FINAL DRIVE WITH DIFFERENTIAL REPAIRING

ATCDR401

Repair final drive with differential

Competence

RTQF Level: 4

Learning hours

100

Credits: 10

Sector: Transport and Logistic

Sub-sector: Automobile technology

Module Note Issue date: June, 2020

Purpose statement

This module will allow the Learner to identify, describe, maintain and repair final drive with differential. The learner will be able to dismount, disassemble, inspect, clean, replace, adjust and reassemble components of final drive with differential. Also the learner should be able to test a final drive with differential.

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Learning Unit 1: Dismount final drive with differential

Introduction

Whether your vehicle is front-wheel drive (FWD), rear-wheel drive (RWD), four-wheel drive (4WD), or all-wheel drive (AWD), power must be delivered to at least one pair of left and right wheels so the vehicle can move. This is made possible by the differential. The differential is the component that distributes power from the vehicle's transmission, while allowing the wheels to be powered and to rotate at different speeds.

A differential is so named because two wheels on a drive axle need to be able to both receive power, and also turn at different rates of speed. The differential basically allows each wheel to spin freely of the other, while still providing power to both. If one wheel is spinning slower when turning, the differential mechanism will keep driving the other wheel without any jerking, binding, or skidding.

If a vehicle did not have a differential, the driving wheels would be locked together and forced to spin at the same speed, making turning difficult, and increasing the chance of losing control of the vehicle. The absence of a differential would also be hard on the vehicle drivetrain because one tire would have to grab and slip on the road surface to maintain the same speed as the other. This force would transmit through the axle from one wheel to the other and place a huge strain on the axle components as well as the tires.

At least one differential is found on all modern cars, SUVs, and trucks. In front-wheel drive vehicles, the differential is typically built into the transmission or transaxle, and shares the transmission fluid. On a RWD vehicle with a front-mounted engine, the differential is in the rear and has its own housing and lubrication. In the case of 4WD vehicles, there are typically separate front and rear differentials built into fixed axles and possibly a differential integrated into the transfer case which rests in between them. In AWD vehicles there are not only front and rear differentials, but also a center differential, which is typically integrated into the transmission. AWD vehicles need a differential between each set of drive wheels, and also one between the front and back wheels as well, because the front wheels travel a different distance through a turn than the rear wheels.

Figure 1: Differential pics

The differential may have its own housing and fluid, it may be integrated into the transmission housing and share the same fluid as the transmission, or it may be integrated into the transfer case and share the same fluid as the transfer case. Differentials contained within the transmission and transfer case follow the same maintenance and inspection requirements as the transmission and transfer case. All differentials require oil. Inspecting and changing differential oil are two of the most overlooked vehicle maintenance tasks.

Heat, friction, and metal on metal contact eventually break down the fluid, which inevitably wears and weakens gears and bearings and leads to failure.

Differential oil contained in its own housing is sometimes referred to as gear oil. It is thicker than engine and transmission oil and designed to perform under the high pressure of gears mashing together. The gear oil splashes throughout the housing, lubricating gears, bearings, and clutch packs. The purpose of differential oil is to cool and lubricate the differential. Without the oil, the differential would overheat due to metal on metal contact and burn itself out.

Due to normal wear and tear, differential oil may contain small metal particles. Often, differential fluid fill and drain plugs are equipped with a magnet to attract and hold these particles, and to keep them from circulating through vital components. These magnets are not intended to compensate for neglect and abuse, and should not be thought of as a replacement for regular maintenance. A substantial presence of metal particles on the magnet may be evidence of failure within the differential.

It is important to regularly inspect the differential(s) for any damage, leaks, or other concerns, and also to inspect the differential fluid level and condition. Differential fluid may leak from the axle shaft seals, pinion seal, cover gasket, vent malfunction, plugs, or any transaxle or transfer case gasket or seal if the differential is located inside these components. A good way to determine if there are problems with the differential is to test drive your vehicle with the radio off and listen carefully while turning, and driving at both slower and highway speeds.

