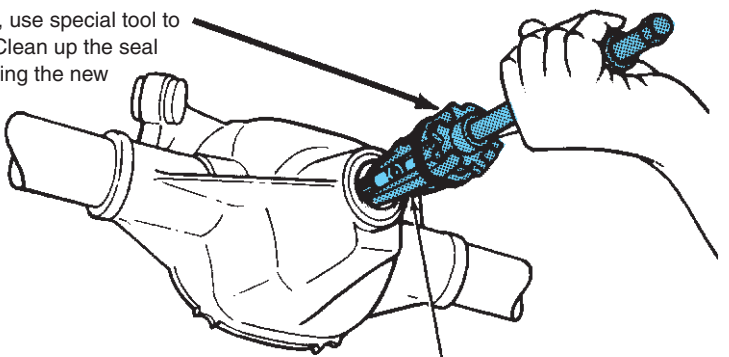
To remove and replace a drive pinion seal:

1. Disconnect the driveshaft from the companion flange, and support the driveshaft so it does not hang from the front U-joint.
2. Measure the torque required to rotate the pinion shaft (pinion and carrier bearing preload) using a low-reading torque wrench, and record this measurement (Figure 12-45).
3. Remove the drive pinion nut and companion flange.
4. Check the sealing surface on the companion flange to ensure a good, smooth surface.

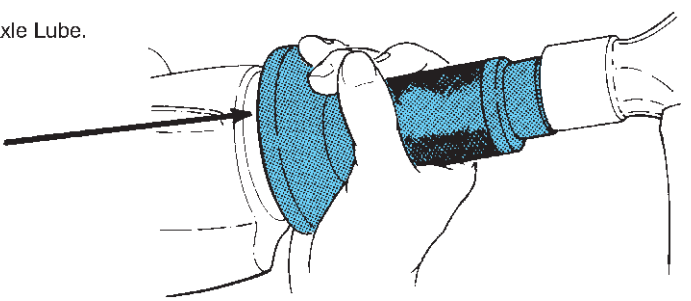
(a) After removing the wheels and eliminating any brake drag, use an inch-pound torque wrench to measure the pinion bearing preload. It should be between 17–22 inch-pounds or slightly lower.



(b) After removing the U-joint flange, use special tool to pull the seal out of the housing. Clean up the seal area in the housing before installing the new seal. Check the pinion shaft and flange splines for burrs.



(c) Lubricate the New Seal with Rear Axle Lube.



(d) Replace the flange, and tighten the nut to get a preload slightly higher than recorded in Step a, at least 17–22 inch-pounds.

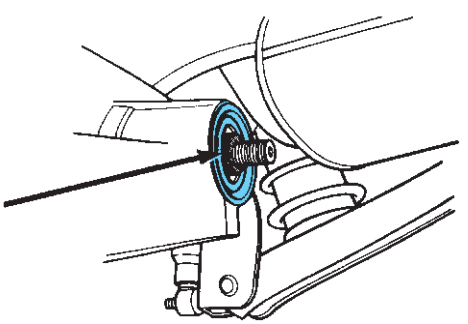


FIGURE 12-45 A leaky drive pinion seal is repaired by first measuring the axle preload (a), removing the pinion flange and the seal (b), replacing the seal (c), checking the shaft splines and flange (d), and replacing the flange and tightening the nut to get a slightly higher preload than measured in step a. *(Courtesy of Ford Motor Company)*

REAL WORLD FIX

The drive axle pinion shaft seal in a 1989 S10 Blazer (166,000 mil) was replaced, but it still leaked. The seal was replaced again along with a repair sleeve on the companion flange surface, but it still leaked. A careful visual inspection during this last repair did not reveal any problems.

While replacing the seal for the third time, the technician determined that the leak was along the splines between the pinion shaft and the companion flange and around the seal shell. A check of the axle housing vent tube showed that it was open. Replacement of the seal with the addition of a sealant on the outer surface and on the inner surface of the companion flange washer fixed this problem.

REAL WORLD PROBLEM

Imagine that you are working in a general automotive repair shop and these problems are brought to you.

Case 1

The pickup you're working on has a bad axle seal. You removed the differential cover, but as you try to remove the differential shaft retaining bolt, the head snaps off. What will you do now so that you can remove this hardened, broken-off remainder of the bolt that is still holding the differential shaft in place?

Case 2

The problem began with axle gear oil on the brakes, and you pulled the bearing-retained axle. You check in the axle housing to pull the grease seal, but there is no seal in there and there is no sign of a sealing surface on the axle. Where is the seal?

5. Remove and replace the seal. If the new seal does not have a coating on the outer surface, apply a thin film of RTV sealant before installing it.
6. Apply a thin film of gear oil to the lip of the seal and the sealing surface of the flange, and replace the companion flange.
7. Install a new pinion nut, and tighten the nut until the bearing preload is slightly greater than that recorded in step 2. The pinion nut should be very tight.
8. Replace the driveshaft.

CARRIER REMOVAL AND REPLACEMENT

On removable carrier axles, the carrier is removed from the axle housing to service or repair the differential, ring and pinion gears, or any of the bearings.

To remove a carrier:

1. Raise and securely support the vehicle on a hoist or jack stands.
2. Remove the axles as described on page 347.
3. Remove the driveshaft as described in Chapter 10 on page 277.
4. Place a drain pan under the axle assembly, and remove the nuts or bolts that are securing the carrier to the housing. Also remove the copper washers used to seal the studs (Figure 12-46).
5. Be ready to support the heavy carrier as you break the gasket seal and remove the carrier from the housing.

To replace a carrier:

1. Clean the gasket surface on the axle housing and carrier and remove any old grease and debris from the bottom of the housing.
2. On housings using studs, place a new gasket in position on the housing. If cap screws are used, place the gasket on the carrier (Figure 12-47).
3. Set the carrier in position, install new copper washers and the nuts or cap screws. Tighten them to the specified torque.

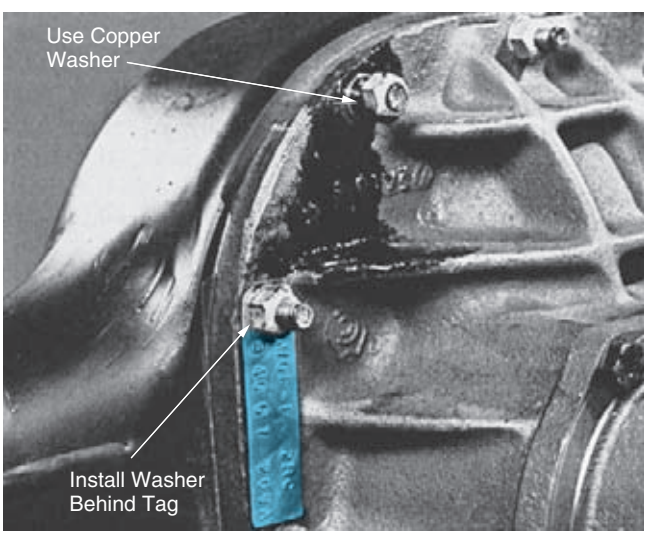


FIGURE 12-46 After removing the axles, this carrier can be detached by removing the nuts and copper washers and lifting the carrier housing from the axle housing. (Courtesy of Ford Motor Company)

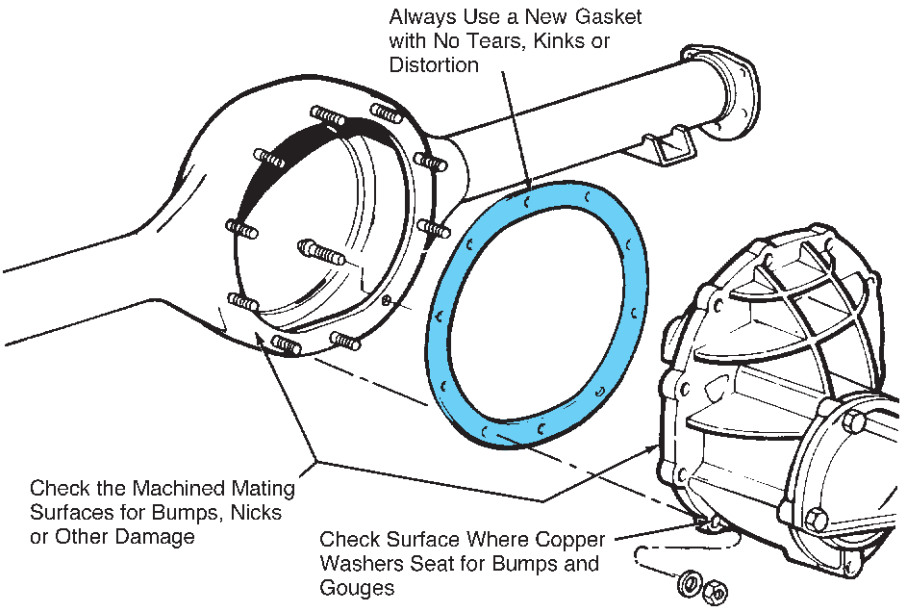


FIGURE 12-47 A new gasket should be used when replacing a carrier. *(Courtesy of Ford Motor Company)*

4. Replace the axles as described on page 347.
5. Replace the driveshaft as described in Chapter 10, on page 277.

CARRIER OVERHAUL

Carrier overhaul includes:

- An inspection of the gears and bearings before teardown
- A check for ring gear runout
- Removal and replacement of the differential and ring gear
- Removal and replacement of the pinion gear
- Inspection and repair of the differential
- Assembly adjustments for pinion depth, pinion bearing preload, backlash, and carrier bearing preload (Figure 12-48)

Due to the variety of carriers, there are at least two ways of making each of these adjustments. **Pinion depth** can be adjusted by a **shim** right next to the gear of an overhung pinion, or it can be adjusted by a shim at the bearing retainer of a straddle-mounted pinion. In most carriers, **pinion bearing preload** is adjusted using a collapsible bearing spacer. Some carriers, however, use a solid spacer and shims. Backlash and carrier bearing preload can be adjusted using threaded adjusters in some axles; most modern axles use shims for these two adjustments.

For secure support during the overhaul procedure, removable carriers are normally mounted in fixtures attached to a shop bench (Figure 12-49). Most integral carriers are overhauled in the vehicle, or the axle assembly can be removed and overhauled at the bench. The parts needed to rebuild a carrier assembly are normally purchased as needed. Some suppliers market installation kits, which include the parts needed during the installation and adjustment of a ring and pinion gear (Figure 12-50).

Inspection Before Teardown

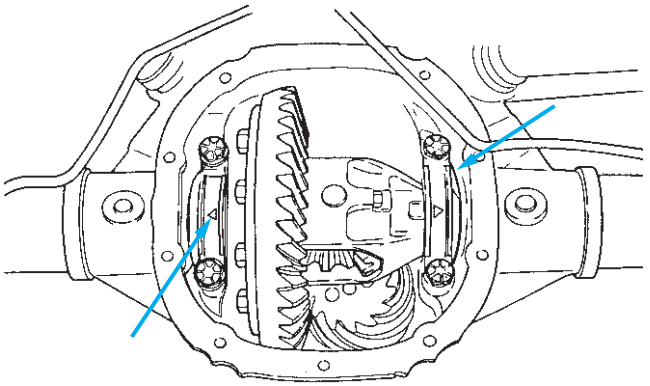
Inspection begins with a complete cleanup.

TECH TIP

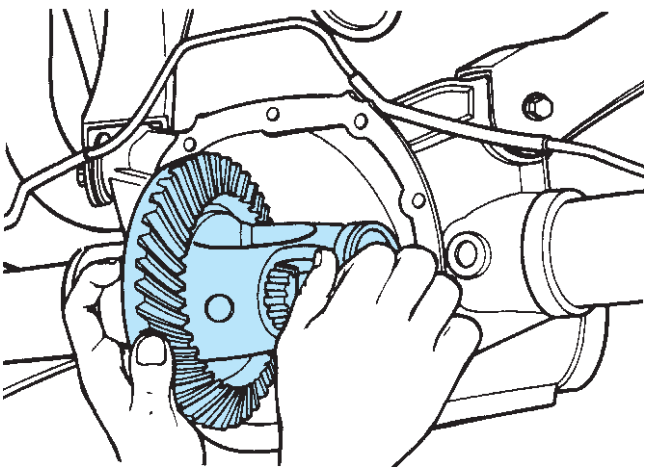
On C-lock axle units, be aware that the differential gears can fall out; you may want to slide the differential pinion shaft back in place to hold them.

TECH TIP

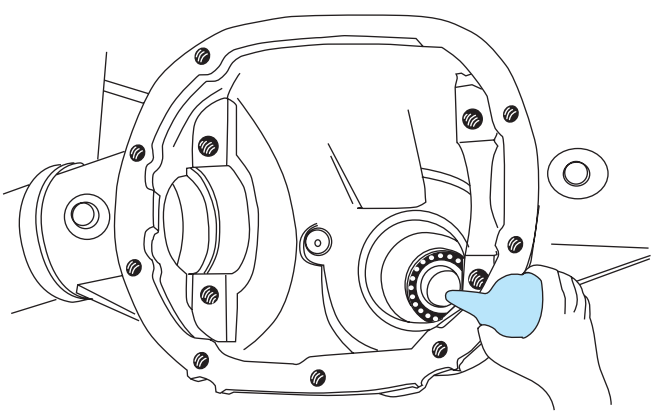
Occasionally, a ring gear will wear in a smooth pattern, with the only noticeable wear being a step near the bottom of the teeth.



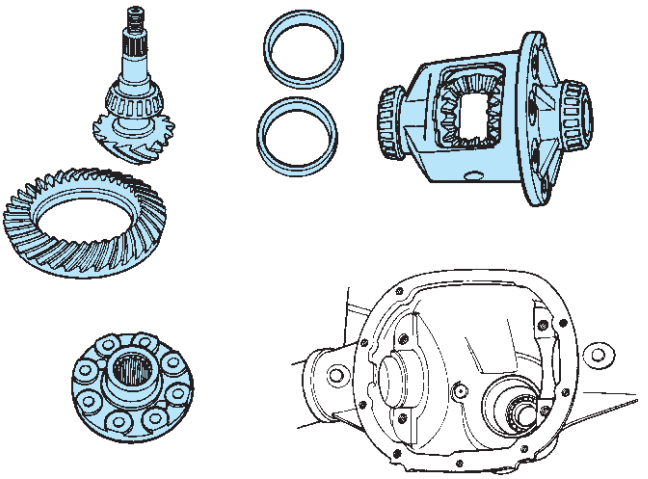
(a) Mark Caps



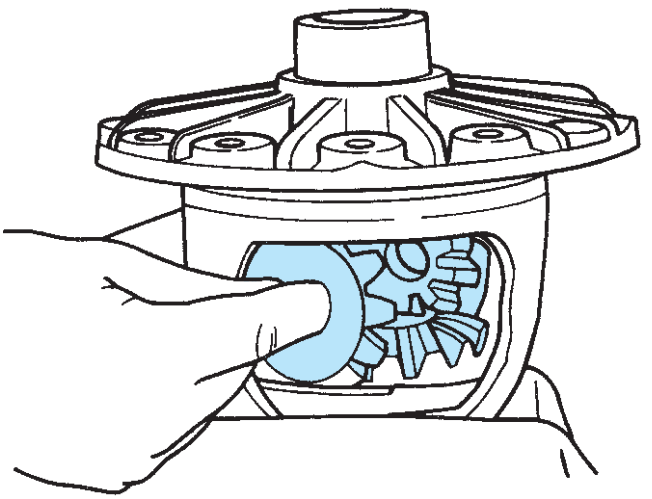
(b) Remove Caps, Differential, and Bearings with Cups



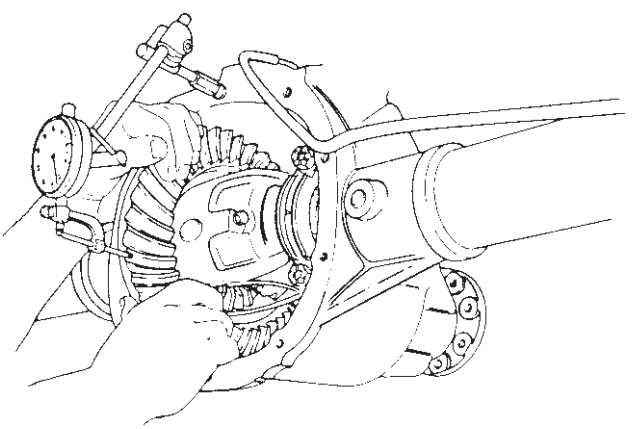
(c) Remove Companion Flange and Remove Drive Pinion Gear



(d) Inspect Gears, Bearings, Differential Case and Gears, Housing, and Companion Flange



(e) Check Differential Gears



(f) Assemble Axle and Make Adjustments

FIGURE 12-48 Procedure to overhaul an axle assembly.

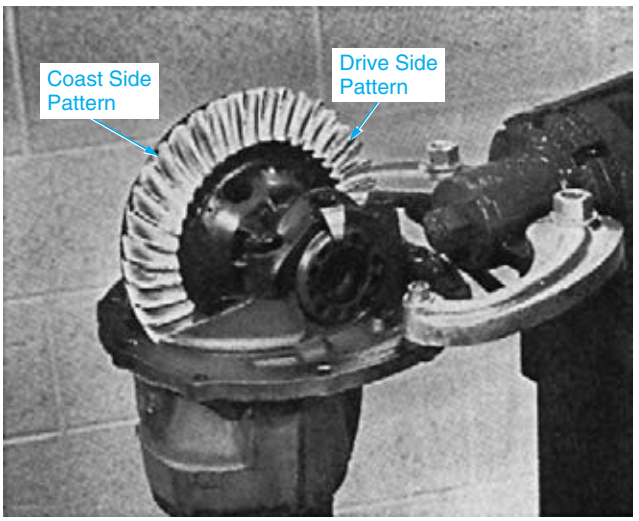
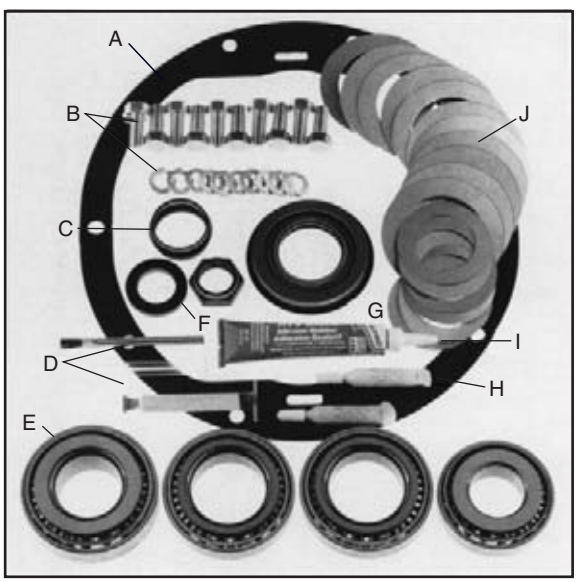


FIGURE 12-49 This carrier is supported securely using a bench support. *(Courtesy of Ford Motor Company)*



A. Cover Gasket
B. Ring Gear Bolts and Washers
C. Crush Sleeve
D. Marking Compound and Brush
E. Pinion and Carrier Bearings
F. Pinion Nut and Washer
G. Pinion Seal
H. Thread Locking Compound
I. Silicone Sealer
J. Pinion and Carrier Shims

FIGURE 12-50 This ring and pinion installation kit includes all the parts needed for installation and adjustment of a ring and pinion gear. *(Courtesy of Richmond Gear)*

REAL WORLD FIX

A 1997 Jeep Grand Cherokee (44,000 mil) had a whine when operated between 55 and 70 mph. It was most noticeable under light deceleration, but not present under cruise or acceleration. The rear axle was inspected, and the ring and pinion gears and the bearings appeared questionable. They were replaced, but this did not help. The front axle was inspected, and the carrier bearing appeared bad. All the bearings were replaced, but this did not help. The ring and the pinion appeared good, but the contact pattern ran the full length of the gear tooth on one side.

