MODULE CONTENT

| Unit of Competency | **DIAGNOSE AND OVERHAUL DIFFERENTIAL** |
| --- | --- |
| Module Title | **DIAGNOSING AND OVERHAULING DIFFERENTIAL** |
| Module Descriptor | This unit identifies the competence required to diagnose and overhaul the differential. |
| Nominal Duration | **hours** |
| Summary of the Learning Outcomes: | |
| Upon completion of this module the student must be able to: | |
| LO1. Prepare to diagnose differential assembly | |
| LO2. Diagnose differential assembly | |
| LO3. Disassemble and evaluate differential assembly and components | |
| LO4. Assemble differential assembly and components | |
| LO5. Complete work processes | |

**LEARNING EXPERIENCES**

**LEARNING OUTCOMES NO.3**

**DISASSEMBLE AND EVALUATE DIFFERENTIAL ASSEMBLY AND COMPONENTS**

| **Learning Activities** | **Special Instructions** |
| --- | --- |
| Read Information Sheet 3.1-1 Disassemble and evaluate differential assembly and components | If you have some problem with the content of the information sheet don’t hesitate to approach your Trainer.  If you feel that you are now knowledgeable on the content of the information sheet, you can now answer the self-check provided in the module. |
| Answer Self-Check 3.1-1 on Disassemble and evaluate differential assembly and components | Try to answer the Self-check without looking at the Answer Key  Compare your answer to Answer Key 3.1-1 |
| Observe Trainer’s demonstration on Task Sheet 3.1-1 on Disassemble and evaluate differential assembly and components | Listen carefully and attentively so that you may be able to perform a task correctly  Ask questions if are in doubt for clarification |
| Perform the Task Sheet 3.1-1 on Disassemble and evaluate differential assembly and components | Remember the step-by-step procedure the Disassemble and evaluate differential assembly and components |
| Evaluate the performance using the Performance Criteria Checklist 3.1-1 | Repeat the task in case fail to meet the criteria |

**INFORMATION SHEET 1.1-1**

**DISASSEMBLE AND EVALUATE DIFFERENTIAL ASSEMBLY AND COMPONENTS**

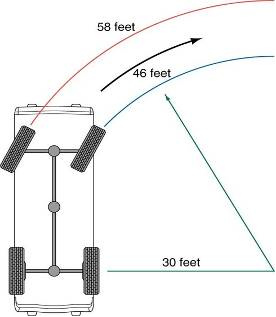
**Learning Objectives:**

After reading this **Information Sheet**, you must be able to:

1. Made final inspection.
2. Turned-over vehicle.
3. Restored work area.
4. Managed wastes.
5. Checked and stored tools and equipment.
6. Accomplished workplace documents.

**DIFFERENTIAL AND DRVE AXLES**

The differential is a geared mechanism located between the driving axles of a vehicle. It rotates the driving axles at different speeds when the vehicle is turning a corner **(Figure 38-21).** It also allows both axles to turn at the same speed when the vehicle is moving in a straight line.



**Figure 38-21** Travel of wheels when a vehicle is turning a corner.

The drive axle assembly directs driveline torque to the vehicle’s drive wheels. The gear ratio of the drive axle’s ring and pinion gears is used to increase torque. The differential serves to establish a state of balance between the forces between the drive wheels and allows the drive wheels to turn at different speeds when the vehicle changes direction.

On FWD car or truck, the differential is normally an integral part of the transaxle assembly located at the front of the vehicle. Transaxle design and operation depends on whether the engine is mounted transversely or longitudinally. With a transversely mounted engine, the crankshaft centreline and drive axle are on the same plane. With a longitudinally mounted power plant, the differential must change the power flow 90 degrees.

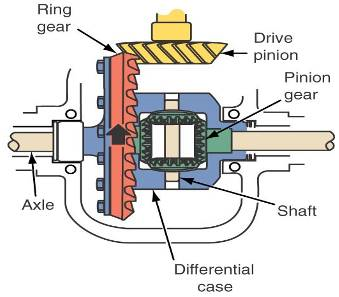
On RWD vehicles, the differential is located in the rear axle housing or carrier. The drive shaft connects the transmission with the rear axle gearing. Four-wheel-drive vehicles have differentials on both their front and rear axle.

The differential allows the drive wheels to rotate at different speeds when negotiating a turn or curve in the road and redirects the engine torque from the drive shaft to the rear drive axle shafts. The drive shaft turns in a motion perpendicular to the rotation of the drive wheels. The final drive gears redirect the torque so that the drive axle shafts turn in a motion parallel to the rotation of the drive wheels.

The final drive gears in the drive axle assembly are also sized to provide a gear reduction, or a torque multiplication. Axles with a low (numerically high) gear ratio allow for fast acceleration and good pulling power. Axles with high gear ratios allow the engine to run slower at any given speed, resulting in better fuel conservation.

**Differential Components**

The components of commonly used final drive units are shown in **Figure 38-22**. There are several other basic design arrangements. However, the most commonly used design has pinion/ring gears and a **pinion shaft**. The later is normally a spiral bevel gear mounted on an input (pinion) shaft. The shaft is mounted in the front end of the carrier and supported by two or three bearings. An overhung pinion gear is supported by two tapered bearing spaced far enough apart to provide the needed leverage to rotate the ring gear and drive axles.