Do not overlook the differential(s) in your vehicle. To avoid costly repairs and keep your differential in optimum working condition, have your vehicle's differential and differential fluid inspected whenever you have the vehicle serviced. Follow the manufacturer's recommendation regarding fluid type and how often it should be replaced. If the differential oil is contaminated, shows evidence of metal particles, or is black in color, it is time to replace it.

When buying a used vehicle, you need to make sure the differential is in good shape and the oil is not excessively contaminated, otherwise, the vehicle may soon need expensive repairs.

LO 1.1: Select tools, materials and equipment for dismounting final drive and differential

- Topic 1: **Introduction on tools, materials and equipment**

Repairing the modern automobile requires the use of various tools. Many of these tools are common hand and power tools used every day by a technician. Other tools are very specialized and are only for specific repairs on specific systems and/or vehicles. This chapter presents some of the more commonly used hand and power tools with which every technician must be familiar. Because units of measurement play such an important part in tool selection and in diagnosing automotive problems, this chapter begins with a presentation of measuring systems. Prior to the discussion on tools, there is a discussion on another topic that relates very much to measuring systems—fasteners.

✓ **Definition and function of tools**

A **tool** is an object used to extend the **ability** of an individual to modify features of the surrounding environment. Although many animals use simple tools, only human beings, whose use of stone tools dates back hundreds of millennia, have been observed using tools to make other tools.

- ✓ **Definition and function of materials**

A **material** is a substance or mixture of substances that constitutes an object. Materials can be pure or impure, living or non-living matter. Materials can be classified based on their physical and chemical properties, or on their geological origin or biological function.

- ✓ **Definition and function of equipment**

Equipment most commonly refers to a set of tools or other objects commonly used to achieve a particular objective. Different jobs require different kinds of equipment.

<u>Types of tools:</u>

- ➢ Hand tools

A hand tool is any tool that is powered by hand rather than a motor. Categories of hand tools include wrenches, pliers, and cutters, files, striking tools, struck or hammered tools, screwdrivers, vises, clamps, snips, saws, drills and knives.

Figure 2 Hands tools: Spanners - Screw driver - Hammer - Pliers - Files - Cutters - Punches and chisels - Bolts extractors - Brushes - Threads restore kit - Hand riveter - Air impact spanners - Air brow gun - Vernier caliper - Dial gauge - Telescopic gauge - Multimeter- Feeler gauge - Straight edge - Auto-Data B

- Power tools

A power tool is a tool that is actuated by an additional power source and mechanism other than the solely manual labor used with hand tools. The most common types of power tools use electric motors. Internal combustion engines and compressed air are also commonly used.

- **Tool safety**

- Keep all tools in good condition with regular maintenance.
- Use the right tool for the job.
- Examine each tool for damage before use and do not use damaged tools.
- Operate tools according to the manufacturers' instructions.
- Provide and use properly the right personal protective equipment.

- **Use of tools**

Tools should be cleaned after finishing a job, checked item by item, and stored in the tool box. Remove dirt and oil from special service tools (SST), testers, gages etc., and put them away neatly in the correct places.

- **Storing and maintaining tools**

LO 1.2 – Drain final drive with differential or transaxle

- Topic 1: Procedures for Drain final drive with differential or transaxle

Changing your rear final drive oil is important to keep your drivetrain smooth. Over time, the oil loses its critical properties that prevent metal on metal contact. This is a easy do-it-yourself as long as you have the proper tools and ability to get your vehicle off the ground safely. If you are unsure of how to do this procedure, please visit a certified mechanic.

While Porsche recommends owners change the rear final drive oil every 16 years or 160,000 miles, we believe this is too long. This is a cheap and easy do-it-yourself as long as you have the proper tools and ability to get your vehicle off the ground safely. Detailed steps, parts, and tools required can be found below.