A test using a Chassis Ear indicated the noise to be coming from the front axle. The ring and pinion gear set was replaced and adjusted to a correct contact pattern. This fixed the problem.

After cleaning, visually inspect the ring gear and differential gears for obvious damage. The surface of the teeth should be smooth and have a polished sheen. Common ring gear wear appears as a rough, scored tooth surface or chipped or nicked teeth (Figure 12-51).

Rotate the pinion shaft and the differential. They should roll smoothly without any end play; both sets of bearings should be preloaded.

Ring Gear Runout

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. Because gear runout will cause backlash to change, it is sometimes referred to as **backlash variation**.

TECH TIP

One manufacturer limits the maximum allowable runout to 0.004 in. (0.1 mm). Others have no specification for runout. Instead, they specify that the backlash must not be less than the minimum specification at the tightest point or larger than the maximum specification at the loosest point.

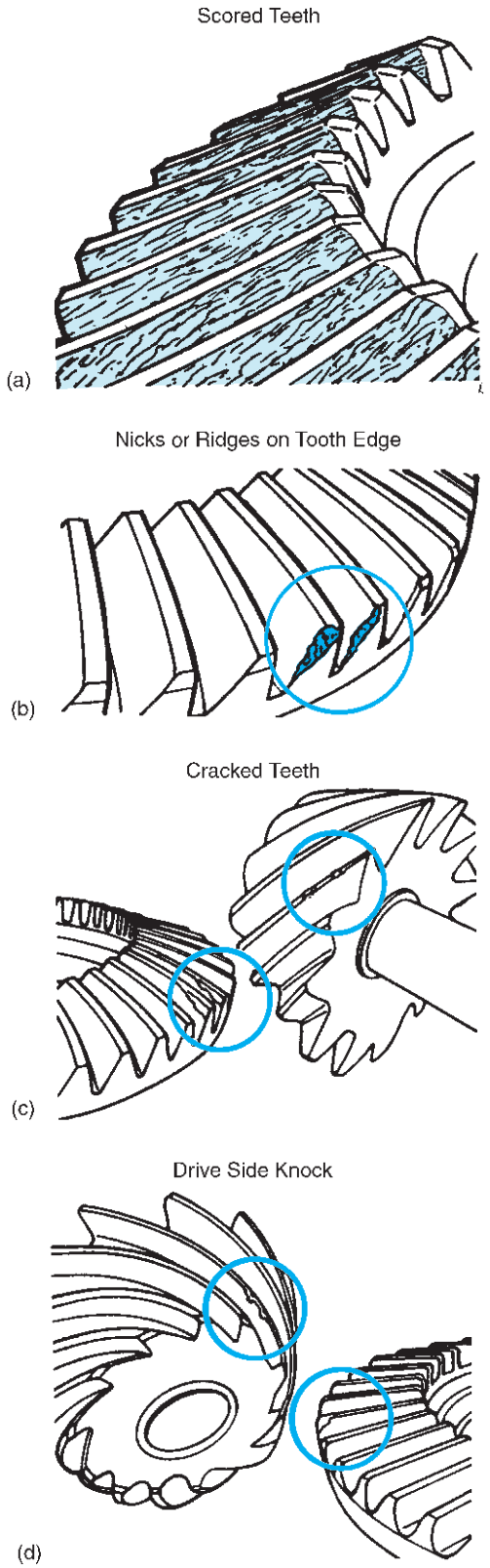


FIGURE 12-51 Noisy gear operation can be caused by scored teeth (a) or cracked or chipped teeth (b, c, and d). *(Courtesy of Ford Motor Company)*

TECH TIP

Runout can sometimes be corrected by the following process:

1. Remove the ring gear from the differential case.
2. Clean them both thoroughly.
3. Remove any metal burrs or raised metal from the case.
4. Replace the gear, tightening the bolts evenly and to the correct torque.

TECH TIP

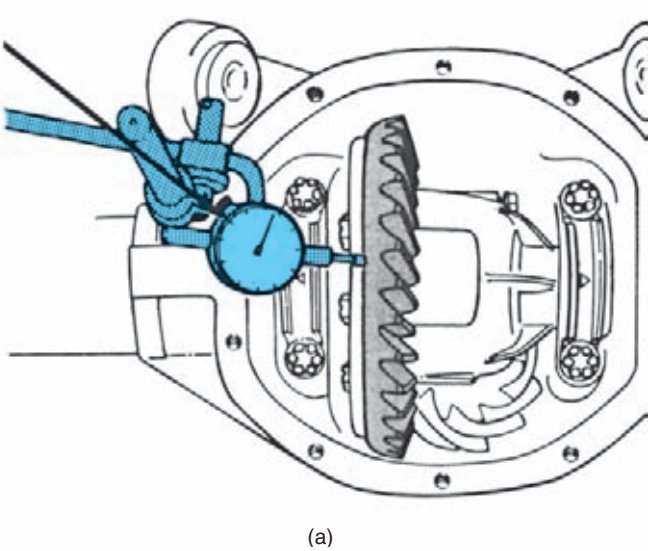
It should be noted that left-hand threads are used on many ring gear bolts. It should also be noted that some manufacturers recommend discarding the old ring gear bolts if they are removed and installing new ones.

To check ring gear runout:

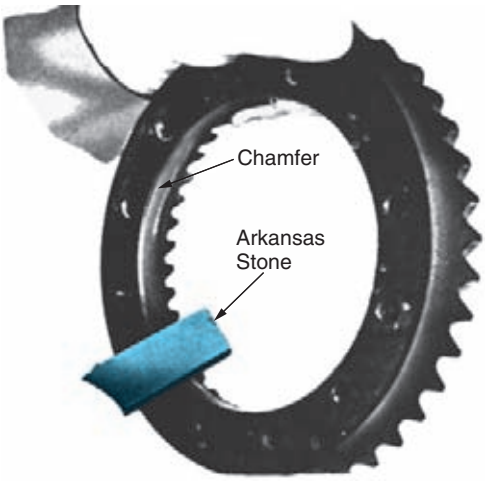
1. Mount a dial indicator so that the indicator stylus is on the back of the ring gear and at a 90° angle to the gear surface (Figure 12-52a). The runout of a differential case can be checked using a similar procedure (Figure 12-52b).
2. Rotate the ring gear and observe the indicator needle movement. This is the total indicated runout (TIR).

TECH TIP

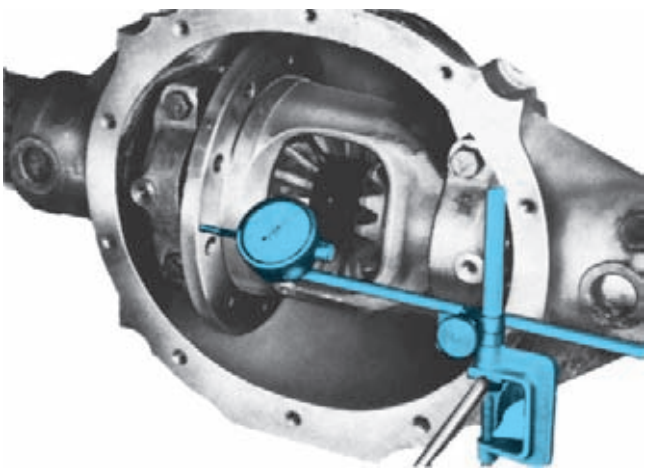
An experienced technician will loosen the ring gear mounting bolts before removing the differential if there is a chance he/she might remove the ring gear from the differential case. These bolts are normally very tight, and the differential is hard to hold when it is out of the carrier. While still in the carrier, the differential case can be held stationary by placing a block of wood between the ring and pinion gears or by placing a box wrench on one of the ring gear bolts and against the side of the carrier.



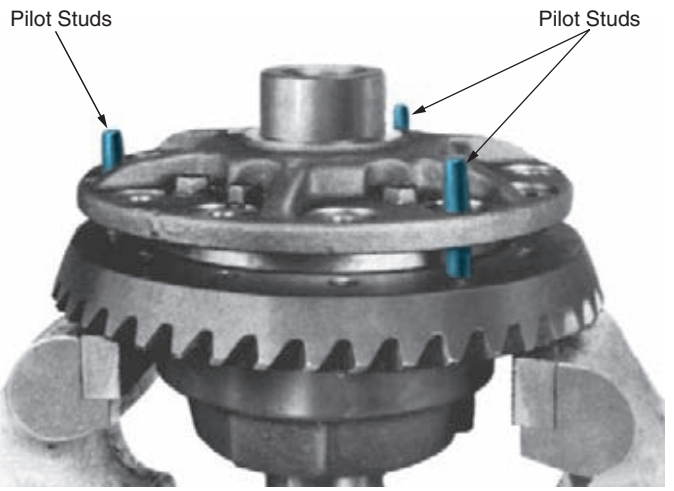
(a)



(c)



(b)



(d)

FIGURE 12-52 A dial indicator has been set up to measure ring gear runout (a). Among other things, excessive runout can be caused by runout of the ring gear mounting flange (b). When replacing a ring gear on the case, be sure to remove any burrs that might interfere with the seating (c) and to use pilot studs for bolt alignment (d). *(a is courtesy of Ford Motor Company; b, c, and d are courtesy of DaimlerChrysler Corporation)*

Differential Removal

To remove a differential:

1. Using a punch and hammer or permanent marker, place index marks on each of the bearing caps (Figure 12-53).
2. On threaded adjusters, remove the adjustment locks, the carrier bearing cap mounting bolts, and the bearing caps (Figure 12-54). On shim-adjusted carriers, remove the bearing cap mounting bolts and the bearing caps.
3. On threaded adjusters, remove the adjuster and lift the differential with bearing cups out of the carrier (Figure 12-55). Mark or tag the bearing cups so that they won't be mixed up.

TECH TIP

Don't forget to check the ring gear bolt heads for markings that indicate left-hand threads, usually an "L."

Some manufacturers recommend the use of a spreader tool to stretch the carrier and take the pressure off the shims and bearings. When using a spreader tool, do not spread the carrier any farther than the manufacturer's limits, or 0.015 in.

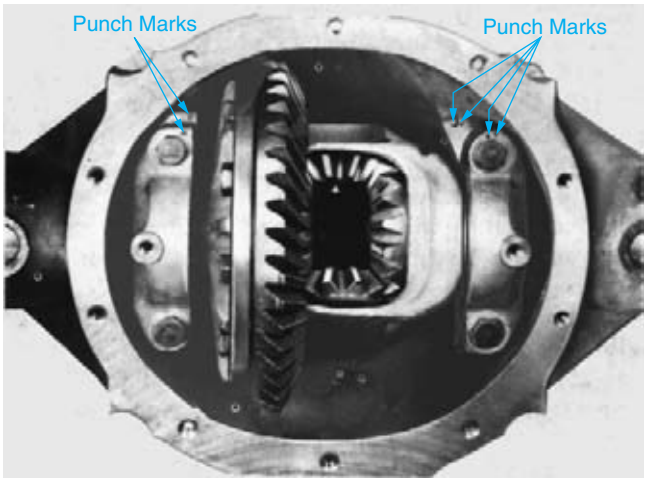


FIGURE 12-53 Index marks should be placed on the bearing caps before removal to ensure proper replacement. *(Courtesy of DaimlerChrysler Corporation)*

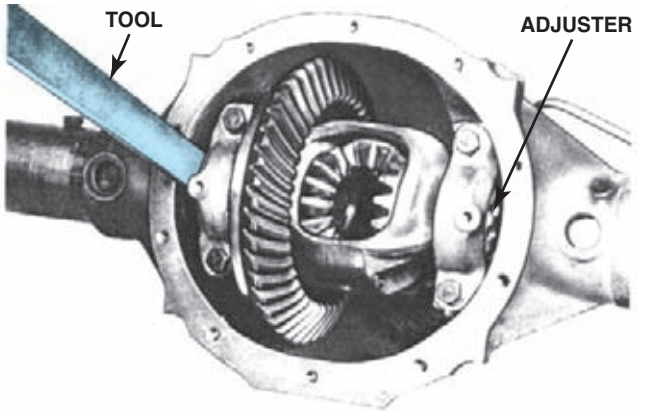


FIGURE 12-54 Loosening the threaded adjusters removes the preload and allows for easy removal of the adjusters and bearing caps. Keep each set of bearing cup, cap, and adjuster separate to ensure reinstallation onto the proper side. *(Courtesy of DaimlerChrysler Corporation)*

TECH TIP

The bores of the carrier bearing caps are normally machined after they are mounted on the carrier. This means that the cap will fit properly only in the original position. Index marks should be put on them before removal to ensure proper replacement.

TECH TIP

Some bearing caps are factory marked with an arrow; even so, this only shows you half of what you need. Mark the caps so you can tell the right and left sides.

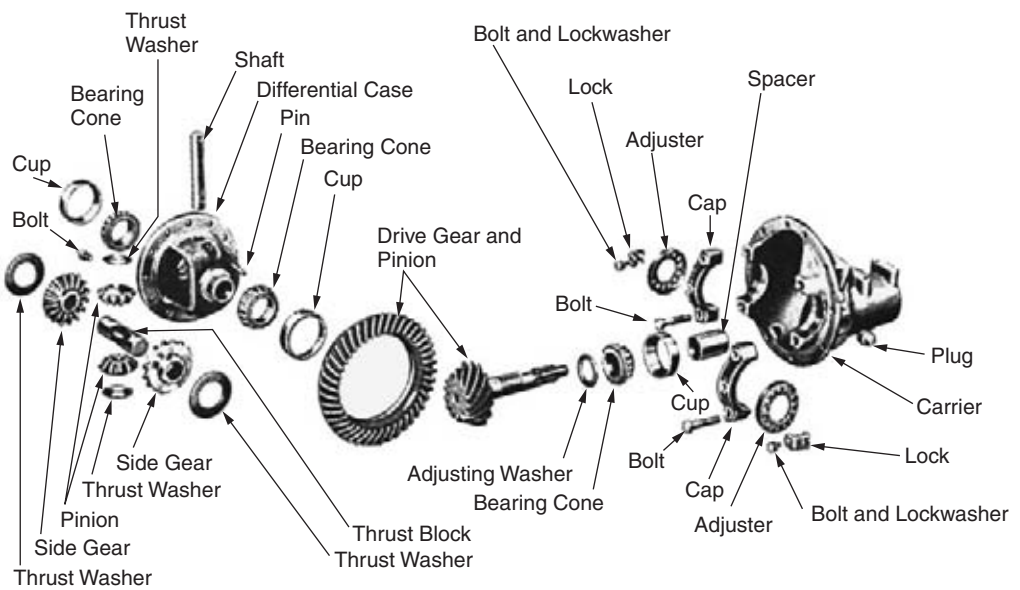


FIGURE 12-55 With the caps removed, the differential case with differential and ring gear can be removed from the housing. *(Courtesy of DaimlerChrysler Corporation)*

TECH TIP

You can lift the bearing cap bolts about halfway out of their holes and use them as a handle to help remove the caps.

TECH TIP

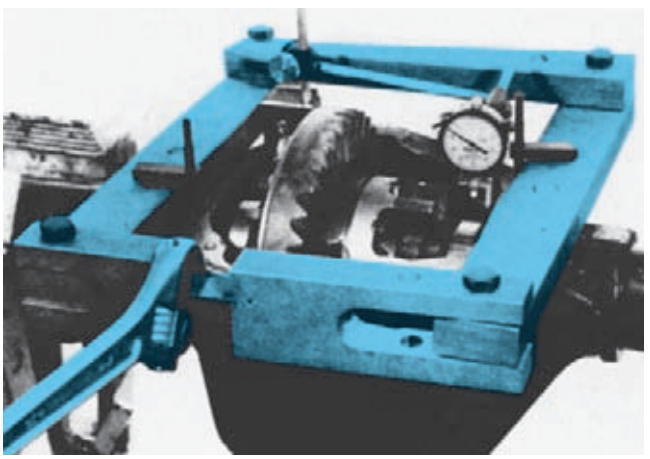
On shim-adjusted carriers, the preload at the shims should be too tight to allow easy removal of the differential (Figure 12-56). Most differentials can be pried out of the carrier, but be careful not to damage the gasket surface on the carrier.

TECH TIP

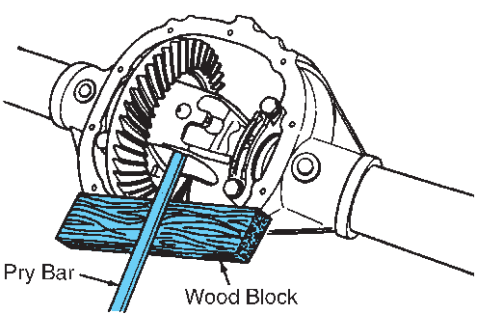
Some differentials can be removed by placing a box wrench on one of the ring gear bolts and turning the pinion gear so that the wrench pushes against the carrier and lifts up the differential. As the differential is removed from the carrier, tag or mark the shims and bearing cup from each side so they won't be mixed up.

TECH TIP

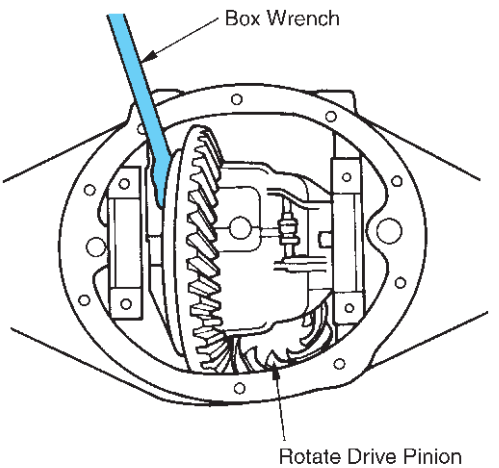
The drive pinion gear is held in place by the companion flange, and the self-locking nut that secures it is very tight. You can expect to exert 150 to 300 ft-lb (203 to 407 N-m) of torque to break it loose.