**Figure 38-22 The component of a typical final drive unit.**

A straddle mounted pinion gear rests on three bearings: two tapered bearings on the front support the input shaft and one roller bearing is fitted over a short shaft extending from the rear end of the **pinion gear.**

The pinion gear meshes with a **ring gear.** The ring gear is a ring of hardened steel with curved teeth on one side and threaded holes on the other. The ring gear is bolted to the differential case. When the pinion gear is rotated by the drive shaft, the rig gear is forced to rotate, turning the differential case and axle shafts. In most automotive application, two pinions gears are mounted on a straight shaft in the differential case. On heavier trucks, the differential contains four pinion gears mounted on a cross-shaped spider in the differential case. The pinion shafts are mounted in holes in the case (or in matching grooves in the case halves) and are secured in place with a lock bolt or retaining rings.

Ring and pinion gears are normally classified as hunting, nonhunting, or partial nonhunting gears. Each type of gearset has its own requirements for a satisfactory gear tooth contact pattern. These classifications are based on the number of teeth on the pinion and ring gears.

v *Hunting Gearset.* When one drive pinion gear tooth contacts every ring gear tooth after several revolutions, the gearset is a **hunting gearset.** In other words the drive pinion hunts out each ring gear tooth. A typical hunting gearset may have nine drive pinion teeth and thirty-seven ring gear teeth. The rear-axle ratio for combination would be 4.11:1.

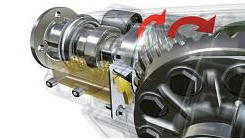
v *Nonhunting Gearset.* When one drive pinion gear tooth contacts only certain ring gear teeth, the gear is a **nonhunting gearset.** A typical nonhunting gearset may have ten drive pinion teeth and thirty ring gear teeth. The rear-axle ratio for this combination would be 3.00:1.For every revolution of the ring gear, each drive pinion tooth would contact the same three teeth of the ring gear. The drive pinion gear teeth do not hunt out all ring gear teeth.

v *Partial Nonhunting Gearset.* The difference between nonhunting and a **partial nonhunting gearset** is the amount of ring gear teeth that are contacted. In a partial nonhunting gearset, one drive pinion tooth contacts six ring gear teeth instead of three. During the first revolution of the ring gear, one drive pinion contacts three ring gear teeth. During the second revolution of the ring gear, the drive pinion tooth contacts three different ring gear teeth. During the other ring gear revolution, one drive pinion tooth contact the same ring gear teeth. A typical partial nonhunting gearset may have ten drive pinion teeth and thirty-five ring gear teeth. The rear axle ratio for this combination would be 3.50:1.

The number of the teeth on the drive pinion and ring determine whether the gearset is hunting, nonhunting, partial nonhunting. Knowing the type of gearset in important in diagnosing ring and pinion problems.

A **hypoid gear** contacts more than one tooth at a time. The hypoid gear also makes contact with a sliding motion. This sliding action, however, is smoother than that of the spiral gear, resulting in quieter operation. The biggest difference is that, in a hypoid gear, the centrelines of the ring and the pinion gears do not match. Using hypoid gears, the drive pinion gear is placed lower in the differential. The drive pinion meshes with the ring gear at a point below its centreline.

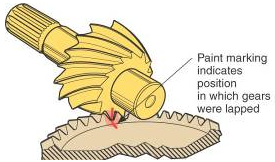
The sliding effects of two hypoid gears meshing tend to wipe lubricant from the face of the gears **(Figure 38-23),** resulting in eventual damage. Differentials require the use of extreme pressure-type lubricants. The additives in this type of lubricant allow the lubricant to withstand the wiping action of the gear teeth without separating from the gear face.



**Figure 38-23**  The flow of oil in a hypoid gear set as it spins. *Courtesy of Dana Corporation*

The differential also contains two side gears. The inside bore of the side gears is splined and mates with splines on the ends of the axles. The differential pinion gears are mounted on a pinion gear shaft, which is mounted in the differential casing. As the casing turns with the ring gear, the pinion shaft and gears also turn. The pinion gears deliver torque to the side gears.

When the pinion and ring gears are manufactured, the faces of the gear teeth are machined to provide smooth mating surfaces. The pinion gear and ring gears are always matched to provide a good mesh **(Figure 38-24).** Pinion gears and the ring gears should always be installed as a set. Otherwise, the mismatched gearset code is etched in each drive pinion and ring gearset.

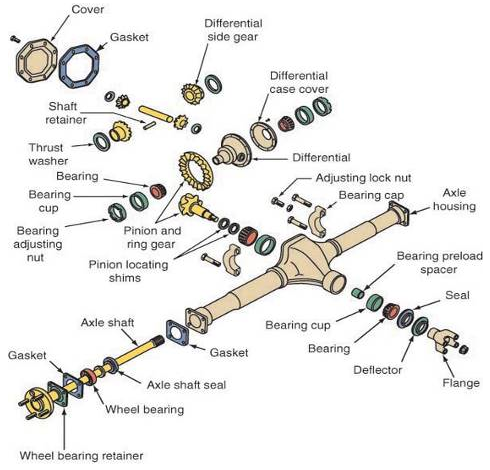


**Figure 38-24** Index marks on a ring and pinion gearset. *Courtesy of Ford Motor Company*

**Rear Axle Housing and Casing**

The differential and final drive gears in a rear-drive-vehicle are housed in the rear axle housing, or carrier. The axle housing also contains the two drive axle shafts. Two types of axle housing are found on modern automobiles: the removable carrier and the integral carrier. The removable carrier axle housing is open on the front side. Because it resembles a banjo, it is often called banjo housing. The backside of the housing is closed to seal out dirt and contaminants and keep in the lubricant. The differential is mounted in a carrier assembly that can be removed as a unit from the axle housing **(Figure 38-25).** Removable carrier axle housings are most commonly used today on trucks and other heavy-duty vehicles.