- Position vehicle

1. Starting with a cold engine, drive your car lightly for 5 minutes to get the drivetrain fluid warmed up; this will make it easier to drain the final drive oil.
2. Park your car on a flat surface.
3. Gather required tools and parts.
4. Put on gloves and eye protection.

- **Topic 2:Definition and function of final drive with differential**

The drivetrain of a motor vehicle is the group of components that deliver power to the driving wheels. This excludes the engine or motor that generates the power. In contrast, the powertrain is considered to include both the engine or motor and the drivetrain.

A **differential** is a mechanical device made up of several gears. It is used in almost all mechanized four-wheel vehicles. It is used to transmit the power from the driveshaft to the drive wheels. Its main function is to allow the drive wheels to turn at different rpms allowing the wheels to go around corners while still receiving power from the engine.

The purpose of the final drive gear assembly is to provide the final stage of gear reduction to decrease RPM and increase rotational torque. Typical final drive ratios can be between 3:1 and 4.5:1.

✓ Types of oil and fluid

1. ACDelco® GM Original Equipment SAE 75W-90 Synthetic API GL-5 Differential Fluid. ...
2. ACDelco® SAE 75W-90 Synthetic API GL-5 Dexron Gear Oil. ...
3. ACDelco® GM Original Equipment SAE 75W-90 Synthetic API GL-5 Dexron LS Gear Oil. ...
4. ACDelco® GM Original Equipment SAE 75W-85 Synthetic API GL-5 Differential Fluid.

✓ Draining procedure:

Gathering tools

1. Mechanic's Tool Set
2. Fluid Transfer Pump Kit
3. Oil Drain Pan, 16 Quarts Capacity
4. Low Profile Jack
5. Slotted Polyurethane Jack Pad (1 required)
6. Steel Jack Auto Stands, 3 Ton Capacity, 1 Pair (4 required)
7. Wheel Chocks
8. Metric Hex Bit Socket Set, 2mm to 14mm
9. 3/8 Inch Drive Click Torque Wrench (10-80 ft.-lb.)
10. Safety Glasses
11. Disposable Gloves

Filer bolt location and removal

1. Place all necessary tools, oil pan and gloves within your reach while working under the car.
2. Slide underneath the car from the rear and locate the rear final drive (aka "differential").
3. On the left-hand side of the final drive housing and just in front of the CV axle, locate the oil fill plug.
4. At the driver's side of the final drive housing, just in front of the CV axle, locate an oil fill plug.
5. Use a ratchet, appropriate length extension, and a 10mm hex bit to break loose and remove the fill plug.
6. If you cannot remove the fill plug, STOP AND DO NOT PROCEEDS; you will not be able to fill your rear final drive with oil.

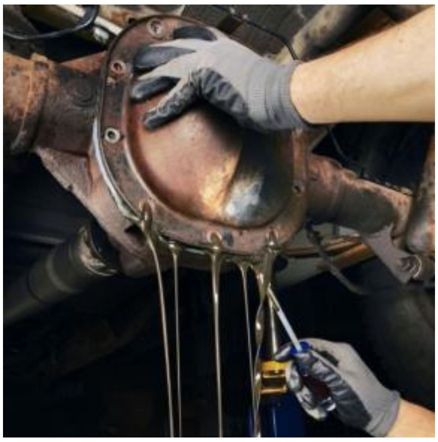

Figure 3: Loosen the bolt at the very top of the cover, but leave the bolt in place to prevent the cover from falling off completely and drenching the floor—and you—in differential oil.

Depending on the design of your differential, this can be a very messy or a very tidy job. Some differentials have a drain plug; others require you to remove the housing cover. In either case, you'll need a wide catch pan; a plastic drop cloth beneath that would be good insurance. Drive your vehicle for a few minutes to warm the oil, then change into your grungy clothes—you'll probably get dirty.