(a)



(b)



(c)

FIGURE 12-56 Some manufacturers recommend the use of a case spreader to spread the housing (0.015 in. maximum) so that the differential case can be removed (a). Often, however, the differential case can be pried out of the housing using a pry bar and block of wood to protect the gasket surface; note that the bearing caps are in place with the bolts loosened (b). Some differentials can be lifted from the housing by placing a box wrench onto one of the ring gear bolts and rotating the drive pinion shaft (c). *(a courtesy of Dana Corporation; b is courtesy of Ford Motor Company)*

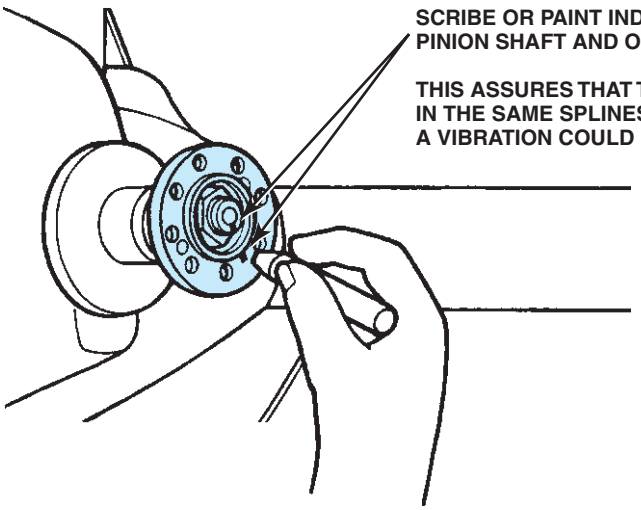


FIGURE 12-57 Place index marks on the drive pinion shaft and flange so that you can replace the flange in the same position and reduce the possibility of flange runout. *(Courtesy of Ford Motor Company)*

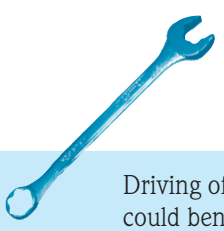
Pinion Gear Removal

To remove a drive pinion:

1. Remove the differential as described on page 361.
2. Place index marks on the end of the pinion shaft and the companion flange so that you can replace the flange back on the same spline (Figure 12-57).
3. Attach a holding tool to the flange. Use a socket and the longest handle available to loosen the nut (Figure 12-58). A torque multiplier is very helpful. Once loosened, a ratchet handle can be used to remove the nut.
4. Slide the companion flange off the drive pinion shaft. If necessary, use a puller to remove the flange.
5. Use a soft hammer or brass punch to tap the pinion shaft into the carrier (Figure 12-59). Be ready to catch the pinion gear as it slides out.

Inspection of Bearings and Gears

After disassembly, the parts should be cleaned in solvent and inspected to ensure their usability. Gears are checked in the same manner as transmission gears; this procedure is described in Chapter 8, on page 203. Bearing inspection is also similar to that described for transmission bearings in Chapter 8 on page 208 (Figure 12-60). Reused bearings should be oiled to prevent rusting.



TECH TIP

Driving off a flange by hammering on the lugs could bend it and cause a future vibration.

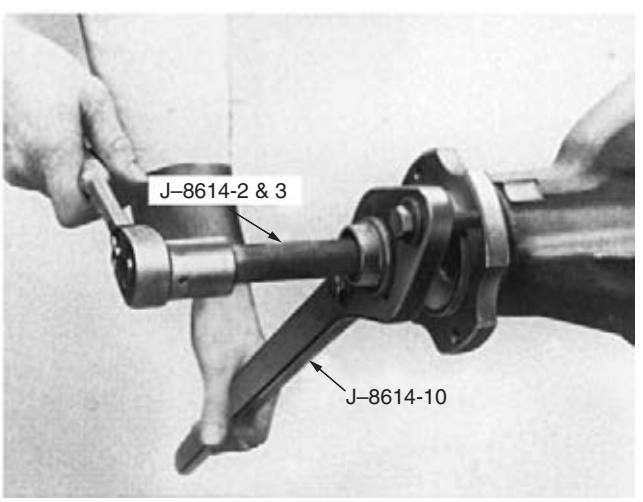


FIGURE 12-58 When attached to the pinion flange, this tool will provide the leverage needed to hold the pinion flange as the drive pinion nut is loosened and tightened. It can also be used as a puller when removing the flange (inset). *(Courtesy of Kent-Moore)*

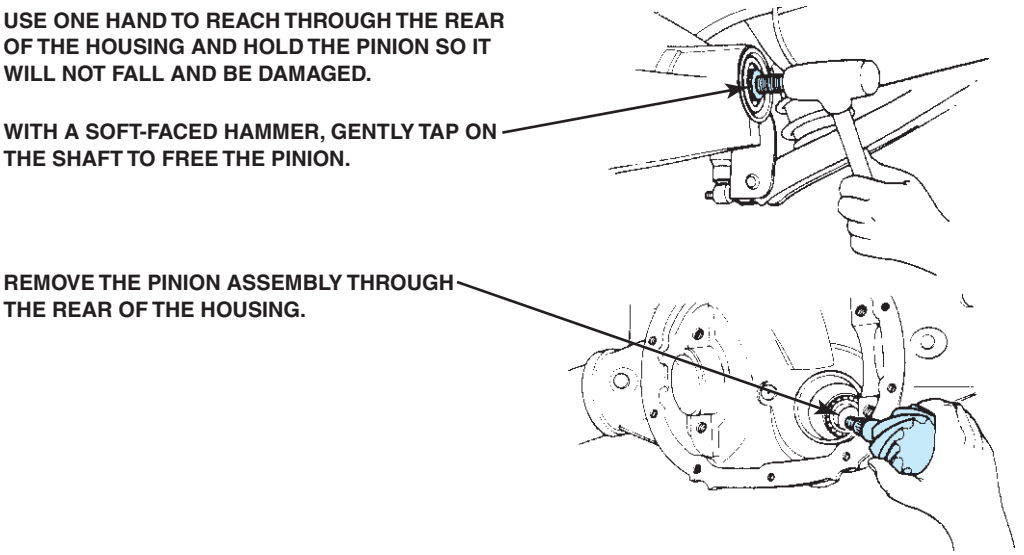
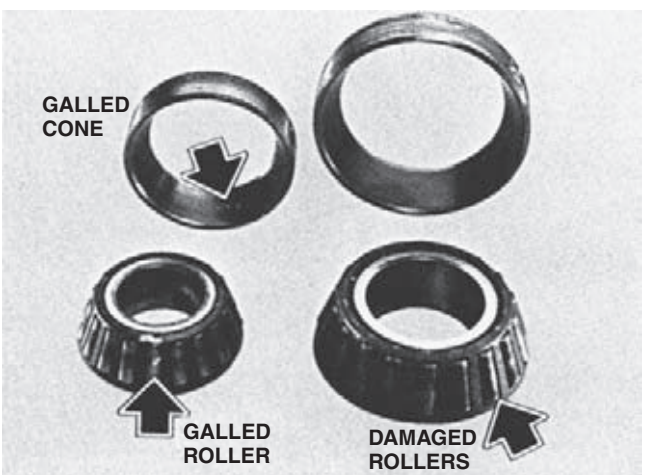


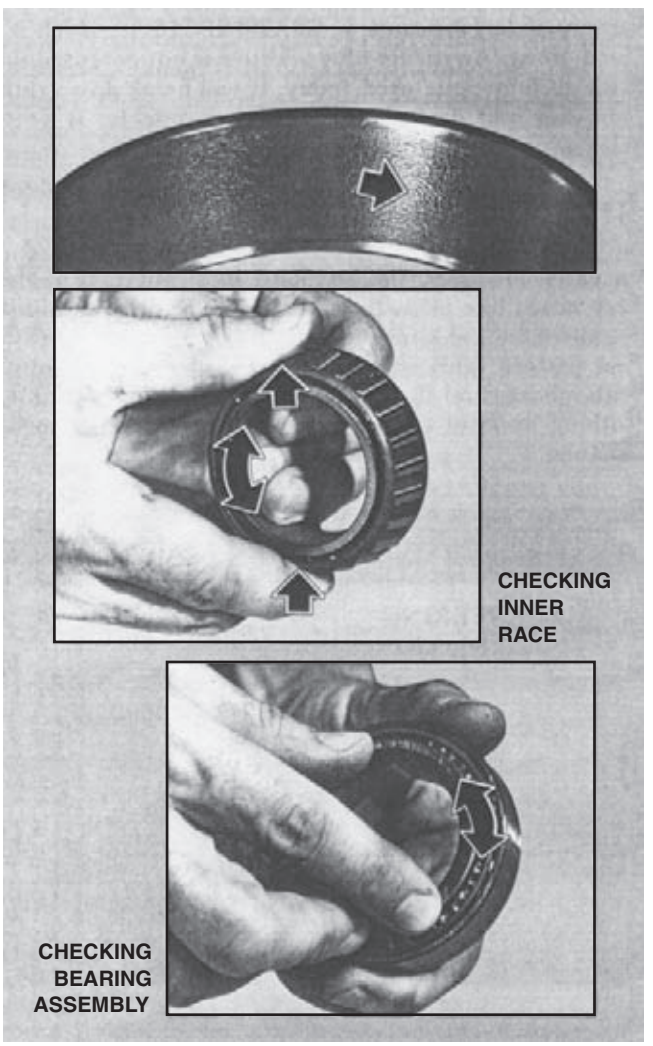
FIGURE 12-59 A soft hammer is usually needed to drive the pinion shaft from the bearings. *(Courtesy of Ford Motor Company)*

TECH TIP

New cups are installed by driving them into place using a bearing cup driver and hammer. An old cup is sometimes used as the driving tool.

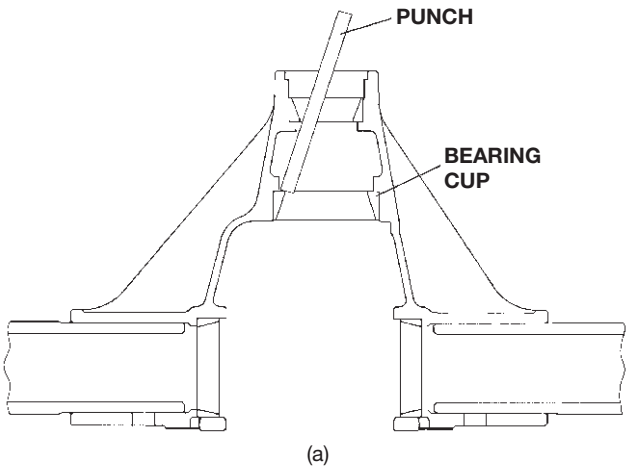


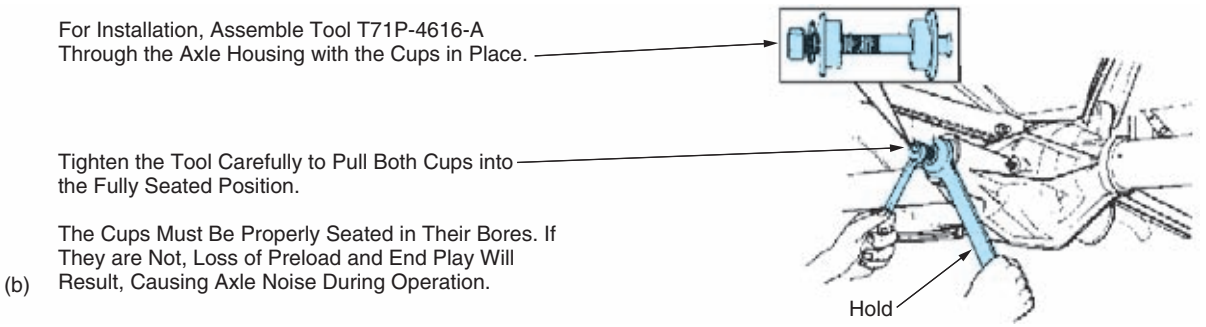
(a)



(b)

FIGURE 12-60 Used tapered roller bearings and their cups should be inspected for damage (a). It is also a good practice to press them together as you rotate them so that you can feel for any damage (b). *(Courtesy of Ford Motor Company)*





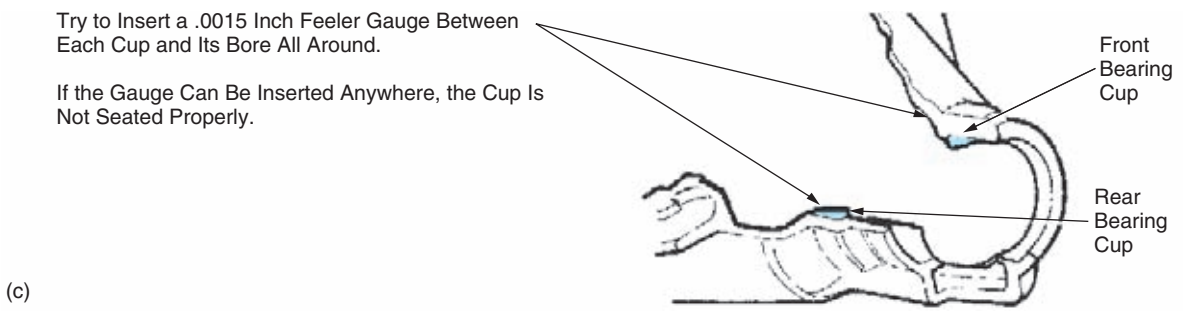


FIGURE 12-61 A damaged bearing cup can be driven out of the housing using a long punch (a). A special tool can be used to pull the new bearing cup into position, making sure that it is completely seated (b and c). *(Courtesy of Ford Motor Company)*

The inside of the carrier or axle housing should be cleaned. Worn drive pinion bearing cups are normally removed from the carrier using a punch and hammer (Figure 12-61).

Never hammer directly on the new cup. The drive pinion seal should be checked to make sure that it is in good condition. The seal lip must not have excess wear, be cut or torn, nor be overly hardened. Many technicians will replace this seal during an overhaul. Also, make sure that the sealing surface on the companion flange is not damaged or worn (Figure 12-62).

TECH TIP

Normally during disassembly, the carrier bearings are left on the differential case unless the case bearings, or a shim behind the bearing, needs to be replaced. Also, the rear drive pinion bearing is left in place unless the drive pinion, bearing, or pinion depth shim needs to be replaced. In some cases, the bearing is ruined during removal. A sturdy puller and step plate are required to remove a carrier bearing (Figure 12-63). The new bearing is normally pressed into place.

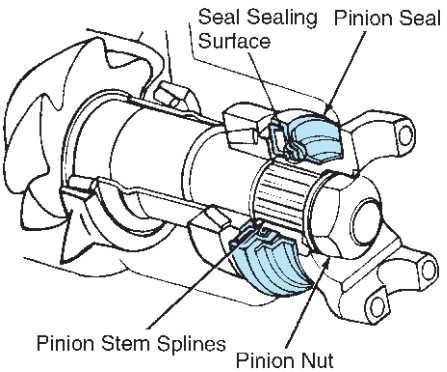
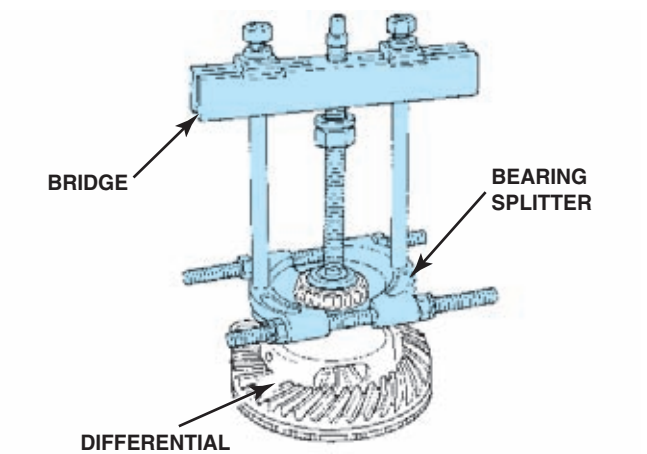


FIGURE 12-62 When the drive pinion is replaced the flange sealing surface should be inspected, and a new drive pinion seal should be installed. *(Courtesy of Ford Motor Company)*

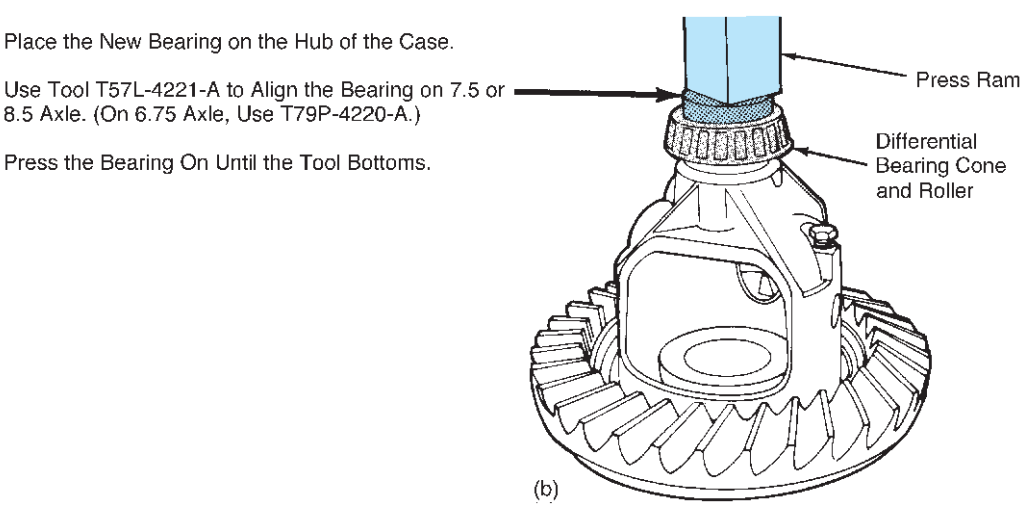
REAL WORLD FIX

A 1998 Ford F150 (115,000 mil) had bad drive axle bearings, so the pinion and carrier bearings were replaced. The proper synthetic gear oil and friction modifier were put in the axle. A road test revealed a rhythmic thumping noise during deceleration. With the vehicle on a lift, the noise came from the axle housing.

The ring and pinion gears were replaced even though a close inspection revealed only a scuff mark on the coast side of a ring gear tooth.The gear replacement cured this problem.