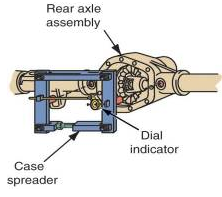
The **integral housing** is most often found on late-model cars and light trucks **(Figure 38-26).** A cast-iron carrier forms the center of the axle housing. Steel axle tubes are passed into both sides of the carrier to form the housing.



**Figure 38-26** An exploded view of integral-carrier axle housing.

The housing and carrier have a removable rear cover that allows access to the differential assembly. Because the carrier is not removable, the differential components must be removed and serviced separately. For many operations, a case spreader **(Figure 38-27)** must be used to remove the components. In addition to providing a mounting place for the differential, the axle housing also contains brackets for mounting suspension components such as control arms, leaf springs, and coil springs.

Some vehicles have an ABS speed sensor attached to the carrier housing for rear-wheel lockup prevention during braking.

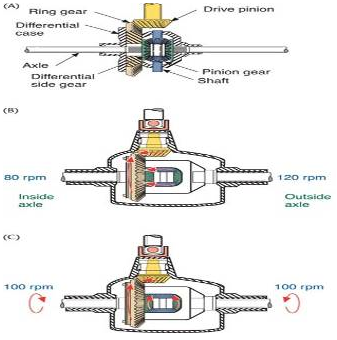


**Figure 38-27** A case spreader.

**Differential Operation**

The amount of power delivered to each driving wheel by differential is expressed as a percentage. When the vehicle moves straight ahead, each driving wheel rotates at 100% of the differential case speed. When the vehicle is turning, the inside wheel might be getting 90% of the differential case speed. At the same time, the outside wheel might be getting 110% of the differential case speed.

Power flow through the axle begins at the drive pinion yoke, or companion flange **(Figure 38-28).** The companion flange accepts torque from the rear U-joint. The companion flange is attached to the drive pinion gear, which transfers torque to the ring gear. As the ring gear turns, it turns the differential case and the pinion shaft.



**Figure 38-28 (A)** Basic differential components, (B) differential action while the vehicle is turning left, and (C) differential action while the vehicle is moving straight.

The differential pinion gears transfer torque to the side gears to turn the driving axle shafts. The differential pinion gears determine how much torque goes to each driving axle, depending on the resistance an axle shaft or wheel has while turning. The pinion gears can move with the carrier, and they can rotate on the pinion shaft.

When drive-shaft torque is applied to the input shaft and drive pinion, the shaft rotates in a direction that is perpendicular to the vehicle’s drive axles. When this rotary motion is transferred to the ring gear, The torque flow changes direction and becomes parallel to the axle shafts and wheels. Because the ring gear is bolted to the differential case must also rotate with the case and the ring gear. The pinions turn end over end. Gears do not rotate on the pinion shaft when both driving wheels are turning at the same speed. They rotate end over end as the differential case rotates. Because the pinions are meshed with both side gears, the side gears rotate and turn the axle shafts turn together without variation in speed as long as the vehicle is moving in a straight line.

When a vehicle turns into a curve or negotiates a turn, the wheels on the outside of the curve must travel a greater distance than the wheels on the inside of the curve. The outer wheels must then rotate faster than the inside wheels. This would be impossible if the axle shafts were locked solidly to the ring gear. However, the differential allows the outer wheels and axle to slow down, thus preventing the skidding and rapid tire wear that would otherwise occur. The differential action also makes the vehicle mush easier to control while turning.

For example, when a car makes a sharp right-hand turn, the left-side wheels, axle shaft, and side gear must rotate faster than the right-side wheels, axle shaft, and side gear. The left side of the axle must speed up and the right side must slow down. This is possible because the pinions to which the side gears are meshed are free to rotate on the pinion shaft. They increased speed of the left-side wheels causes the side gear to rotate faster than the differential case. This causes the pinions to rotate and walk around the slowing down side gear. As the pinions turn to allow the left-side gear to increase speed, a reverse action—known as a reverse walking effect—is produced on the right-side gear. It slow down an amount that is inversely proportional to the increase in the left-side gear.

**LIMITED-SLIP DIFFERENTIALS**

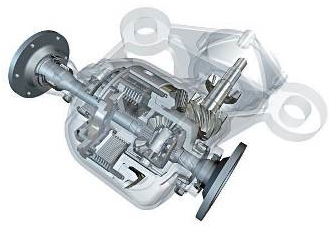
Driveline torque is evenly divided between the two rear drive axle shafts by the differential. As long as the tires grip the road, providing a resistance to turning, the drivetrain forces the vehicle forward. When one tire encounters a slippery spot on the road, it loses traction, resistance to rotation drops, and the wheel begins to spin. Because resistance has dropped, the torque delivered to both drive wheel changes. The wheel with good traction is no longer driven. If the vehicle is stationary in this situation, only the wheel over the slippery spot rotates. When this is occurring, the differential case is driving the differential pinion gears around the stationary side gears.