It's just changing oil, right? Nothing that complicated, but brace yourself, because old differential oil has the foulest smell in the automotive world. With that warning, remove the fill-hole plug at the top of the diff casing, and then unscrew the drain plug. If you don't have a drain plug, unscrew the housing bolts, leaving a couple of bolts on top loosely attached to hold the cover in place.

Using a standard screwdriver, pry open the cover gently or the oil will gush out and cover you in that unholy stink. Be careful not to mar the surface of the differential housing. Let the oil drain completely, and then remove the cover.

- **Topic 3: Confining with Resource Efficiency and Cleaner Production**

Assume that all the leftover oil in the axle is loaded with metal shavings. If you're an oil-changing Boy Scout, you don't have to worry about this, but the rest of us should take the time to wipe the remaining oil out of the housing, the gears, and the wet side of the housing cover. Make sure to get it all, because there could be some shavings hiding in the nooks and crannies.

A basic degreaser or just a series of shop towels is all that's necessary to clean out the housing cover. Use gloves you won't mind throwing away. Once the cover is shiny, run a magnet around the inside to pick up stray metal shavings.

Clean the tip of the fill-hole plug too; most are fitted with a magnet to grab fine metal particles. Don't go crazy with harsh cleaners—you wouldn't want the residue to affect your new oil. Grab a razor scraper or light abrasive pad and clear off the mating surface of both the housing and cover. Wipe down both faces using a lint-free shop towel and brake cleaner.

Some cars have pre-made gaskets. If not, use a liquid gasket product designed for harsh conditions and oil exposure, such as Permatex Ultra Black. Lay a single bead on the mating face of the cover and draw a circle around each mounting hole, then bolt the cover in place with just enough clamping force to flatten the bead. Let it harden according to the instructions, and then tighten the bolts to your vehicle's specs with a torque wrench.

Fill to the Brim

Figure 4: Use a tube or pump to fill the differential with new oil if you can't use the bottle alone. Use the highest-quality gear oil you can afford to fill the differential. The weight and capacity will be listed in your owner's manual; your differential will usually hold as much as 3 quarts. Be sure to read that manual, though, because some limited-slip differentials require a secondary friction-modifying additive.

Fill the differential directly from the bottle if you've got clearance, but if space is tight, you can get a pump or extension hose to make the job easier. The bottom of the plug hole is the maximum fill line, so when oil starts dripping out, you're finished.

Install the plug, torque it to spec, and you're good for tens of thousands of miles.

LO 1.3 – Dismount wheels and tires

- Topic 1 : Identification of the types of drives

✓ **Front wheel drive**

FWD final drives are very simple compared to RWD set-ups. Almost all FWD engines are transverse mounted, which means that rotational torque is created parallel to the direction that the wheels must rotate. There is no need to change/pivot the direction of rotation in the final drive. The final drive pinion gear will sit on the end of the output shaft. (Multiple output shafts and pinion gears are possible) The pinion gear(s) will mesh with the final drive ring gear. In almost all cases the pinion and ring gear will have helical cut teeth just like the rest of the transmission/transaxle. The pinion gear will be smaller and have a much lower tooth count than the ring gear. This produces the final drive ratio. The ring gear will drive the differential. (Differential operation will be explained in the differential section of this article) Rotational torque is delivered to the front wheels through CV shafts. (CV shafts are commonly referred to as axles)