(a)

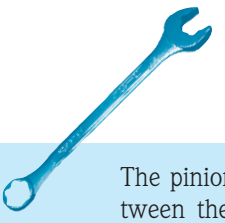


(b)

FIGURE 12-63 A puller and bearing splitter are set up to remove the differential bearing (a). A new bearing being installed using a press (b). *(a is courtesy of Daimler Chrysler Corporation; be is courtesy of Ford Motor Company)*

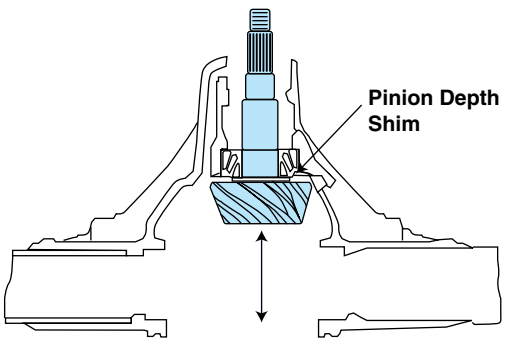
Drive Pinion Depth Shim Selection

Pinion depth is the first step in the adjustment sequence on most carriers (Figure 12-64). On overhung pinion gears, the pinion depth shim selection is the first step in reassembly. This shim places the drive pinion gear in the proper position relative to the ring gear and carrier (Figure 12-65). 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.

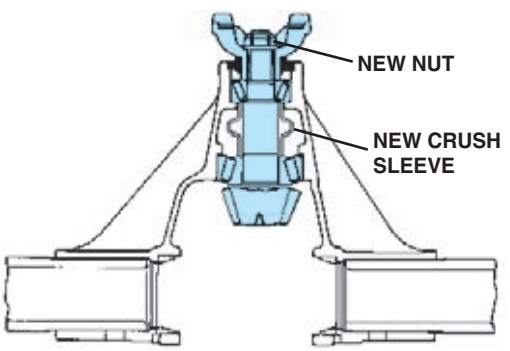


TECH TIP

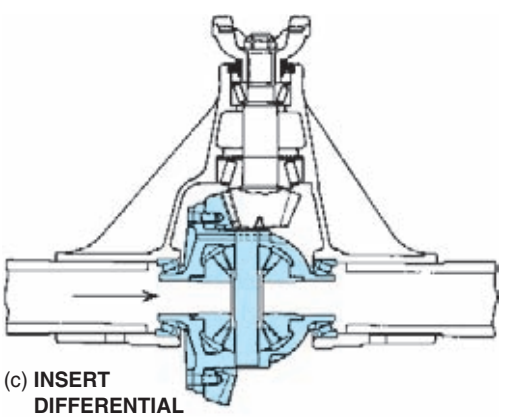
The pinion depth shim is usually located between the rear bearing and the pinion gear head. On some carriers it is located under the rear bearing cup (Figure 12-66). If a carrier is assembled with the wrong pinion depth shim, it will need to be disassembled so that the shim can be changed.



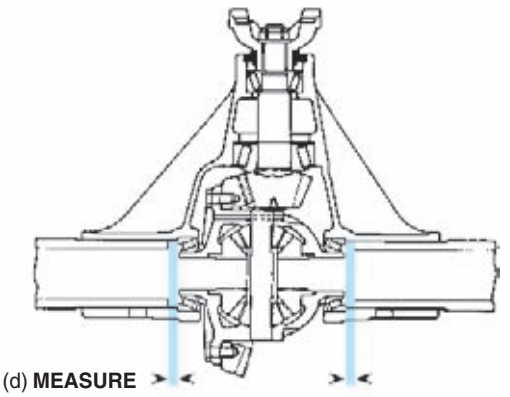
(a) **Adjust Pinion Depth**



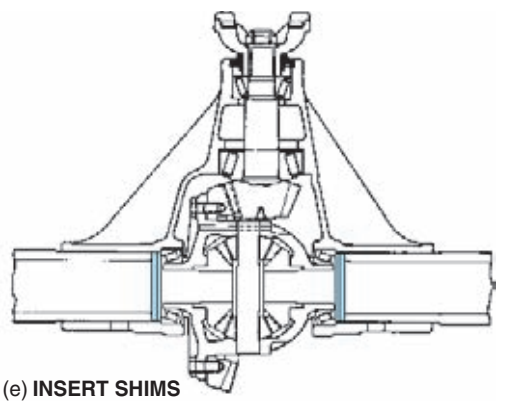
(b) **ADJUST PINION BEARING PRELOAD**



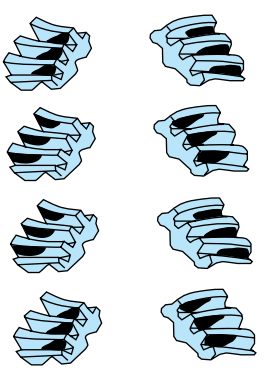
(c) **INSERT DIFFERENTIAL**



(d) **MEASURE SHIM SPACE**

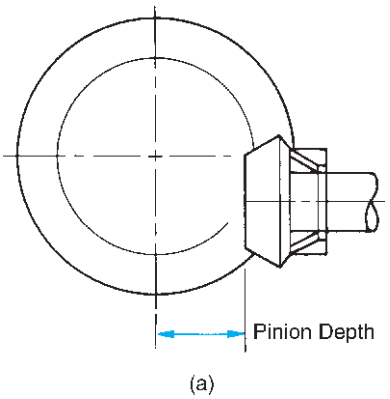


(e) **INSERT SHIMS**



(f) **Run Contact Pattern to Check Adjustments**

FIGURE 12-64 Procedure to adjust most drive axle assemblies.



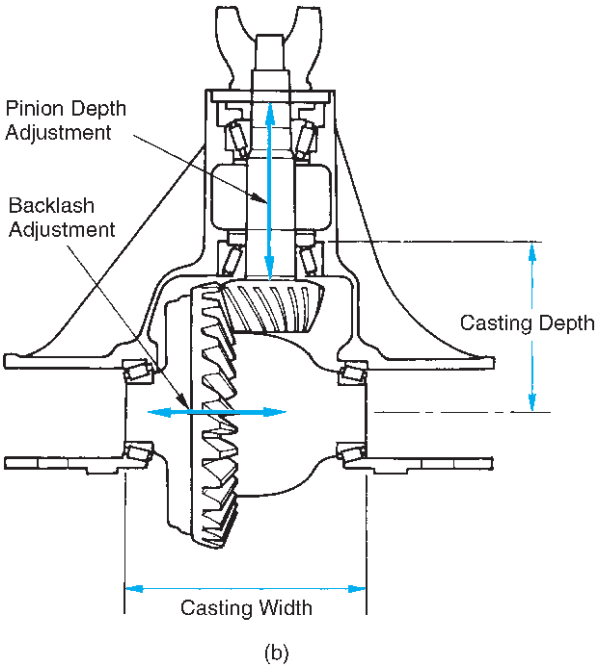
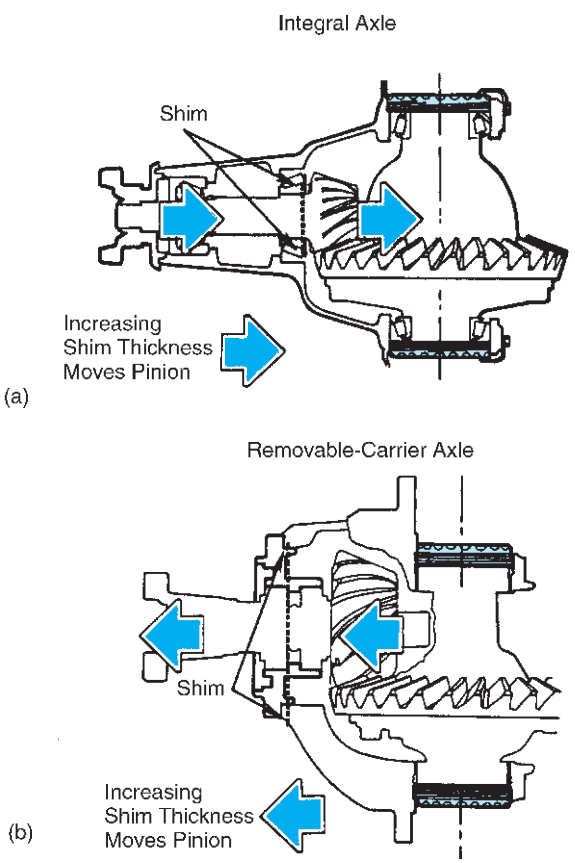


FIGURE 12-65 The drive pinion must be positioned at the design distance from the ring gear center (a). Shims are used at the drive pinion gear to compensate for variations in the casting depth, and shims or threaded adjusters are used at the carrier bearings to compensate for variations in the casting width when adjusting the ring and pinion gear (b).



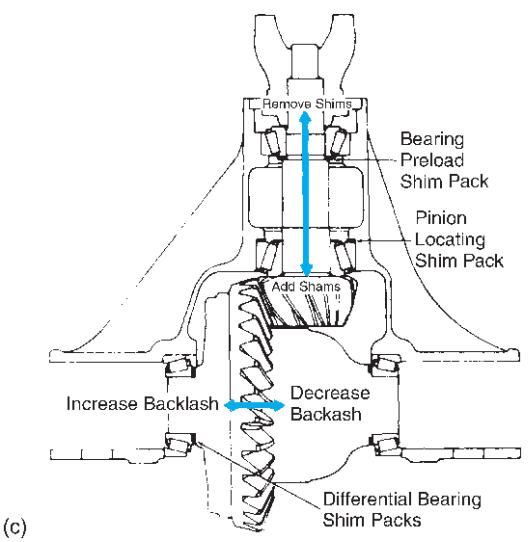


FIGURE 12-66 Pinion depth shims are usually positioned between the pinion gear head and the rear pinion bearing (a). Sometimes they are between the bearing support and the housing (b) or between the rear bearing cup and the housing (c). *(a and b are courtesy of Ford Motor Company; c is courtesy of Dana Corporation)*

TECH TIP

Some adjustments require that you insert a shim, press the bearing in place, and then check to see if you inserted a shim of the correct size. If you need to change the shim, you must pull the tight-fitting bearing back off. Some technicians make up slip-fit bearings so the shim can be easily changed. Slipfit bearings are made by honing the bearing ID to enlarge it slightly. If using a slip-fit bearing, be sure to check the bearing width and compensate for any width difference with the new bearing.

TECH TIP

Straddle-mounted pinion gears allow for easy depth shim change and adjustment because the shim is located under the bearing retainer.

There are different methods used to determine the correct size for a pinion depth shim: (1) + or − markings on the pinion gear, (2) gauge block and fixtures, (3) contact patterns, and (4) pinion depth micrometer with gear depth marking. At one time, many passenger vehicle drive pinion gears were marked with a + or − and a number that indicated the position of that gear relative to a perfect gear. The + or − indicated the direction, and the number (up to about 0.005 in.) indicated the distance. This number was etched or painted on the head or stem of the gear (Figure 12-67). When a ring and pinion gear set is replaced, the technician checks the markings on both the old and new pinion gears and changes the shim to compensate for any difference. These markings are no longer used by all manufacturers.

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 (Figure 12-68). Most gauging sets can be used only on the carriers they are designed for. There is no universal gauge set or procedure for all drive axles.

(a)

Old Pinion Marking	New Pinion Marking								
	−4	−3	−2	−1	0	+1	+2	+3	+4
+4	+0.008	+0.007	+0.006	+0.005	+0.004	+0.003	+0.002	+0.001	0
+3	+0.007	+0.006	+0.005	+0.004	+0.003	+0.002	+0.001	0	−0.001
+2	+0.006	+0.005	+0.004	+0.003	+0.002	+0.001	0	−0.001	−0.002
+1	+0.005	+0.004	+0.003	+0.002	+0.001	0	−0.001	−0.002	−0.003
0	+0.004	+0.003	+0.002	+0.001	0	−0.001	−0.002	−0.003	−0.004
−1	+0.003	+0.002	+0.001	0	−0.001	−0.002	−0.003	−0.004	−0.005
−2	+0.002	+0.001	0	−0.001	−0.002	−0.003	−0.004	−0.005	−0.006
−3	+0.001	0	−0.001	−0.002	−0.003	−0.004	−0.005	−0.006	−0.007
−4	0	−0.001	−0.002	−0.003	−0.004	−0.005	−0.006	−0.007	−0.008

(b)

FIGURE 12-67 This pinion gear has a +4 marking on it, which means its best running position is 0.004 in. more than the nominal mounting point (a). If it is replaced, a chart can be used to determine the change needed in the depth shim (b). *(Courtesy of Dana Corporation)*

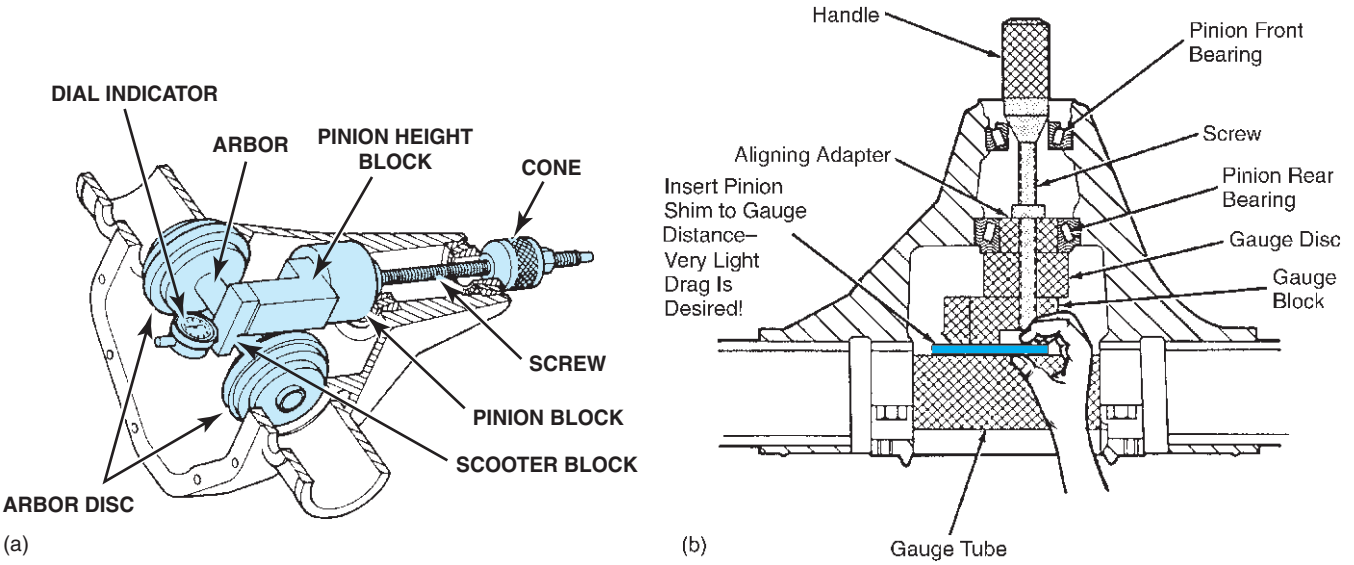


FIGURE 12-68 Some pinion depth gauging tools use a dial indicator to indicate the size of the depth shim needed (a). With others, the actual shim size is used (b). *(a is courtesy of DaimlerChrysler Corporation; b is courtesy of Ford Motor Company)*

TECH TIP

The only universal method of checking pinion depth is a gear **contact pattern**. After the carrier is assembled and adjusted, a **gear marking compound** is put on the ring gear, and the gears are rolled against each other. Improper depth will cause a high or low contact, as well as contact that is toward the toe on one side of the tooth and toward the heel on the other (see Figure 12-90). The major drawback with this method is that you have to remove the differential and disassemble the drive pinion gear in order to change the shim with an overhung pinion. The process of making and interpreting a contact pattern is described on page 380.

TECH TIP

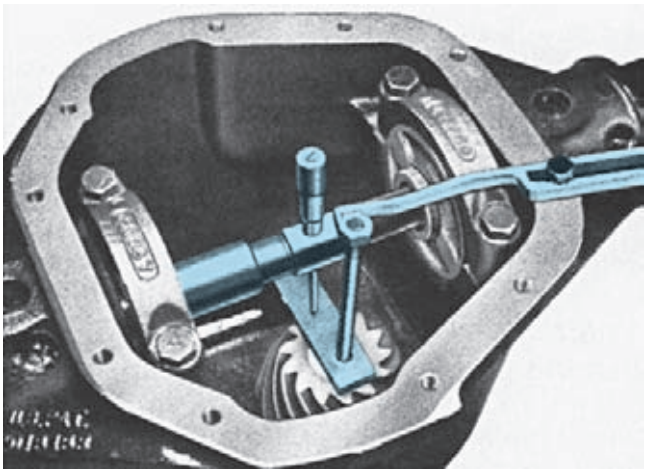
Some aftermarket drive pinion gears are marked with the actual setting distance on the head of the gear (Figure 12-69). A special depth micrometer is mounted in the carrier bearing bores to measure this distance. It is usually the distance from the center of the ring gear to the head of the pinion gear. If the distance measured is different from the pinion gear marking, the shim size is changed to make the adjustment.

TECH TIP

If the pinion gear is going to be moved deeper into the ring gear, be aware that the pinion gear will contact the ring gear. Move the ring gear away from the pinion gear before making this adjustment. Increase the backlash, and then move the pinion gear.

Because these procedures (except for the contact pattern) vary with different manufacturers, it will be necessary to follow the procedure given by the vehicle or equipment manufacturer. If using a contact pattern, assemble the new parts using the original depth shim or the nominal size recommended by the manufacturer. This shim should put the pattern in the ballpark so that correction can be made with the fewest number of shim changes.

The pinion gear and bearings on straddle-mounted pinion gears are installed in the bearing retainer, and pinion bearing preload adjusted as described on page 372. This assembly is installed into the carrier using the original depth shim or the nominal shim recommended by the manufacturer. Backlash and carrier bearing preload are adjusted as the ring gear and differential are installed (see page 375), and a contact pattern is rolled (see page 380). The contact pattern is read to determine if pinion depth is correct. If it is not, the bearing retainer is removed, the depth shim is increased or decreased, the bearing retainer and pinion gear are reinstalled, backlash



(a)

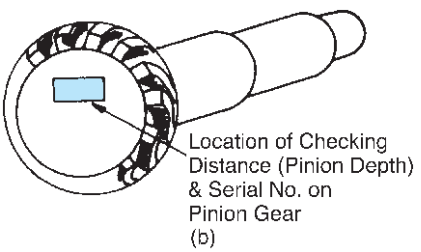


FIGURE 12-69 A pinion depth micrometer is measuring the distance from the ring gear centerline to the end of the pinion gear (a). The measured distance should be the same as that etched on the pinion gear (b). *(a is courtesy of DaimlerChrysler Corporation; b is courtesy of Richmond Gear)*

is readjusted to compensate for the pinion gear movement, and a new contact pattern is rolled. This procedure is repeated until the correct contact pattern is obtained.

Drive Pinion Bearing Preload Adjustment

After installation of the pinion depth shim 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. 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. Collapsing a crush sleeve takes a substantial amount of force.

TECH TIP

A **collapsible spacer** is normally replaced with a new one each time the pinion gear is removed or the nut is removed from the pinion shaft.

TECH TIP

In emergencies, the collapsible spacer can be reused by adding a shim right next to it.