This situation places stress on the differential gears. When the wheel spins because of traction loss, the speed of some of the differential gears increases greatly, while other remains idle. The amount of heat developed increases rapidly, the lube film break down, metal-to metal contact occurs, and the parts are damaged. If spinout is allowed to continue long enough, the axle could break. The final drive or differential gears can also be damaged from prolonged spinning of one wheel. This is especially true if the spinning wheel suddenly has traction. The shock of the sudden traction can cause severe damage to the drive axle assembly.

To overcome these problems, differential manufacturers have developed the **limited-slip differential (LSD).** Limited-slip differentials are manufactured under such names as sure-grip, no-spin, or equal-lock. Some vehicles use a viscous clutch in their limited-slip drive axles. These units are predominantly used in 4WD vehicles and are discussed in Chapter 41.

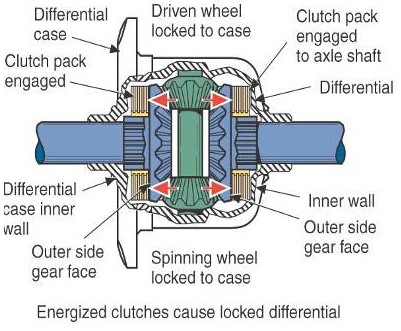
**Clutch-Based Units**

Many LSDs use friction material to transfer the torque applied to a slipping wheel to the one with traction. Those that use a clutch pack **(Figure 38-29)** have two sets (one for each side gear) of clutch plates and friction discs are steel plates with an abrasive coating on both sides. These discs fit over the external splines on the side gears’ hub. The clutch plates are also made of steel but have no friction material bonded to them. The plates are placed between the friction discs and fit into internal splines in the differential case. Pressure is kept on the clutch packs by either an S-shaped spring or coil springs.



**Figure 38-29** A late-model sophisticated LSD with friction clutches*.*

As long as the friction discs maintain their grip on the steel plates, the differential side gears are locked to the differential case **(Figure 38-30),** allowing the case and drive axles to rotate at the same speed and preventing one wheel from spinning faster than the other.



**Figure 38-30** Action of the clutches in a limited-slip differential.

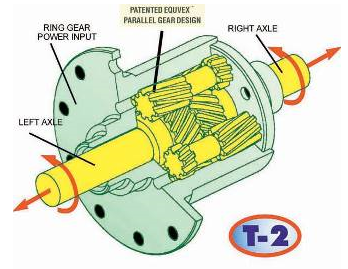
A common LSD uses two cone-shaped parts to lock the side gears to the differential case. The cones are located between the side gears and the case and are splined to the side gear hubs. The exterior surface of the cones is coated with a friction material that grabs the inside surface of the case. Four to six coil springs mounted in thrust plates between the side gears maintain a preload on the cones. When the cones are forced against the case, the axles rotate the differential case.

The clutch plates cones are designed to slip when a predetermined amount of torque is applied to them which allows the vehicle to have differential action when it is turning a corner.

**Gear-Based Units**

Manufacturers are using a wide range of LSD designs other than the typical clutch type. These designs were born out of the need to improve vehicle stability and tire traction. Many are gear-based and are often called torque-bias or torque-sensing (Torsen) units. The basis of these units is a parallel-axis helical gearset **(Figure 38-31).** The Torsen differential multiplies the torque available from the wheel that is starting to spin or lose traction and sends it to the lower turning wheel with the better traction. This action is initiated by the resistance between the sets of gears in mesh.

Helical-geared LSDs respond very quickly to changes in traction. They also do not lose their effectiveness with wear as clutch-based units can.

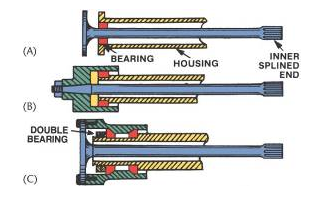


**Figure 38-31** A Torsen torque-sensitive LSD. *Courtesy of Zexel Torsen Inc.*

**AXLE SHAFTS**

The purpose of an axle shaft is to transfer driving torque from the differential assembly to the vehicle’s driving wheels. There are two types of axles: dead and live drive. A **dead axle** does not drive a vehicle. It merely supports the vehicle load and provides a mounting place for the wheels. The rear axle of a FWD vehicle is a dead axle, as are the axle used on trailer.

A **live axle** is one that drives the vehicle. Drive axles transfer torque from the differential to each driving wheel. Depending on the design, rear axles can also help carry the weight of the vehicle of even act as part of the suspension. Three types of driving axles are commonly used **(Figure 38-32):** semifloating, three-quarter floating, and full-floating.



**Figure 38-32** The type of rear axle shafts: (A) semifloating; (B) three-quarter floating; and (C) full-floating.

All three use axle shafts that are splined to the differential side gear. At the wheel ends, the axles can be attached in any one of a number of ways. This attachment defines the type axle it is and the manner in which the shaft are supported by bearings.