✓ Rear wheel drive

RWD Final Drives

A RWD final drive sits in the rear of the vehicle, between the two rear wheels. It is located inside a housing which also may also enclose two axle shafts. Rotational torque is transferred to the final drive through a drive shaft that runs between the transmission and the final drive. The final drive gears will consist of a pinion gear and a ring gear. The pinion gear receives the rotational torque from the drive shaft and uses it to rotate the ring gear. The pinion gear is much smaller and has a much lower tooth count than the large ring gear. This gives the driveline it's final drive ratio .The driveshaft delivers rotational torque at a 90º angle to the direction that the wheels must rotate. The final drive makes up for this with the way the pinion gear drives the ring gear inside the housing. When installing or setting up a final drive, how the pinion gear contacts the ring gear must be considered. Ideally the tooth contact should happen in the exact center of the ring gears teeth, at moderate to full load. (The gears push away from each other as load is applied.) Many final drives are of a hypoid design, which means that the pinion gear sits below the centerline of the ring gear. This allows manufacturers to lower the body of the car (because the drive shaft sits lower) to increase aerodynamics and lower the vehicles center of gravity. Hypoid pinion gear teeth are curved which causes a sliding action as the pinion gear drives the ring gear. It also causes multiple pinion gear teeth to be in contact with the ring gears teeth which makes the connection stronger and quieter. The ring gear drives the differential, which drives the axles or axle shafts which are connected to the rear wheels. (Differential operation will be explained in the differential section of this article) Many final drives house the axle shafts, others use CV shafts like a FWD driveline. Since a RWD final drive is external from the transmission, it requires its own oil for lubrication. This is typically plain gear oil but many hypoid or LSD final drives require a special type of fluid. Refer to the service manual for viscosity and other special requirements.

Note: If you are going to change your rear diff fluid yourself, (or you plan on opening the diff up for service) before you let the fluid out, make sure the fill port can be opened. Nothing worse than letting fluid out and then having no way of getting new fluid back in.

✓ All-wheel drive

An all-wheel drive vehicle is one with a powertrain capable of providing power to all its wheels, whether full-time or on-demand. The most common forms of all-wheel drive are: 4×4 Reflecting two axles with both wheels on each capable of being powered.

- Topic 2 : Procedures of Dismount wheels and tires

✓ Jack installation

Figure 5: Jack under the vehicle

- First ensure your car is on level ground
- Next look under the car in the corner closest to the tire being replaced.
- Then locate a sturdy looking flat piece of metal under your car in that corner
- Finally set your jack up under this spot

✓ **Unscrewing bolts of tire from the axle**

Place the lug wrench on a lug nut and turn it counter-clockwise. Turn the wrench after you've secured it onto one of the nuts, pulling hard until you feel the lug nut begin to loosen. You don't need to remove the lug nut entirely, just use the wrench to loosen it until it's loose enough to remove with your fingers.Jun 2, 2020

Use the appropriate tool to loosen the lug nuts.
Before jacking the car up, use your wrench or tire iron to break the lug nuts loose. Do not remove them completely, but turn them a quarter turn or so in the counter-clockwise direction each to make them loose enough to unscrew while the vehicle is in the air.

Wheel and tire removal

1. Use the appropriate tool to loosen the lug nuts. Before jacking the car up, use your wrench or tire iron to break the lug nuts loose. Do not remove them completely, but turn them a quarter turn or so in the counter-clockwise direction each to make them loose enough to unscrew while the vehicle is in the air.

- You can purchase tire irons from your local auto parts stores that usually have an end that fits all vehicles.
- You may also choose to simply use a deep socket of the appropriate size with a ratchet or breaker bar.

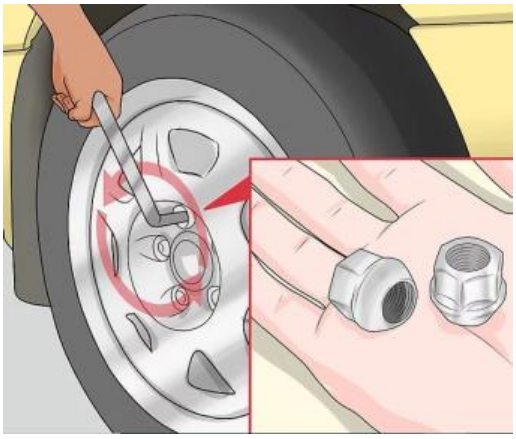

Figure 6: Wheel and tire Removal

2. Remove the lug nuts. Because the lug nuts are already loose from before you lifted the car, they should be fairly easy to unscrew the rest of the way. Use a wrench if need be to turn the lug nuts counter-clockwise until they come off of the lug studs.