TECH TIP

An experienced technician is concerned with two things while adjusting pinion bearing preload. One is the actual adjustment. If the bearings are too loose, the pinion gear can change mesh contact with the ring gear; this will cause noise and probable gear failure. If the bearings are too tight, a power loss will result because of the excess drag, and bearing failure will probably occur. The pinion shaft nut is the other concern. It must be tight enough to retain the preload. This is a self-locking, prevailing torque nut that should never be reused. If it is too loose on the pinion threads, it can back off and allow pinion bearing preload to disappear. The amount of torque is specified by manufacturers; a rule of thumb is a minimum of 125 ft-lb (167 N-m).

TECH TIP

It is recommended that the pinion shaft be in a vertical position during the preload adjustment. In this way, gravity moves the shaft downward and centers it in the bearing cone (Figure 12-70).

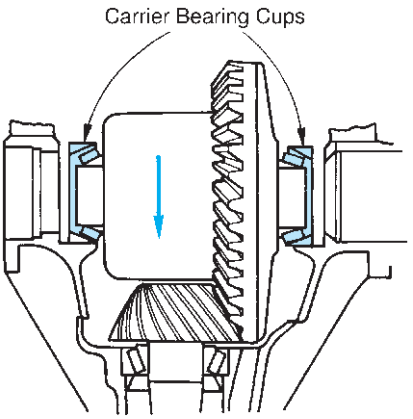
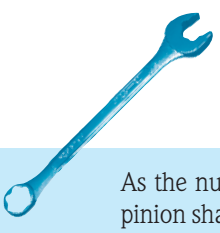


FIGURE 12-70 When checking for the size of the backlash and carrier bearing preload shims, remember that the carrier bearing cups will try to spread from the weight of the differential and thus try to give a false reading.

To adjust drive pinion bearing preload using a collapsible spacer:

1. Lubricate the bearings and slide the pinion gear with the rear bearing, depth shim, and new collapsible spacer into the carrier through the front bearing and seal (Figure 12-71).
2. Lubricate the splines and seal area, and install the companion flange, being sure to align the index marks.
3. Oil the inner face of the new nut and install it on the pinion shaft.
4. Attach a holding tool to the flange and begin tightening the nut.



TECH TIP

As the nut tightens onto the flange, rotate the pinion shaft to help seat the bearings. From this point on, rotate the pinion a turn or so for every half-turn of the nut. It is also a good practice to tap on the casting with a steel hammer to help seat the bearings.

TECH TIP

If the drive pinion preload occurs at too low a tightening torque, install a new nut and collapsible spacer and repeat this operation.

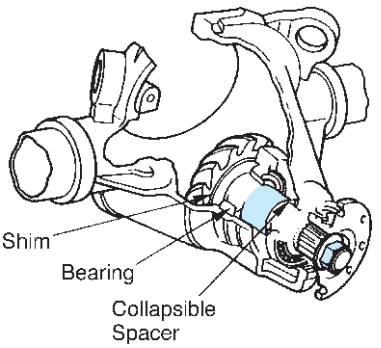


FIGURE 12-71 When the drive pinion is replaced, a new collapsible spacer and nut should be used.The bearings, seal, spline, and nut should be lubricated. *(Courtesy of Ford Motor Company)*

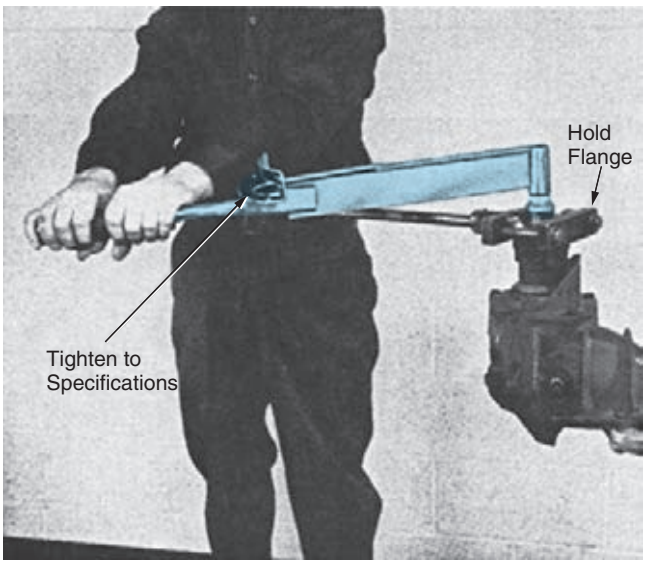
TECH TIP

Note that the bearing preload specification will vary depending on whether new or used bearings or a new seal is used. New bearings or a new seal usually require a higher amount of preload.

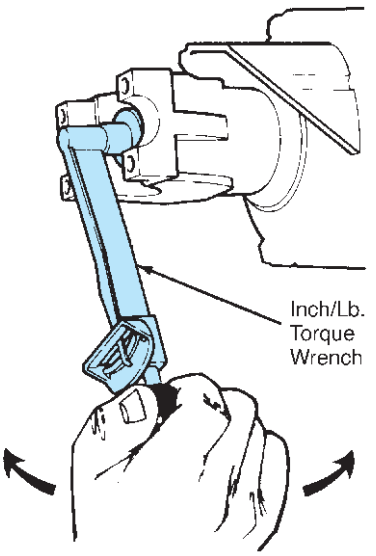
5. Continue tightening the nut as you check two things: the minimum torque to obtain the preload using a high-reading, foot-pound torque wrench and the amount of preload using a very low-reading inch-pound torque wrench (Figure 12-72). Stop tightening when the preload is within specifications.

To adjust drive pinion bearing preload using a solid spacer:

1. Install the solid spacer onto the pinion shaft with a starting shim that should be thicker than needed (Figure 12-73).
2. Follow steps 1 through 4 of the procedure used with a collapsible spacer. Torque tighten the nut to about 50 ft-lb (68 N-m) of torque.
3. If there is no free play, measure the bearing preload as described in step 5 of the collapsible spacer procedure. If the preload is within specifications, you have the correct shim; go to step 8. If the preload is too high, the starting shim will have to be replaced with a thicker one. If the preload is too low, a thinner shim is needed. If there is no preload, as expected, continue to step 4.
4. Mount a dial indicator on the carrier and position the indicator stylus on the end of and parallel to the pinion shaft (Figure 12-74).



(a)



(b)

FIGURE 12-72 The drive pinion nut should require a minimum amount of torque to crush the collapsible spacer (a). From this point, the nut is tightened until the correct preload is reached (b). *(Courtesy of Ford Motor Company)*

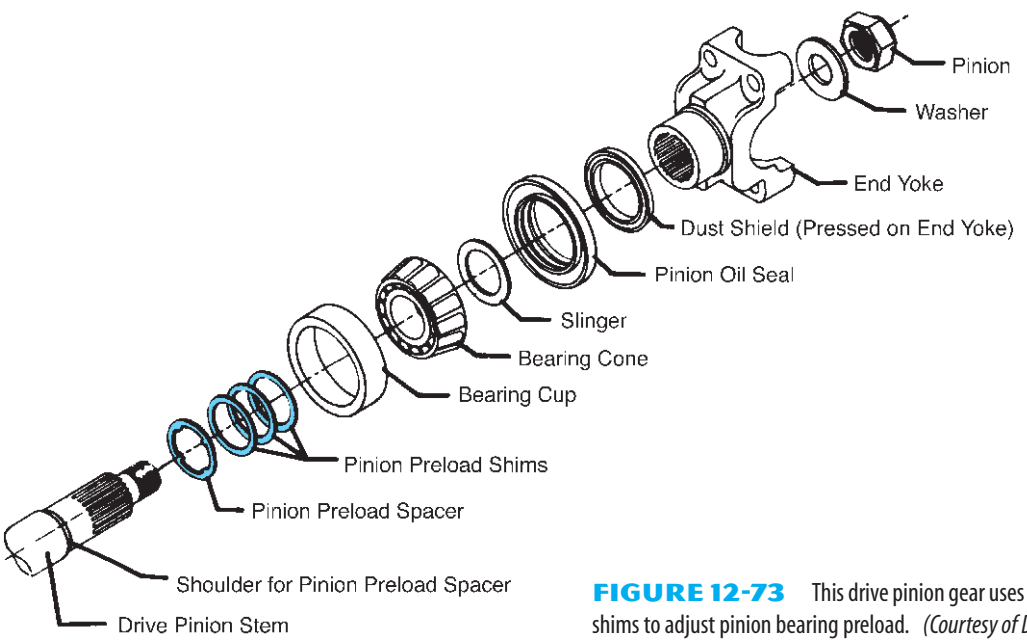


FIGURE 12-73 This drive pinion gear uses a solid spacer and a set of shims to adjust pinion bearing preload. *(Courtesy of Dana Corporation)*

TECH TIP

To select the correct preload shim, if there is a starting shim size of 0.030, 0.010 in. of free play, and a factor of 0.003, the procedure would be 0.030—0.010—0.003—0.017, for a shim size of 0.017 in.

5. Move the pinion shaft through its free play and read the dial indicator needle movement to determine the amount of free play.
6. Determine the amount of shim change by subtracting a factor specified by the manufacturer and the free play from the size of the starting shim.
7. Remove the pinion gear and replace the starting shim with the size just determined. Repeat steps 1 through 3.
8. Tighten the pinion nut to the correct torque and check pinion bearing preload as described in step 3.

FIGURE 12-74 Drive pinion end play is measured using a dial indicator. *(Courtesy of Ford Motor Company)*

Backlash and Carrier Side Bearing Preload Adjustments

These two adjustments are made at the same time as part of the installation of the ring gear and differential 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 (toward the right side) to reduce backlash, or away from the pinion (toward the left side) to increase backlash (Figure 12-75). Incorrect backlash will cause the contact pattern on both sides of the gear tooth to be too close to the heel or too close to the toe.

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. Preload is increased by moving one or both of the carrier bearing cups toward each other, and it is reduced by moving them away from each other. These adjustments are made using the threaded adjusters or by changing the shims.

To adjust backlash and carrier bearing preload using threaded adjusters:

1. Set the differential with bearing cups in place into the carrier (Figure 12-76).

TECH TIP

After carrier bearing preload has been adjusted, the overall preload of the carrier should increase a noticeable amount from the pinion bearing preload.

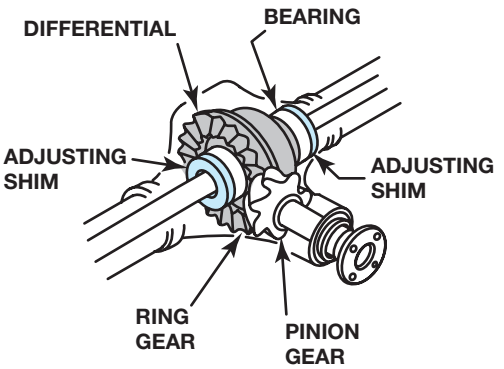


FIGURE 12-75 The sizes of the left and right shims are used to adjust ring gear backlash and bearing preload.

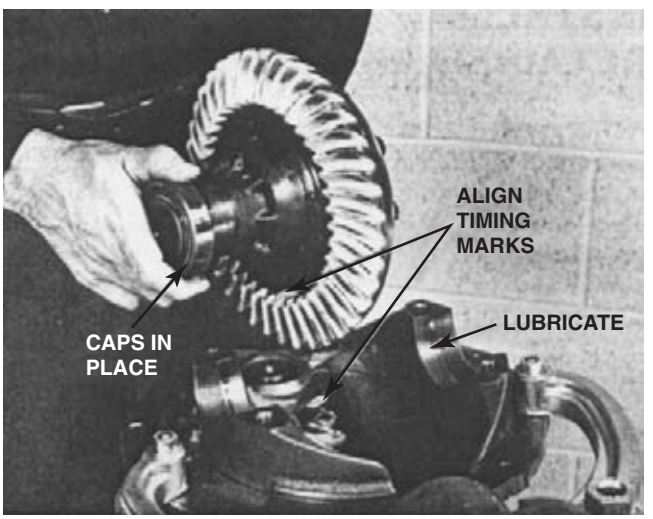


FIGURE 12-76 With threaded adjusters, the differential with bearing cups in place is set into the case. Make sure to align the timing marks on nonhunting gear sets. *(Courtesy of Ford Motor Company)*

TECH TIP

Be sure to align the index marks on the gear teeth of nonhunting and partial nonhunting gear sets.

2. Place the threaded adjusters in position and thread them next to the bearing cups (Figure 12-77).
3. Turn the adjusters to move the ring gear completely into mesh with the pinion gear so that there is no backlash and no clearance at the bearings.
4. Install the bearing caps, making sure to align your index marks. Align the bearing caps by threading the bolts into

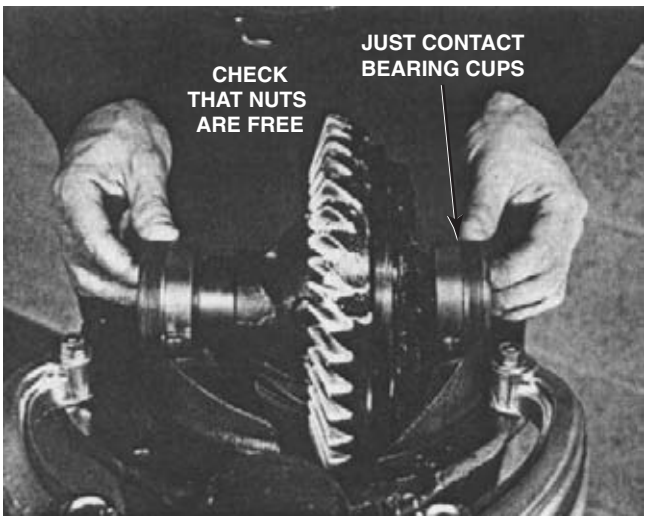


FIGURE 12-77 The threaded adjusters are set into place and rotated in their threads to just contact the cups; move the cups into contact with the bearings, and bring the ring gear into contact with the pinion gear. *(Courtesy of Ford Motor Company)*

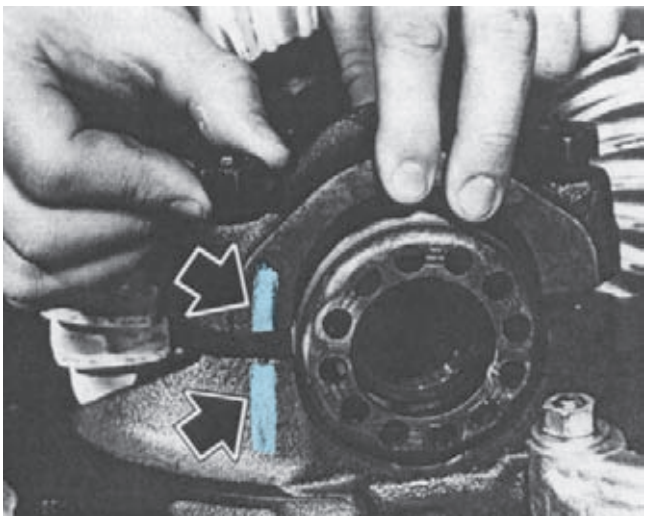


FIGURE 12-78 Start the bearing cap bolts into their threads; the bearing caps should drop into alignment with the threaded adjusters. Be sure to align the bearing cap index marks. *(Courtesy of Ford Motor Company)*

TECH TIP

Rotate the differential to seat the bearings as the adjustments are made.

TECH TIP

When the caps drop, they should sit right next to the carrier; if they don't, the adjuster is probably cross-threaded.

TECH TIP

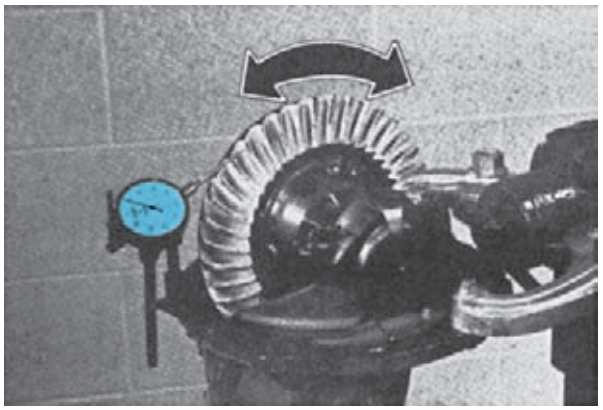
Note that an adjuster can only push inward on a bearing cup and that the other adjuster must be backed off to allow its bearing cup to move away. Thread the right adjuster inward so there is no clearance at the bearings with no preload.

TECH TIP

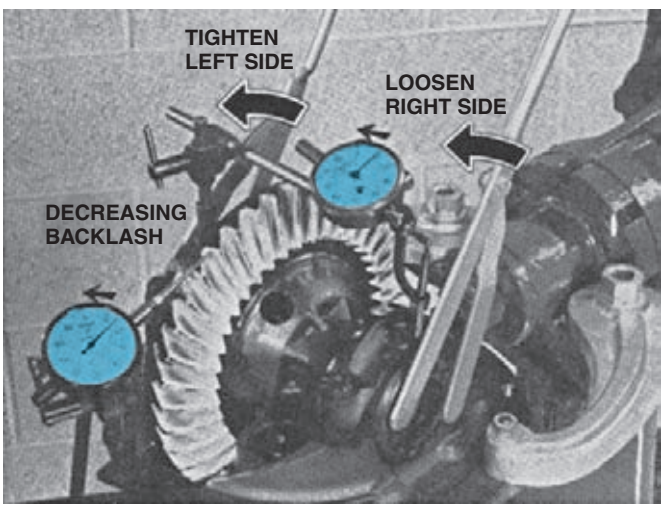
A technician found the threads in the carrier for the threaded adjuster were damaged, making the adjuster very difficult to turn. He put valve grinding compound (an abrasive paste) onto the damaged area and worked the adjuster back and forth through the threads. After about six passes, the threads were repaired. The remaining compound was removed with a thorough cleaning.

their holes as you hold the caps upward; then drop the caps into position. (Figure 12-78).

5. Tighten the bearing cap bolts so they are snug, about 10 to 20 ft-lb (13 to 27 N-m). Rotate the differential to seat the bearings.
6. Turn the adjusters to push the differential case to the left so there is a slight backlash and then back to the right until the backlash just disappears; this should be zero backlash with no load between the gears.
7. Mount a dial indicator on the carrier. Position it so that the indicator stylus is on the heel of a ring gear tooth and parallel to the ring gear in one plane while being as close as possible to tangent with the ring gear in the other plane (Figure 12-79).
8. Hold the pinion gear stationary while you try to rotate the ring gear back and forth. There should be no backlash or indicator needle motion.