**Semifloating Axle Shafts**

**Semifloating axles** help to support the weight of the vehicle. The axles are supported by bearings located in the axle housing. An axle shaft bearing supports the vehicle’s weight and reduces rotational friction. The inner ends of the axle shafts are splined to the axle side gears. The axle shafts transmit only driving torque and are not acted upon by other forces. Therefore, the axle shafts are said to be floating.

The driving wheels are bolted to the outer ends of the axle shafts. The outer axle bearings are located between the axle shaft and axle housing. This type of axle has a bearing pressed into the end of the axle housing. This bearing supports the axle shaft. The axle shaft is held in place with either a bearing retainer belted to a flange on the end of the axle housing of by a C-shaped washer that fits into grooves machined in the splined end of the shaft. A flange on the wheel end shaft is used to attach the wheel.

When semifloating axles are used to drive the vehicle, the axle shafts push on the shaft bearings as they rotate. This places a driving force on the axle housing, springs, and vehicle chassis, moving the vehicle forward. The axle shaft faces the bending stresses associated with turning corners and curves, skidding, and bent or wobbling wheels, as well as the weight of the vehicle. In the semifloating axle arrangement with a C-shaped washer-type retainer, if the axle shaft breaks, the driving wheel comes away from or out of the axle housing.

**Three-Quarter Floating Axle**

The wheel bearing on a **three-quarter floating axle** is on the outside of the axle housing instead the housing as in the semifloating axle. The wheel hubs are bolted to the end of the axle shaft and are supported by the bearing. In this arrangement, the axle shaft only supported 25% of the vehicle’s weight is transferred through the wheel hub and bearing to the axle housing. Three-quarter floating axles are found on older vehicles and some trucks.

**Full-Floating Axle Shafts**

Mot medium-and heavy-duty vehicles use a **full-floating axle shaft.** This design is similar to the three-quarter floating axle except that two bearings than one are used to support the wheel hub. These are slid over the outside of the axle housing and carry all the stresses caused by torque loading and turning. The wheel hubs are bolted to flanges on the outer end of each axle shaft.

In operation, the axle shaft transmits only the driving torque. The driving torque from the axle shaft rotates the axle flange, wheel hub, and rear driving wheel. The hub forces its bearings against the axle housing to move the vehicle. The stresses caused by turning, kidding, and bent or wobbling wheels are taken by the axle housing through the wheel bearings. If a full-floating axle shaft should break, it can be removed from the axle housing. Because the rear wheels rotate around the rear axle housing the disabled vehicle can be towed to a service area for replacement of the axle shaft.

**Independently Suspended Axles**

In an independently suspended axle system, the driving axles are usually open instead of being enclosed in an axle housing. The two most common suspended rear driving axles are the DeDion axle system and the swing axle system.

The DeDion axle system resembles a normal driveline. The driving axles look like a drive shaft with U-joints at each end of the axle. A slip joint is attached to the nermost U-joint. The outboard U-joint is connected to the wheel hub, which allows the driving axle to move up and down as it rotates.

On vehicles that use a swing axle, the driving axle shafts can be open or enclosed. An axle fits into the differential by way of a ball-and-socket system. The ball-and –socket system allows the axle to pivot up and down. As the axle pivots, the driving wheel swings up and down. This system best describes the drive axles of a FWD vehicle.

**Axle Shaft Bearings**

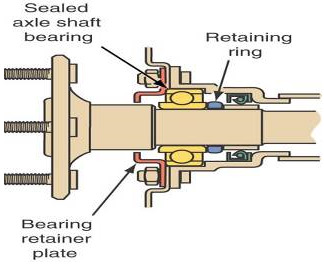
The axle shaft bearing supports the vehicle’s weight and reduces rotational friction. In an axle mount, radial and thrust loads are always present on the axle shaft bearing when the vehicle is moving. Radial bearing loads act at 90 degrees to the axle shaft’s center of axis. **Radial loading** is always present whether or not the vehicle is moving.

**Thrust loading** acts on the axle bearing parallel with the center of axis. It is present on the driving wheels, axle shafts, and axle bearings when the vehicle turns corners or curves.

There are three designs of axle shaft bearing used in semifloating axles: ball-type bearing, straight roller bearing, and tapered roller bearing.

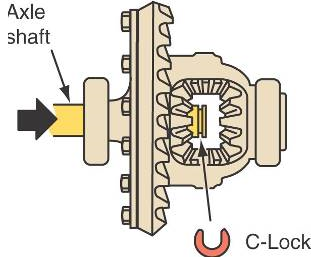
The bearing load of primary concern is axle shaft end trust. When a vehicle moves around the corner, centrifugal force acts on the vehicle body, causing it to the outside of the curve. The vehicle’s chassis does not lean because of the tires’ contact with the road’s surface. As the body leans outward, a thrust load is placed on the axle shaft and axle bearing. Each type of axle shaft bearing handles end thrust differently

Normally, the way the axles are held in the housing is quite obvious after the rear wheels and brake assemblies have been removed. If the axle shaft is held in by a retainer and three or four bolts, it is necessary to remove the differential cover to remove the axle. Most ball and tapered roller bearing supported axle shafts are retained in this manner **(Figure 38-33).** To remove the axle, remove the bolts that hold the retainer to the backing plate, then pull the axle aid of a puller. Sometimes a puller is required.