- The wheel may shift as you remove the lug nuts, so watch your fingers for pinches.
- Remove the lug nuts across from one another in a star pattern, rather than each one in a row.

Figure 7: Star pattern wheel and tire removal

3. Apply liquid thread loosen it if need be. If the lug nuts have rusted over, apply a generous amount of a thread loosener or rust remover to the nuts. Allow it to sit for a few minutes, and then attempt to loosen the lug nut again.

- If the lug nut and stud break, you will need to have a new lug stud installed in order to repair the vehicle.
- Be sure to use the correct sized socket. A socket that is slightly too large could round off the lug nut.
- A stripped or rounded lug nut will have to be cut off by a professional.

4. Set the lug nuts aside someplace safe. Place the lug nuts in a safe place to be sure you don' t lose them. If you lose a lug nut, you may be able to secure the wheel temporarily with the remaining nuts, but if you lose more than one, it will not be safe to drive the vehicle until they have been replaced.

- You can purchase replacement lug nuts at your local auto parts store.
- Store the lug nuts in a small bowl or container so they can' t roll away as you work.
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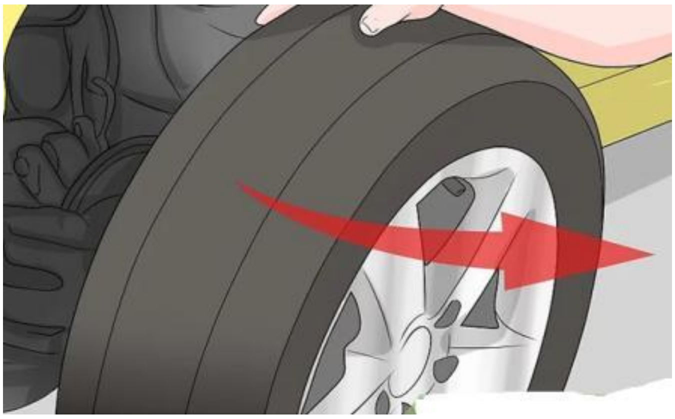


Figure 8: How to remove lug nut and tire.

5. **Pull the wheel toward you.** Once the lug nuts have been removed, place your hands on either side of the tire. Grip the back of the tire and pull it toward you to remove the wheel from the lug studs. If the wheel has not been removed in a long time, it may require quite a bit of force to pull the wheel off.

- Be careful, if the tire is damaged there may be metal wire sticking out of it that can cut you.
- Wear gloves to pull on a damaged tire.

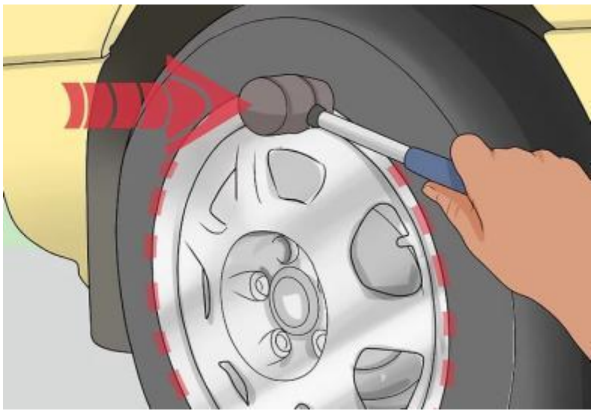


Figure 9: Use a mallet hummer

6. Use a rubber mallet to loosen stuck on wheels. If the wheel is seized in place and won't come off from you pulling on it, use a rubber mallet to bang it loose. Strike the tire where the rim and tire meet all along the circumference of the wheel until it breaks loose.
Do not use a metal hammer to hit the rims or you may damage them.

It may take a good deal of force to remove the stuck wheel if it is rusted in place.