(a)



(d)

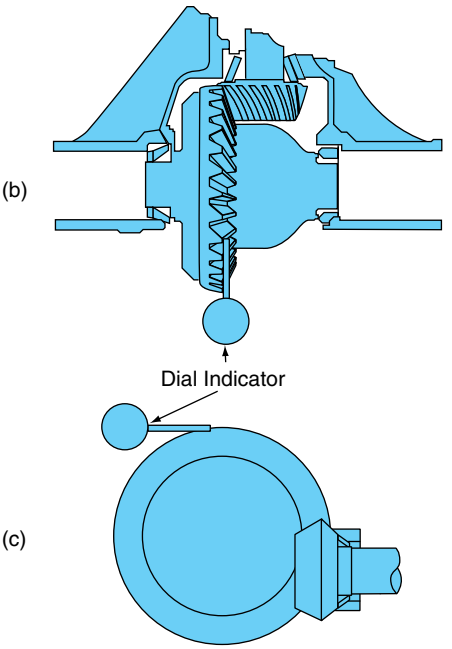


FIGURE 12-79 A dial indicator is set up with the indicator stylus on a tooth of the ring gear; the ring gear is rocked back and forth against a stationary pinion gear to measure backlash (a). The indicator stylus should be parallel to the ring gear (b) and pointed straight toward the outer edge (c). Backlash is adjusted by loosening one adjuster while tightening the other one. The second dial indicator in (d) is measuring case spread to adjust for the correct carrier bearing preload (d). *(a and d are courtesy of Ford Motor Company)*

TECH TIP

Because the right-side adjuster was stationary as the left-side adjuster was turned inward, carrier bearing preload is also being increased.

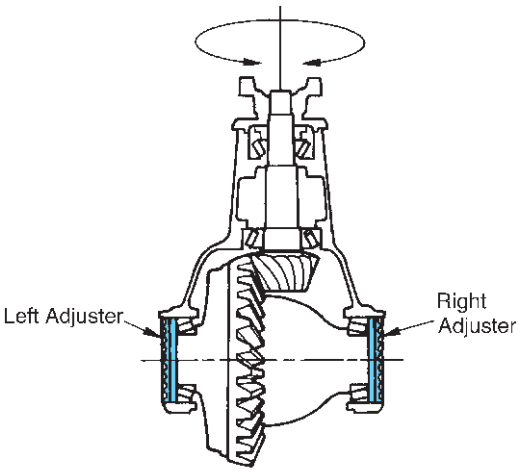
9. Keep the left-side adjuster stationary as you thread the right-side adjuster inward. Recheck backlash as you do this, and stop adjusting when the backlash is within specifications.
10. Confirm the preload adjustment by
    a. marking the right-side adjuster position and backing the adjuster off about one-half turn
    b. slowly turning the right-side adjuster back inward as you watch the rollers of that bearing (Figure 12-80); at some point, when the adjuster contacts the bearing cone, the rollers should begin to rotate
    c. turning the adjuster inward at least one full adjuster lock hole but not more than two; stop at the point where the adjuster lock will line up.

OR:

    a. back off the left adjuster one notch,
    b. set up a dial indicator with stylus touching the side of the left bearing race,
    c. turn the right bearing adjuster inward until the dial indicator shows movement of the race,
    d. remove the dial indicator and turn the left adjuster back inward one notch,
    e. turn the right adjuster inward one to two notches further.

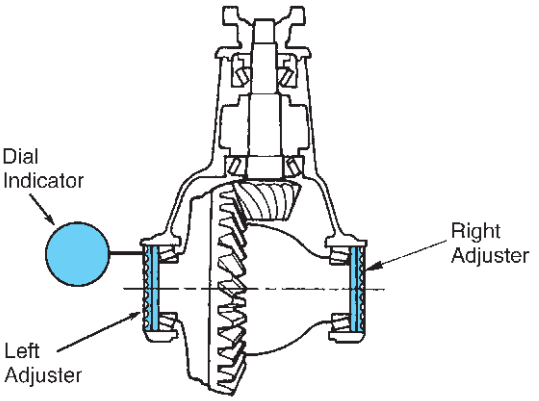
OR: Set up a dial indicator between the carrier bearing caps to measure case spread (Figure 12-81). As the adjuster is turned inward to preload the bearings, the case will spread apart and the amount of spread can be read on the dial indicator. Some manufacturers provide a case spread specification.

OR: Measure the increase in torque required to rotate the drive pinion shaft as described in page 373.



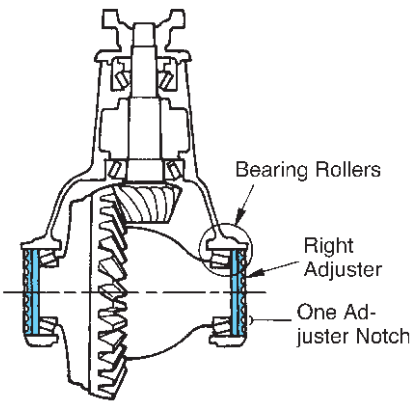
1. Measure Drive Pinion Bearing Preload.
2. Turn Carrier Bearing Adjusters Inward to Increase Preload
3. Recheck Backlash.

(a)



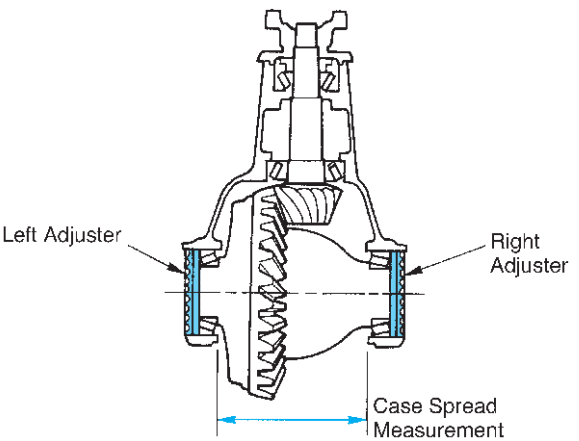
1. Set Up Dial Indicator on Left Bearing Race.
2. Turn Right Adjuster Inward Until Dial Indicator Shows Movement.
3. Turn Indicator 1 or 2 Notches Farther.
4. Recheck Backlash.

(c)



1. Turn Right Adjuster Inward Until Bearing Roller Moves.
2. Turn Adjuster 1 to 2 Notches Further.
3. Recheck Backlash.

(b)



1. Set Up for Case Spread Measurement.
2. Turn Adjuster Inward to Increase Case Spread by Proper Value.
3. Recheck Backlash.

(d)

FIGURE 12-80 Four methods of adjusting carrier bearing preload. Note that once the bearings are preloaded properly, the adjusters must be turned in equal but opposite motions if backlash must be readjusted.

11. Tighten the bearing cap bolts to the correct torque and rotate the differential to seat the bearings.
12. Recheck backlash at four or more points around the ring gear, making sure that the backlash is within specifications and that there is not too much variation. Readjust the adjusters if backlash is incorrect; at this time, you should turn one adjuster out one notch and then the other one in one notch to maintain the bearing preload. If there is excessive backlash variation, check the ring gear runout as described on page 359.
13. Install the adjuster locks, and tighten their bolts to the correct torque.

TECH TIP

Test your carrier bearing preload adjustment by trying to rock the ring gear through its backlash using just the tip of your finger. You should not be able to move it unless you hook your fingertip on a gear tooth.

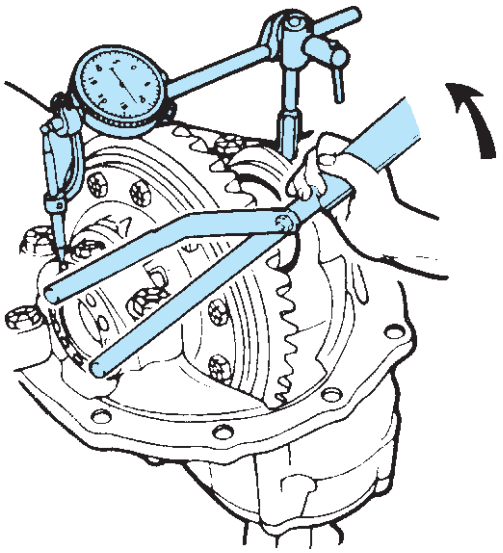


FIGURE 12-81 Turning the adjuster as shown will reduce the amount of case spread and preload on the carrier bearings and increase backlash slightly. The amount of case spread can be read on the dial indicator. *(Courtesy of Ford Motor Company)*

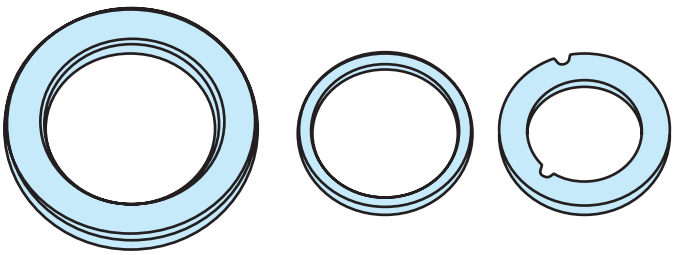
During manufacture of a carrier, the bearings and gears are adjusted using a single, cast-iron production shim at each carrier bearing. The sizes of these two shims are carefully selected to provide the proper backlash and carrier bearing preload. The production shims are normally replaced with a fixed-size **service spacer** and a selective-size shim when the carrier is adjusted. This replacement provides the shim size range that is required to readjust the slightly worn bearings and gears.

To adjust backlash and carrier bearing preload using shims:

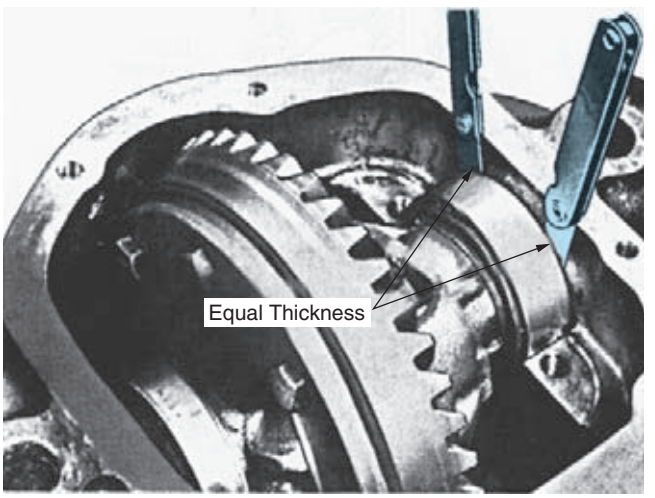
1. Set the differential with the bearing cups and ring gear into the carrier.
2. Use a group of shims, spacers, and feeler gauge pairs on each side, between the bearing cups and the carrier, so that there will be zero backlash and preload at the ring and pinion gears as well as removing any clearance at the bearings (Figure 12-82).

TECH TIP

Note that gravity tries to move the bearing cups outward from the bearings, and this can cause false readings.

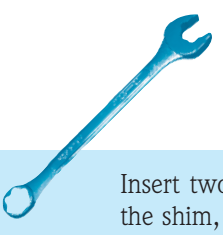


(a)



(b)

FIGURE 12-82 Cast-iron production shim (OEM use), service spacer, and shim used to adjust backlash and carrier bearing preload (a). Two feeler gauges, inserted below the middle of the race will give more accurate measurements for shim sizes (b). *(b is courtesy of DaimlerChrysler Corporation)*



TECH TIP

Insert two feeler gauges, one at each side of the shim, below the bearing cup boss so that the shims will not cock and cause a false reading.

TECH TIP

The feeler gauges should have a slight but definite drag. Be sure to rotate the differential during the final readings to ensure that the bearings are seated.

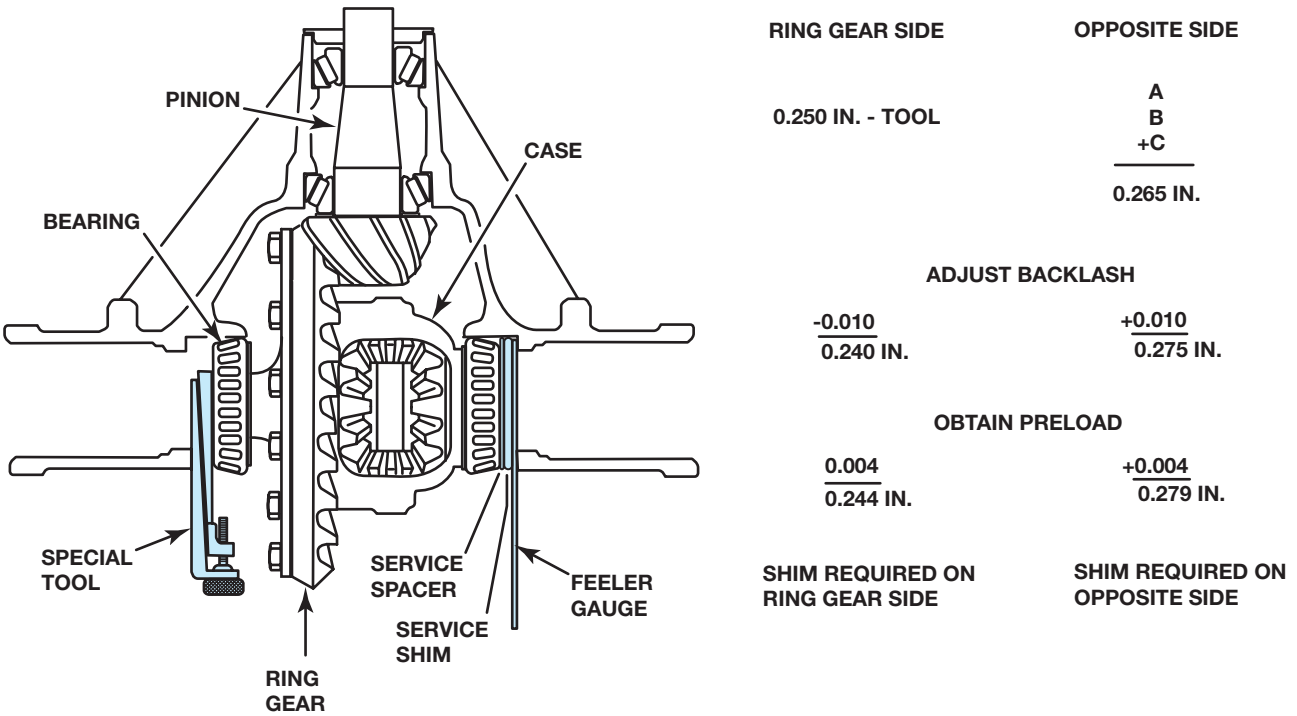


FIGURE 12-83 Procedure used to measure and determine the correct shims. Note that in this example, a special tool (J-22779) is used to measure the gap on the left side, while a service spacer, shim, and feeler gauge are used on the right side.

TECH TIP

Moving 0.002 in. (0.05 mm) of shim size will change backlash about 0.001 in. (0.03 mm).

3. Add the spacer, shims, and feeler gauges used on each side, and record these as shim sizes (Figure 12-83).
4. Adjust the shim sizes to obtain the correct amount of backlash by subtracting the specified amount from the left side and adding that amount to the right side.
5. Adjust the shim packs to obtain the correct preload by adding the specified amount to each shim pack. This will be about 0.004 to 0.006 in. (0.1 to 0.15 mm) to each side.
6. Install the selected shim. It will be necessary to use a soft hammer or a special tool to tap the second shim into place (Figure 12-84).
7. Install the bearing caps, and tighten the bolts to the correct torque.
8. Rotate the differential several turns to make sure that there is no binding and to seat the bearings. Measure the backlash as described in step 7 of the procedure for threaded adjusters. Measure the backlash at four or more locations around the ring gear to ensure that any variation is within the limits and that the backlash is within specifications. If there is too much or too little backlash, move some of the shim pack from one side to the other to correct it.

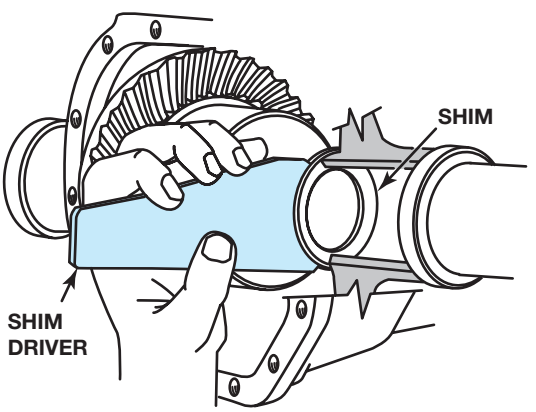


FIGURE 12-84 The last shim should be rather tight to install. It should be driven into place using either a soft hammer or special tool.

Tooth Contact Pattern Check

Most technicians use a contact pattern as a quality control check to ensure that the gear set is adjusted correctly. It may take a few minutes but can save much more time and frustration by preventing a comeback. A contact pattern is also used during a preteardown as a diagnostic check.

TECH TIP

An alternative method of adjusting backlash and carrier bearing preload is to start with too small a shim at the left side and add enough shims to obtain zero bearing clearance and preload. Now, measure the backlash and adjust the shim packs to correct backlash. Next, increase the size of both shim packs to adjust the bearing preload (Figure 12-85).

TECH TIP

Marking compound is available from some gear or vehicle manufacturers (GM gear marking compound, part number 1052351).