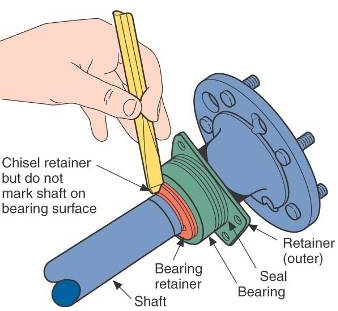
**Figure 38-33** The location of an axle bearing retainer.

A straight-roller bearing supported axle shaft does not use a retainer to secure it. Rather, a C-shaped washer is used to retain the axle **(Figure 38-34).** This C-shaped washer is located inside the differential, and the differential cover must be removed to gain access to it. To remove this type of axle, first remove the wheel, brake drum, and differential cover. Then, remove the differential pinion shaft retaining bolt and differential pinion shaft. Now push the axle in and remove the C-shaped washer. The axle can now be pulled out of the housing.



**Figure 38-34** The location of C-clock-type axle shaft.

Ball bearings are lubricated with grease packed in the bearing at the factory. An inner seal, designed to keep the gear oil from the bearing, rides on the axle shaft just in front of the retaining ring. This type of bearing also has an outer seal to prevent grease from spraying onto the rear brakes. Ball-type axle bearings are pressed on and off the axle shaft. The retainer ring is made of soft metal and is pressed onto the shaft against the wheel bearing. Never use a torch to remove the ring. Rather, drill into it or notch it in several places wuth a cold chisel to break the seal **(Figure 38-35).** The ring can then slid off the shaft easily. Heat should not be used to remove the ring because it can take the temper out of the shaft and thereby weaken it. Likewise, a torch should never be used to remove a bearing from an axle shaft.



**Figure 38-35**  Freeing the retainer ring from an axle shaft.

Roller axle bearings are lubricated by the gear oil in the axle housing. Therefore, only a seal to protect the brakes is necessary with these bearings. These bearings are typically pressed into the axle housing and not onto the axle. To remove them, the axle must first be removed and then the bearing pulled out of the housing. With the axle out, inspect the are where it rides on the bearing for pits or scores. If pits or score marks are present, replace the axle.

Tapered-roller axle bearings are not lubricated by gear oil. They are sealed and lubricated with wheel grease. This type of bearing uses two seals and must be pressed on and off the axle shaft using a press. After the bearing is pressed onto the shaft, it must be packed with wheel bearing grease. After packing the bearing, install the axle in the housing. Shaft endplay must be checked. Use a dial indicator and adjust the endplay to the specifications given in the service manual. If the endplay is not within specifications, change the size of the bearing shim.

The installation of new axle shafts seals is recommended whenever the axle shafts have been removed. Some axle seals in each side. Check the seals or making of right or left or for color coding.

| USING SERVICE MANUALS    The driveline can create some especially difficult  diagnostic problems. The driveline easily picks up  vibrations and noises from other parts of the vehicle.  a test drive is the best way to begin diagnosis. Note  what happens during any speeds or during  speed changes. |
| --- |

**Diagnosis**

Before the test drive, check out the test-drive chart **(Figure 38-36).** The four modes of driving given in most service manuals should be checked out for driving-axle and differential problems. For the drive mode, accelerate the vehicle. The throttle must ne depressed enough to apply sufficient engine torque. In the cruise mode, vehicle speed must be constant, which means that the throttle must be applied at all times. The speed must be held at a predetermined rpm on a travel road. For the coast mode, take the foot off the throttle. Let the vehicle coast down from a specific speed. The float mode is a controlled deceleration. Back off the throttle gradually and continually. Do not brake or accelerate during this mode.

Remember that driving safety is always important! Hard cornering of sudden braking should be avoided. Driving conditions other than normal can worsen a problem or create a new one. Carelessness during the test drive can result in an accident. Remember, you are responsible for someone else’s vehicle.

**SERVICING THE FINAL ASSEMBLY**

Before removing a final drive unit for service, make sure it needs to be serviced. Typically, problems with the differential and drive axles are first noticed as a leak or noise. As the problem worsens, vibrations or a clunking noise might be felt during certain operating conditions. Diagnosis of the problem should deign with a road test in which the vehicle is taken through the different modes of operation.

**Basic Diagnosis**

It is common for the source of a noise to be tires, not the final drive unit. To make sure the noises are not caused by tire tread patterns and/or wear, drive the car on various types of road surfaces (asphalt, concrete, and packed dirt). If the noise changes with the road surfaces, it means the tires are the cause of the noise.

Another way to isolate tire noises is to coast at speeds less than 30 mph (48km/h). If the noise is still heard, the tires are probably the cause. Drive axle and differential noises are less noticeable at these speeds. Accelerate and compare the sounds to those made while coasting. Drive axle and differential noises change. Tire noise remains constant.

Sometimes it is difficult to distinguish between axle bearing noises and noises coming from the differential. Differential noises often change with the driving mode whereas axle-bearing noises are usually constant. The sound of the bearing noise usually increases in speed and loudness as vehicle speed increases.

Operational noises are generally caused by bearings or gears that are worn, loose, or damaged. Bearing noises might be a whine or a rumble. A whine is a high-pitched, continuous “whee” sound. A rumble sounds like distant thunder.

Gear can also whine or emit a howl-a very loud, continuous sound. Howling is often caused by low lubricant in the drive axle housing. The meshing teeth scrape metal from each other and can be heard in all gear ranges. If topping up the lubrication level does not alleviate the howling noise, then the drive pinion and ring gear must be replaced.

**Disassembly**

Although FWD axle final drive units are normally an integral part of the transaxle, most of the procedures for servicing RWD units apply to them. To service a final drive assembly in removable carrier housing, the unit must be removed from the- housing. Using integral carriers are serviced in the housing.

A highly important step in the procedure for dissembling any final drive unit is a careful inspection of each part as it is removed. The bearings should be looked at and felt to determine if there are any defects or evidence of damage.

After the ring and pinion gears have been removed from the assembly, check the side play. Using a screwdriver, attempt to move the differential case assembly laterally. Any movement is evidence of side play. Side play normally indicates that as the result of loose bearing cones on the differential case hubs, the differential case must be replaced.

Prior to disassembling the assembly, measure the runout of the ring gear. Excessive runout can be caused by a warped gear, worn differential side bearing, warped differential case, or particles trapped between the gear and case. Runout is checked with a dial indicator mounted on the carrier assembly. The plunger on the indicator should be set at a right angle to the gear. With the dial indicator in position and its dial set to zero, rotate the gear and note the highest and lowest readings indicates the total runout of the ring gear. Normally, the maximum permissible runout is 0.003 to 0.004 inches (.0762 to .1016 mm).

To determine if the runout is caused by a damaged differential case, remove the ring gear and measure the runout of the ring gear mounting surface on the differential case. Runout should not exceed 0.004 inch (.0116 mm). If runout is greater than that, the case should be replaced. If the runout was within specification the ring gear is probably warped without replacing its mating pinion gear.

Some ring gear assemblies have an excitor ring used, used in antilock brake systems. This ring is normally pressed onto the ring gear hub and can be removed after the ring gear is removed. If the ring gear assembly is equipped with an excitor ring, carefully inspect it and replace it if it is damaged.

Prior to disassembling the unit, the drive shaft must be removed. Before disconnecting it from the pinion’s companion flange, locate the shaft-to-pinion alignment marks. If they are not evident, make new ones. This avoids assembly the unit with the wrong index, which can result in driveline vibration.

During disassembly, keep the right and left shims, cups, and caps separated. If any of those parts are reused, they must be installed on the same side as they were originally located.

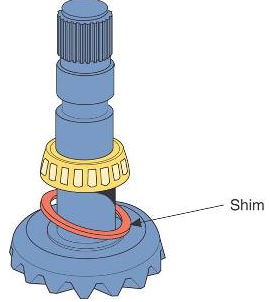
**Assembly**

When installing a ring gear onto the differential case, make sure the bolt holes are aligned before pressing the gear in place. While pressing the gear, pressure should be evenly applied to the gear. Likewise, when tightening the bolts, always tighten them in steps and to the specified torque. These steps reduce the chances of distorting the gear.

Examine the gears to locate any timing marks on the gearset that indicate any timing marks on the gearset that indicate where the gears were lapped by the manufacturer. Normally, one tooth of pinion gear is grooved and painted, while the ring gear has a notch between two painted teeth. If the paint marks are not evident, locate the notches. Proper timing of the gears is set by placing the grooved pinion tooth between the two marked ring gear teeth. Some gearsets have no timing marks. These gears are hunting gears and do not need to be timed. Nonhunting and partial nonhunting gears must be timed.

Whenever the ring and pinion gears or the pinion or differential case bearings are replaced, pinion gear depth, pinion bearing preload, and the ring and pinion gear tooth patterns and backlash must be checked and adjusted. This holds true for all types of differentials except most FWD differentials that use helical-cut gears, and taking tooth patterns is not necessary. Nearly all other final drive units use hypoid gears that must be properly adjusted to ensure a quiet operation.

Pinion gear depth is adjusted with shims placed behind the pinion bearing **(Figure 38-37)** in the housing. The thickness of the drive pinion rear bearing shim controls the depth of the mesh between the pinion and ring gear. To determine and set pinion depth a special tool is normally used to select the proper pinion shim **(Figure 38-38)** . Always follow the procedures in the service manual when setting up the tool and determining the proper shim.



**Figure 38-37** The typical placement of a pinion gear depth shim. *Reprinted with permission*

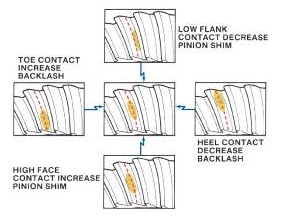
Pinion bearing **preload** is set by tightening the pinion nut until the desired number of inch-pounds is required to turn the shaft. Tightening the nut crushes the collapsible pinion spacer, which maintains the desired preload. Never overtighten and then loosen the pinion nut to reach the desired torque reading. Tightening and loosening the pinion nut damages the collapsible spacer. It must then be replaced. For the exact procedures and specifications for bearing preload can cause differential noise. Some cases use shims to set pinion bearing preload.

It is recommended that a new pinion seal be installed whenever the pinion shaft is removed from the differential. To install a new seal, thoroughly lubricate it and press it in place with an appropriate seal driver.