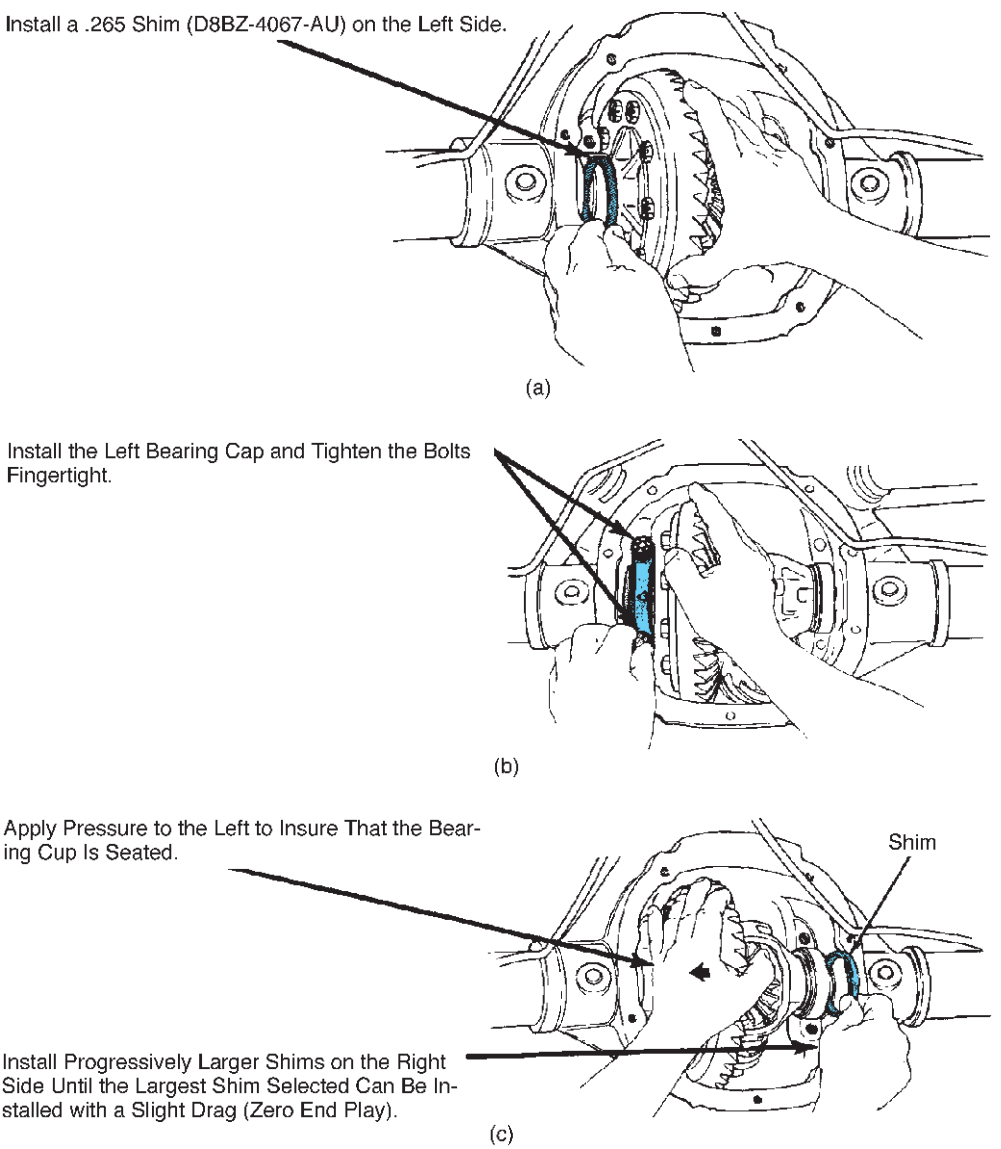
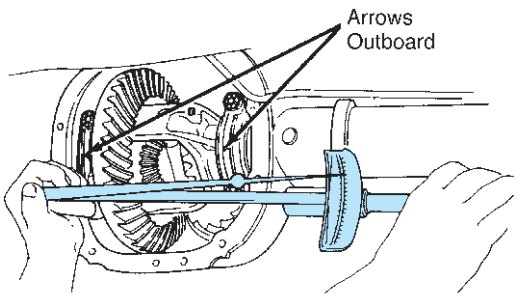
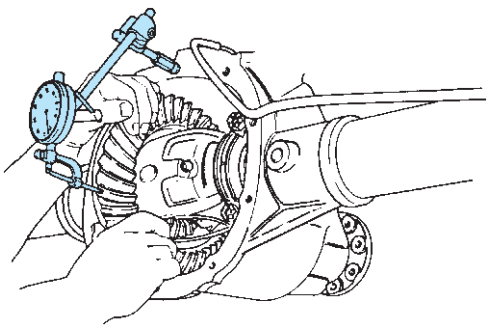


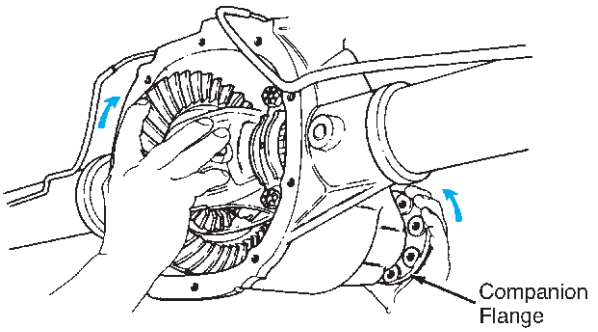
FIGURE 12-85 An alternative method of adjusting backlash and carrier bearing preload is to install a shim on the left side (a), install the left side cap, and snugly tighten the bolts (b). Install a shim that is large enough to provide a slight drag on the right side (c). *(Courtesy of Ford Motor Company)*



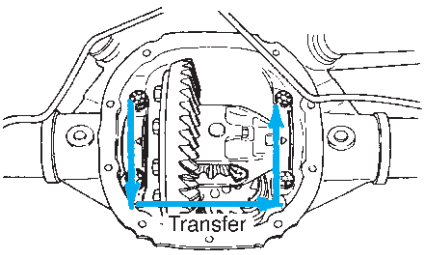
(d)



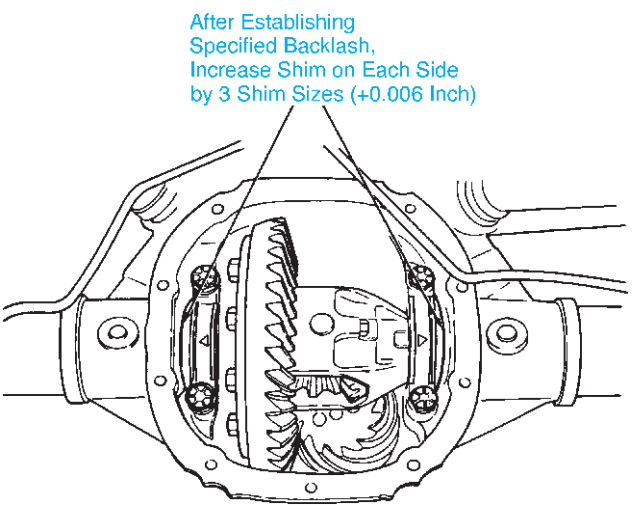
(f)



(e)



(g)



(h)

FIGURE 12-85 *(Continued)* Install the right cap and tighten the bolts (d). Rotate the ring gear to seat the bearings (e) and measure backlash (f), adjust the shims as necessary to correct backlash (g), and adjust shim sizes to get the proper bearing preload (h). *(Courtesy of Ford Motor Company)*

TECH TIP

It is best to roll a pattern in one revolution around the ring gear in each direction, leaving a pattern on both the drive and coast sides of the tooth. Going over a tooth twice tends to smear the pattern and average out the two contacts, possibly hiding a problem. Some sources use a drive-side-only pattern, but comparing the drive-side pattern to the side is very helpful in determining the exact relationship between the two gears. While rolling a contact pattern, the more pressure you can put on the gear teeth, the better and more distinct the pattern will be (Figure 12-86). A socket and long handle should be used to turn the pinion gear as braking action is placed on the ring gear by a bar, block of wood, wrench on a ring gear bolt, or parking brake (Figure 12-87).

TECH TIP

A very good substitute is artist's acrylic or oil paint in either white or yellow. Foot powder in an aerosol form can also be used; it is fast but tends to cake if you have to make an adjustment and roll a second pattern.

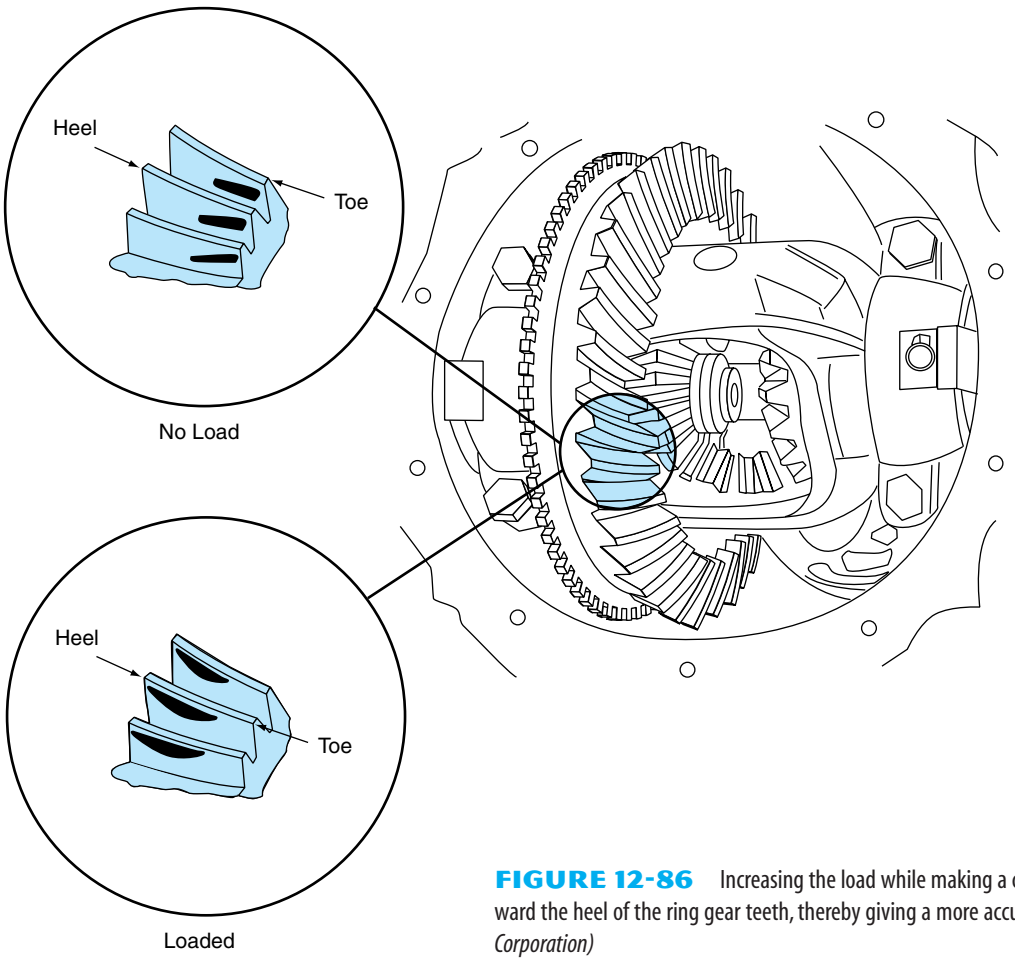


FIGURE 12-86 Increasing the load while making a contact pattern will move the pattern toward the heel of the ring gear teeth, thereby giving a more accurate check. *(Courtesy of DaimlerChrysler Corporation)*

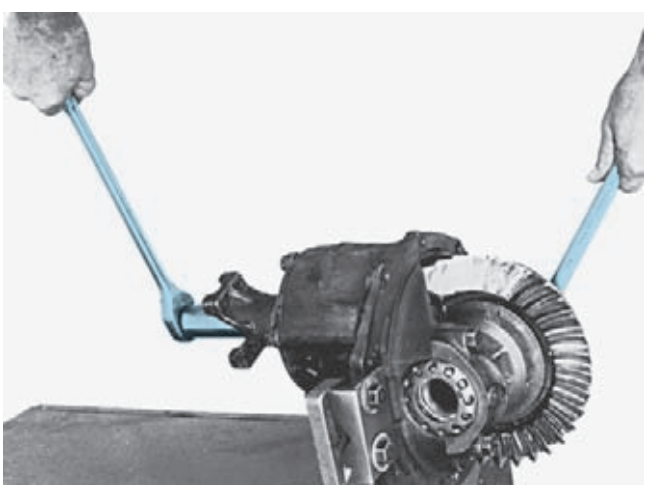


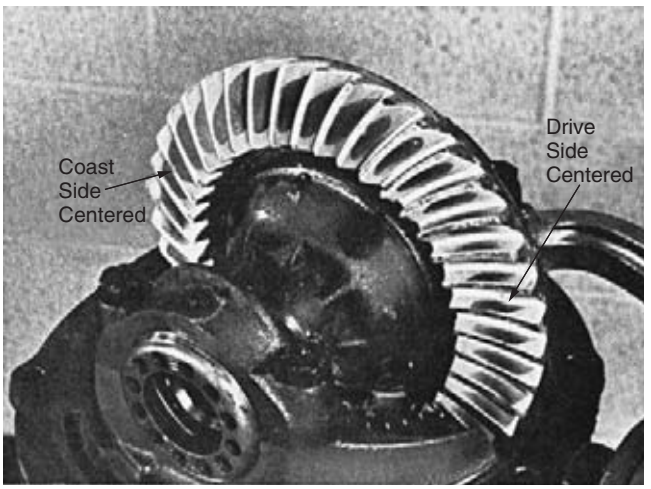
FIGURE 12-87 A gear contact pattern is the final check for a gear adjustment. The more pressure you apply between the ring and pinion gears, the sharper the contact pattern will be. Here a box wrench is on one of the ring gear bolts to load it while the pinion gear is being turned with a socket and ratchet handle.

Rolling a contact pattern is done by coating the ring gear with a marking compound and then turning the pinion gear so that its contact rubs the marking compound off the ring gear. At one time, white lead was used as the marking compound, but it is no longer available.

The pattern should appear as an elongated oval, about half the length of the gear tooth. The center of the oval should be slightly toward the toe of the tooth and midway up the tooth (Figrure 12-88). Under load, the tooth deflects more at the toe, and this will move the contact pressure more toward the heel. The pattern should not have a sharp or straight edge at either the top or bottom. Also, it should be located in the same position on both sides of the tooth.

Gear adjustments will affect the pattern in the following manner:

- Decreasing the backlash moves the ring gear closer to the pinion and will move both the drive-side and coast-side patterns lower and toward the toe.
- Increasing the backlash moves the ring gear away from the pinion and will move both the drive-side and coast-side patterns higher and toward the heel.



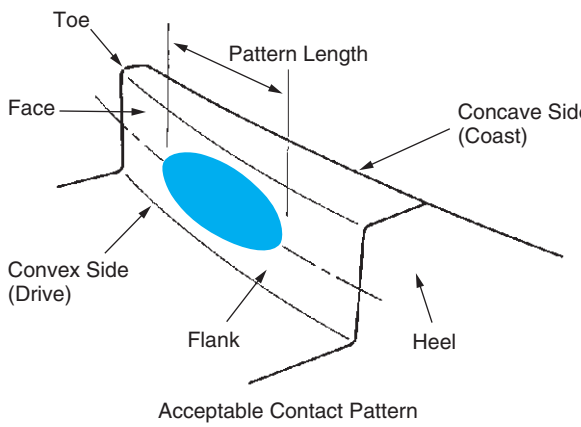


FIGURE 12-88 The ideal contact pattern will be about one-half the length of the gear tooth and slightly off-center toward the toe on both the drive and coast sides of the tooth. *(Courtesy of Ford Motor Company)*

- Changing the depth shim to move the pinion deeper, or closer to the ring gear, will move the drive-side pattern toward the toe and the coast-side pattern toward the heel (with the same backlash).
- Moving the pinion shallower, or away from the ring gear, will move the drive-side pattern toward the heel and the coast-side pattern toward the toe (with the same backlash).

To roll a contact pattern:

1. Apply a very thin film of marking compound on both sides of the ring gear teeth (Figure 12-89). Coat all of the teeth; if you are not concerned with ring or pinion gear runout, coat only a 6- to 10-tooth section.
2. Either use a wrench to turn the pinion gear as you brake the ring gear, or vice versa. Rotate the pinion gear through the marking compound once in each direction.
3. Check the pattern on both sides of the ring gear teeth and compare the pattern to those shown in Figure 12-90.

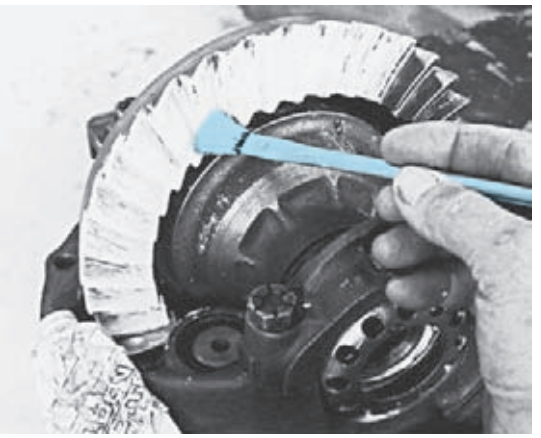


FIGURE 12-89 The marking compound should be applied in a very thin coating over the entire gear tooth.

TECH TIP

If you coated the entire ring gear, check for a pattern variation. One steady change in pattern indicates ring gear runout; two or more changes in pattern indicate pinion gear runout (Figure 12-91).

4. If the pattern shows good contact, complete reassembly of the axle. If the pattern is incorrect, adjust the ring or pinion as necessary and roll another pattern to check your adjustment.

Limited Slip Differential Service

In most cases, this operation involves disassembly and reassembly of the differential with a replacement of worn parts. It can also include adjusting the clearance or preload of the clutch packs and a bench check for rotating torque. Cone clutch limited slip differentials use a split case, which

TECH TIP

If the clutch plates are to be reused, they should be replaced in their original positions. Restacking the plates in different positions will result in increased wear and diminished performance.

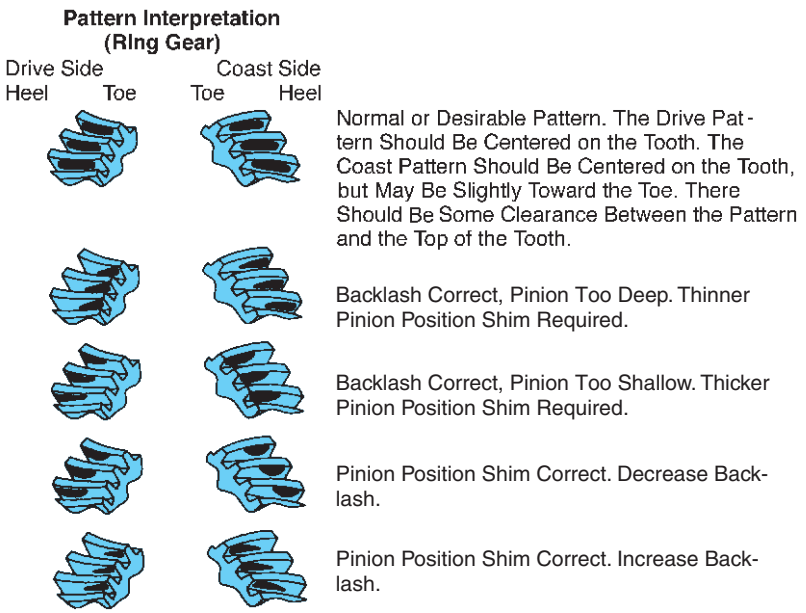


FIGURE 12-90 An incorrect pattern indicates what adjustment is needed. *(Courtesy of Dana Corporation)*

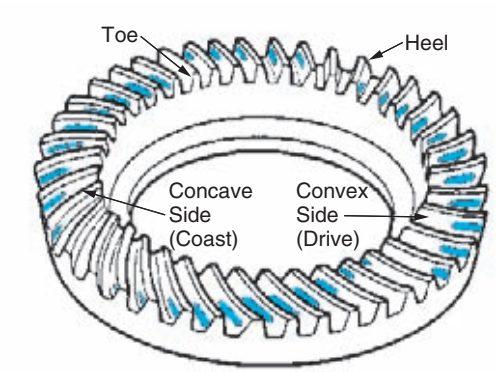
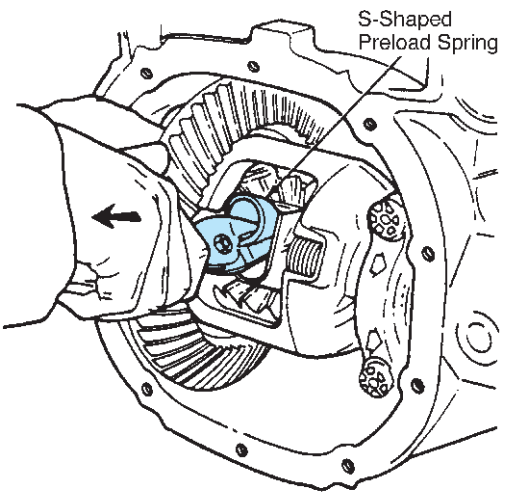
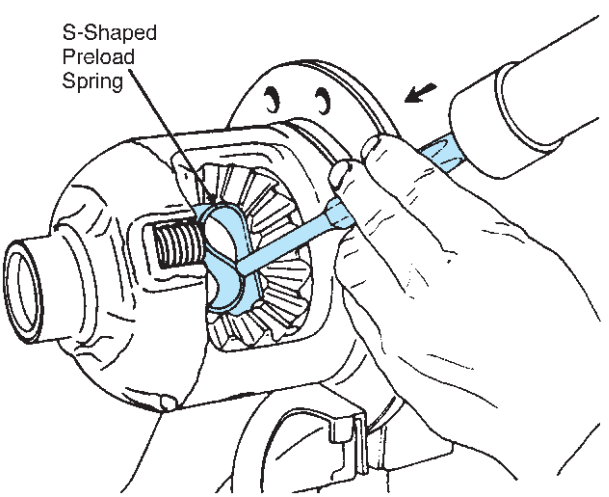


FIGURE 12-91 A pattern that changes as it goes around the ring gear is caused by ring gear runout (one pattern change) or pinion gear runout (several pattern changes).



(a)



(b)

FIGURE 12-92 The preload spring on this differential can be removed using a pair of pliers (a) or a soft punch (b). *(Courtesy of Ford Motor Company)*

makes disassembly easy; plate clutch units are serviced through the case window. This means that you have to rotate the differential gears to the window or from the window to their proper position against the resistance of the clutch packs' preload.

To disassemble a plate clutch limited slip differential:

1. Carefully remove the S-shaped preload spring by tapping it through the window using a punch and hammer, or pulling it out with pliers (Figure 12-92).
2. Roll the differential pinions around to the case windows, and remove them.
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.

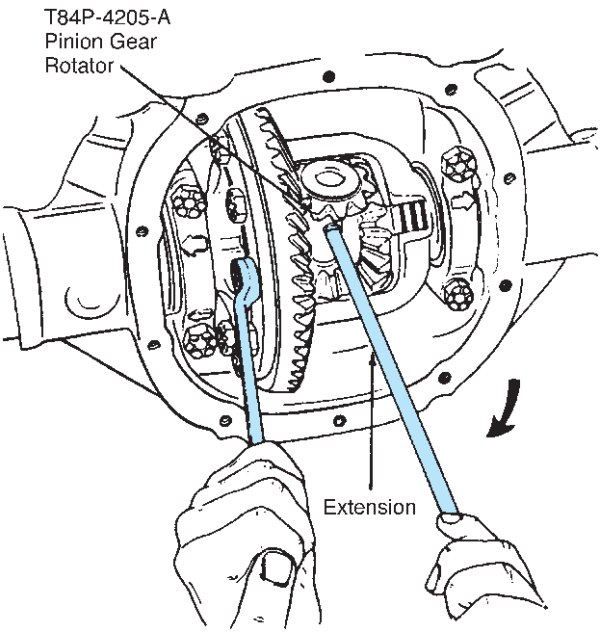


FIGURE 12-93 Because of the clutch pack preload, a rotator is needed to roll the pinion gears around to the differential case windows for removal. *(Courtesy of Ford Motor Company)*

TECH TIP

In some units, there is enough preload on the clutch plates to require the use of a gear rotator (Figure 12-93).

4. Clean the parts by wiping the friction surfaces with a cloth; do not use solvent on them. The differential case and pinion gears can be washed in solvent.
5. Inspect the differential parts as described in Chapter 8 on page 220. The clutch plates or cones should be checked for scores, grooves, or galling.

Reassembly of most limited slip differentials is a reverse of the disassembly procedure. Be sure to lubricate all of the friction surfaces with the recommended gear oil. Some differentials use a shim to set the clutch pack for the correct preload or clearance; this adds a step in the reassembly procedure for determining the pack height and shim size (Figure 12-94).

TECH TIP

The clutch pack surfaces must be thoroughly lubricated with the proper lubricant during assembly (Figure 12-95). One manufacturer recommends soaking them in the lubricant for 20 minutes.

TECH TIP

A pair of old axle shafts may also be used to make a bench check of limited slip clutch holding power.

TECH TIP

In some differentials, the inner hub of the clutch pack is separate from the axle gear. An axle should be slid through them to keep the two sets of splines aligned as the assembly is tightened.

Tools are available to bench check a limited slip differential to make sure that there is enough holding power at the clutches (Figure 12-96).

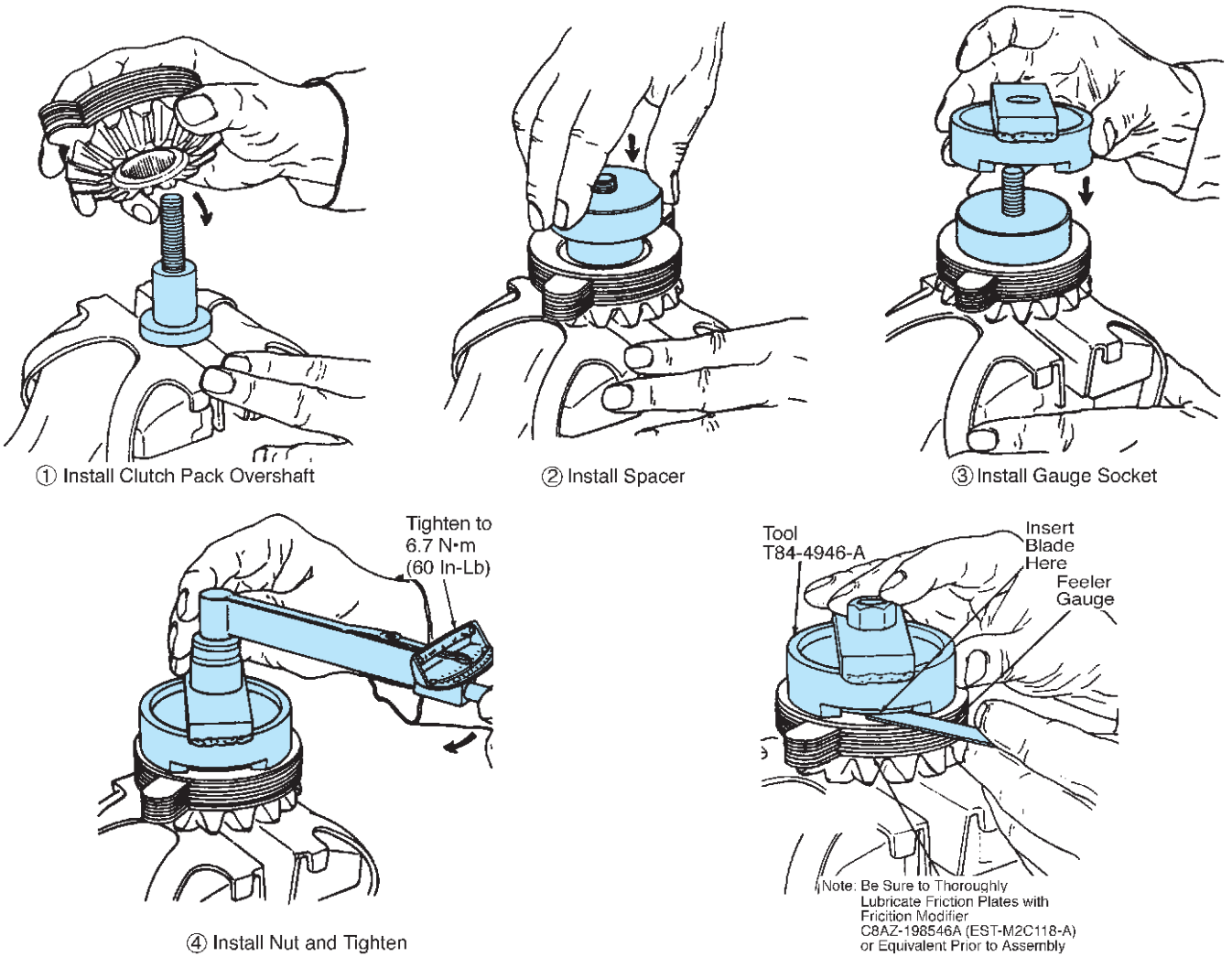


FIGURE 12-94 A five-step procedure using a special gauging set is followed to determine the pack height and the shim size needed to obtain the correct pack preload. *(Courtesy of Ford Motor Company)*

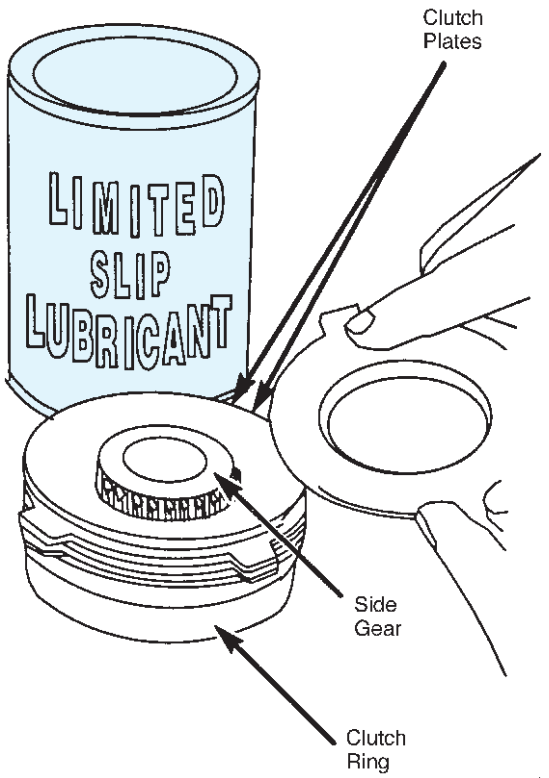


FIGURE 12-95 The clutch plates should be lubricated, using the proper type of lubricant, as they are assembled. *(Courtesy of DaimlerChrysler Corporation)*

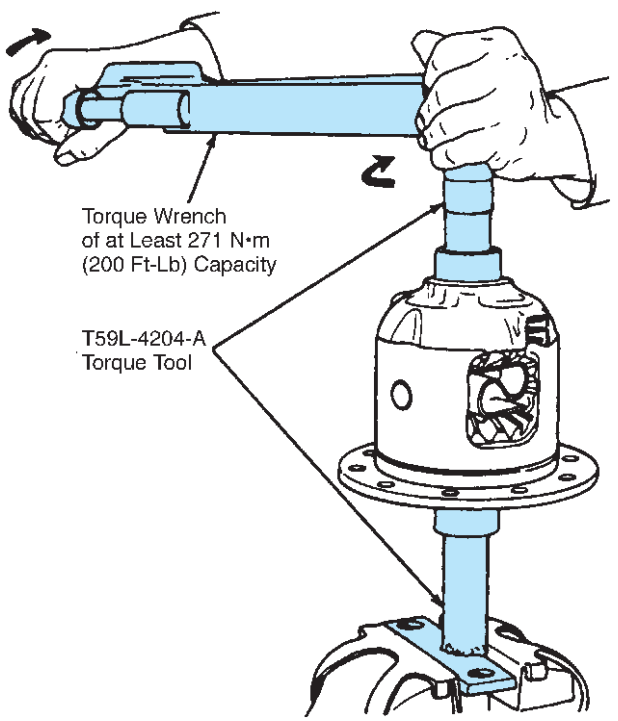


FIGURE 12-96 Torque tools allow the breakaway torque of this limited slip differential to be measured before the differential is installed into the carrier. *(Courtesy of Ford Motor Company)*

REAL WORLD PROBLEM

Imagine that you are working in a general automotive repair shop and these problems are brought to you.

Case 1

You've just finished assembling the carrier and are adjusting backlash. The specification is 0.004 to 0.008 in. You adjusted the backlash to 0.006 in., but when you recheck it, you measure 0.004 in. at one tooth and 0.010 in. at another. Is this acceptable? If not, what is probably wrong? What should you do next?

Case 2

You've assembled the Ford 9-in. axle and completed the adjustments. When you run a tooth contact pattern, the contact shows high on the heel of the drive side and on the toe of the coast side with almost a straight line at the outer edges. What should you do to correct it?

Case 3

You've just assembled a Dana 60 rear axle (Salisbury style) and you encounter the same problem as in Case 2. Do you need to make the same correction? If so, what do you need to do to make it?

SUMMARY

1. Drive axles must have clean gear oil at the proper level and of the proper type.
2. The cause of improper drive axle operation is determined using several diagnostic steps.
3. Some drive axle problems can be repaired on-vehicle.
4. Major internal transmission problems usually require that the drive axle be removed from the vehicle.
5. Drive axle disassembly and reassembly varies between different makes and models.
6. Presses and pullers are often required for complete disassemly.
7. A thorough cleanup is done so parts can be inspected.
8. Gears, bearings, and differentials are the major wear components.
9. Four ring and pinion adjustments are required: pinion depth, pinion bearing preload, carrier bearing preload, and backlash.
10. Proper adjustment can be confirmed with a tooth contact pattern check and pinion shaft turning effort check.

REVIEW QUESTIONS

1. The oil level in a drive axle is usually even with the _____ of the fill opening.
2. Drive axle diagnosis starts with a _____ test and a _____ level check.
3. The four driving conditions used to diagnose a drive axle problem are

   a. _____ b. _____
   c. _____ d. _____

4. _____ is the driving condition when the throttle is closed and the vehicle is decelerating.
5. To remove a _____ retained axle, the differential pinion shaft must be removed.
6. A hole in the axle _____ allows for access to the bolts that secure the axle retainer.
7. _____ axles are removed by unbolting the axle flange bolts and sliding the axle out of the housing.
8. After the axle is removed, the axle seal is easily removed with a _____ _____ and an adapter.
9. Before pressing a bearing off an axle, the _____ _____ must be removed.
10. Before removing the carrier bearing caps, they should be _____ to identify the side and direction for reinstallation.
11. Drive pinion _____ is most often adjusted by a _____ behind the rear drive pinion bearing.
12. Integral carriers use shims to adjust carrier bearing preload and backlash. Adding a shim to the ring gear side of the carrier and removing an identical-size shim from the other side will _____ backlash.
13. Carrier bearing preload is adjusted in an integral carrier by adding a _____ shim to each side of the carrier.
14. The ideal ring and pinion contact pattern will be about _____ _____ the length of the gear tooth and slightly off-center toward the toe.
15. The clutch plates of a limited slip differential should be thoroughly _____ as the differential is assembled.

CHAPTER QUIZ

1. While discussing drive axle gear oil checks, Student A says that the oil level should be even with the bottom of the filler hole in all drive axles. Student B says that a tag is mounted at the filler hole of axles that require special lubricant. Who is correct?
   a. Student A
   b. Student B
   c. Both A and B
   d. Neither A nor B

2. A drive axle makes a howling sound during drive conditions. Student A says this is probably caused by a faulty ring and pinion gear adjustment. Student B says it could be caused by a bad axle bearing. Who is correct?
   a. Student A
   b. Student B
   c. Both A and B
   d. Neither A nor B

3. The vehicle owner's complaint is a clunking noise when the transmission is shifted from reverse to drive. This is probably caused by (A) excessive excessive ring gear backlash; (B) wear in the differential. Which is correct?
   a. A only
   b. B only
   c. Both A and B
   d. Neither A nor B

4. A vehicle makes a chattering noise while turning corners, which is most noticeable after driving straight for a few miles. Student A says that this is a fairly common problem with limited slip differentials and that it might be cured by changing the gear oil. Student B says that this type of noise is caused by a chipped differential pinion gear or worn differential pinion shaft. Who is correct?
   a. Student A
   b. Student B
   c. Both A and B
   d. Neither A nor B

5. Student A says that an axle shaft is held in the housing by a C-clip, which keeps the shaft from coming out of the differential side gear. Student B says that the bolts holding the brake backing plate to the axle housing also hold some axles in place. Who is correct?
   a. Student A
   b. Student B
   c. Both A and B
   d. Neither A nor B

6. Student A says that excessive radial play of the axle at the outer end can be caused by a worn axle. Student B says that a gear oil leak onto the brakes can be caused by a bad seal or a gear oil level that is too high. Who is correct?
   a. Student A
   b. Student B
   c. Both A and B
   d. Neither A nor B

7. Student A says that some axle bearings can explode as they are being pressed from the shaft. Student B says that the axle bearing used on most C-lock axles comes without an inner race. Who is correct?
   a. Student A
   b. Student B
   c. Both A and B
   d. Neither A nor B

8. Student A says that a carrier with faulty drive pinion bearings should be removed from the vehicle and overhauled at the repair bench. Student B says that with integral carrier axles, this can be done with the carrier in the vehicle. Who is correct?
   a. Student A
   b. Student B
   c. Both A and B
   d. Neither A nor B

9. Student A says that ring gear runout can be caused by sloppy installation of the ring gear onto the differential case. Student B says that ring gear runout can cause the backlash to be okay at one portion of the ring gear and not okay at another. Who is correct?
   a. Student A
   b. Student B
   c. Both A and B
   d. Neither A nor B

10. As a carrier is disassembled, it should be checked for
    a. worn or damaged ring and pinion gears.
    b. rough bearings.
    c. excessive lash in the differential.
    d. all of these.

11. A thicker drive pinion shim will move the pinion gear (A) inward and deeper into the ring gear; (B) outward and less deep into the ring gear. Which is correct?
    a. A only
    b. B only
    c. Both A and B
    d. Neither A nor B

12. Student A says that if you install a thicker shim at the ring gear side carrier bearing, the backlash will decrease. Student B says that this will increase carrier bearing preload. Who is correct?

a. Student A
b. Student B
c. Both A and B
d. Neither A nor B

13. Student A says that part of the tightening force you put on the pinion nut is making the collapsible spacer shorter. Student B says that a new nut and collapsible spacer should be used when you install a pinion gear. Who is correct?

a. Student A
b. Student B
c. Both A and B
d. Neither A nor B

14. Student A says that a contact pattern close to the heel on both the drive and coast sides of the gear tooth is caused by improper pinion depth. Student B says that contact toward the heel on the drive side and toward the toe on the coast side is caused by excessive backlash. Who is correct?

a. Student A
b. Student B
c. Both A and B
d. Neither A nor B

15. Student A says that carrier bearing preload is adjusted using a dial indicator and that backlash is adjusted by carefully watching the gear movement. Student B says that backlash that is only 0.001 in. tight at one location is okay if it is within specifications everywhere else. Who is correct?

a. Student A
b. Student B
c. Both A and B
d. Neither A nor B