**Backlash** of the gearset is adjusted at the same time as the side-bearing preload. Side-bearing preload limits the amount the differential is able to move laterally in the axle housing. Adjusting backlash sets the depth of the mesh between the ring and pinion gear teeth. Both of these are adjusted by shim thickness or by the adjustments made by the side-bearing adjusting nuts. Photo Sequence 40 goes through the typical procedure for measuring and adjusting backlash and side-bearing preload on a gearset that uses shims for adjustment. Photo Sequence 41 covers the same steps for a unit that has adjusting units.

A typical procedure for measuring and adjusting backlash and preload involves rocking the ring gear and measuring its movement with a dial indicator. Compare measured backlash with the specifications. Make the necessary adjustments. Then recheck the backlash at four points equally spaced around the ring gear. Normally, backlash should be less than 0.004 inch (.1016 mm).

The pattern of gear teeth determines how quietly two meshed gears run. The pattern also describes where on the faces of the teeth the two gears mesh. The pattern should be checked during teardown for gear noise diagnosis, after adjusting backlash and side-bearing preload, or after replacing the drive pinion and setting up the pinion bearing preload, The terms commonly used to describe the possible patterns on a ring gear and the necessary corrections are shown in **Figure 38-39.**

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**Figure 38-39** Commonly used terms for describing the possible patterns on a ring gear with the recommended corrections.

To check the gear tooth pattern, paint several ring gear teeth with nondrying Prussian blue, ferric oxide, or red or white lead marking compound. White marking compound is preferred by many technicians because it tends to be more visible than the others are. Use the pinion gear yoke or companion flange to rotate the ring gear. This will preload the ring gear while it is rotating and will simulate vehicle load. Rotate the ring gear so the painted teeth contact the pinion gear. Move it in both directions enough to get a clearly defined pattern. Examine the pattern of the ring gear and make the necessary corrections.

Most new gearsets purchased today come with a pattern prerolled on the teeth. This pattern provides the quietest operation for that gearset. Never wipe this pattern off or cover tip up. When checking the pattern on a new gearset, only coat half of the ring gear with the marking compound and compare the pattern with the presolled pattern.

**Maintenance**

Maintenance includes inspecting the level of and changing the gear lubricant, and lubricating the U-joints if they are equipped with zerk or grease fittings. Most modern U-joints are of the extended life design, meaning they are sealed and require no periodic lubrication. However, it is wise to inspect the joints for hidden grease plugs or fittings.

Proper lubrication is necessary for drive axle durability. Different applications require different gear lubes. The American Petroleum Institute (API) has established a rating system for the various gear lubes available. In general, rear axles use either SAE 80-or 90 weight gear oil for lubrication, meeting API GL-4 or GL-5 specifications. With limited-slip axles, it is very important that the proper gear lube be used. Most often, a special friction modifier fluid should be added to the fluid. If the wrong lubricant is used, damage to the clutch packs and grabbing or chattering on turns will result. If this condition exists, try draining the oil and refilling with the proper gear lube before servicing it.

**DIAGNOSING DIFFERENTIAL NOISES**

If a whining is heard when turning corners or rounding curves, the problem might be damaged differential pinion gears and pinion shaft. This damage is caused when the inside diameter of the differential pinions and the outside diameter of the differential pinion shaft is scored and damaged. The damage is usually caused by allowing one driving wheel to revolve at high speeds while the opposite wheel remains stationary.

Another gear noise that is common in differentials is the chuckle. A chuckle is a low “heh-heh” sound that occurs when gears are worn to the point where there is excessive clearance between the pinion gear and the ring gear. Chuckle sounds occur most often in the decelerating mode, particularly below 40 mph (65km/h). As the vehicle decelerates, the chuckle also slows and can be heard all the way to a stop.

A knock or clunk is caused by excessive wear or loose or broken parts. A knock is a repetitious rapping sound that occurs during all phases of driving but is most noticeable during acceleration and deceleration when the gears are loaded.

A cluck is a sharp, loud noise caused by one part hitting another. Unlike a knock, a clunk can be felt as well as heard. Clunks are generally caused by loose parts striking each other.

Limited-slip clutch packs or cones that need servicing might be heard as a chatter or a rapid clicking noise that creates a vibration in the vehicle. Chattering is usually noticed when rounding a corner. A change of differential lubricant and adding friction modifier to the fluid sometimes corrects this problem. After draining the oil, replace it with the manufacturer’s suggested friction modifier and lubricant. Road test the vehicle again.

To make sure that the noise heard during the test drive is coming from the differential, stop the vehicle and shift the transmission into neutral. Run the engine at various rpm levels. If the noise is heard during this procedure, it is caused by a problem somewhere other than in the differential.

**Vibration Problems**

Often the source of vibration is a bent axle or axle flange, or improper mounting of the wheel to the flange. To check the runout of the flange, position a dial indicator against the outer flange surface of the axle. Apply slight pressure to the center of the axle to remove the endplay, slight pressure to the center of the axle to remove the endplay in the axle, and then zero the indicator. Slowly rotate the axle one complete revolution and observe the readings on the indicator. The total amount of indicator movement is the total amount of axle flange lateral runout. Compare the measured runout with specifications.

Inspect the wheel studs in the axle flange. If they are broken or bent, they should be replaced. Also check the condition of the threads are severely damaged, the stud should be replaced. Studs are normally pressed in and out of the flange. Make sure you install the correct size.