LO 1.4 – Dismount propeller shaft, joints and half shafts

Something you should know that may not be thought of is when a driveshaft is removed the car will no longer be in park. The car will roll because the link between the drive wheels and transmission is removed. You will need to raise the car or truck up using a floor jack and jackstays. Wear protective eyewear and gloves before you begin.

- Topic1: Procedures of Dismount propeller shaft, joints and half shafts

1. **Mark the Driveshaft**

Mark the driveshaft orientation before beginning. This will help return the driveshaft to its original position on the differential which can help avoid driveline vibrations once the driveshaft is reinstalled.

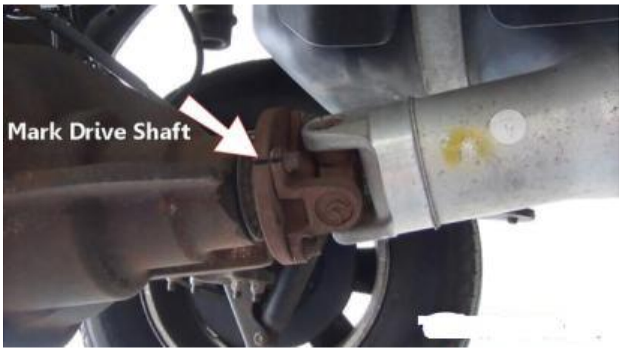


Figure 10: How to mark a drive shaft

2. Remove Driveshaft Bolts

Remove the shaft differential flange mounting bolts. These bolts will be very tight so use good quality tools to avoid stripping. Some bolts can head 12 point heads as in this example which used a 13mm 12 point socket to remove. These bolts also use lock tight to avoid coming loose while in operation and can be reapplied when reinstalling.

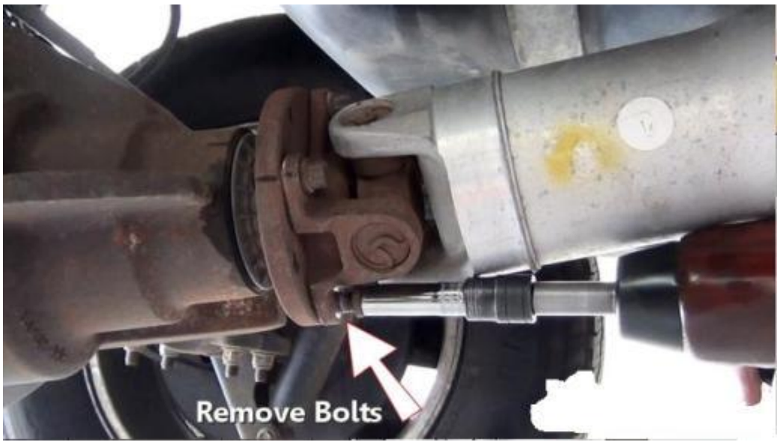


Figure 11: Bolt removal

3. Remove Driveshaft Flange

Using a plastic hammer gently shock the driveshaft loose from the differential flange by striking the rear yoke (U joint mount). At this point the back half of the shaft will be free so hang onto it. On some cars there will be a center support which must be undone by removing the two center support mounting bolts. When removing an older vehicle drive shaft use electrical tape to wrap around the u joint cups so they don't fall off and release the cup needle bearings.

Figure 12: Use a plastic hammer to remove driveshaft flange

4. Remove Driveshaft

Using both hands gently slide the driveshaft from the transmission or transfer case. A small amount of fluid might leak out so have a fluid catch basin ready. This would be a good time to replace leaking transmission tail housing seal, universal joints or if removing the transmission or differential repairs are needed.

Figure 13: Pull outward a driveshaft

5. Check U joints

At this point the U joint at either end of the shaft should be checked. Grasp the yoke and move it in all directions. It should be a smooth motion with no rough spots or play in any direction. If play or rough spots occur then the U joint needs to be replaced.

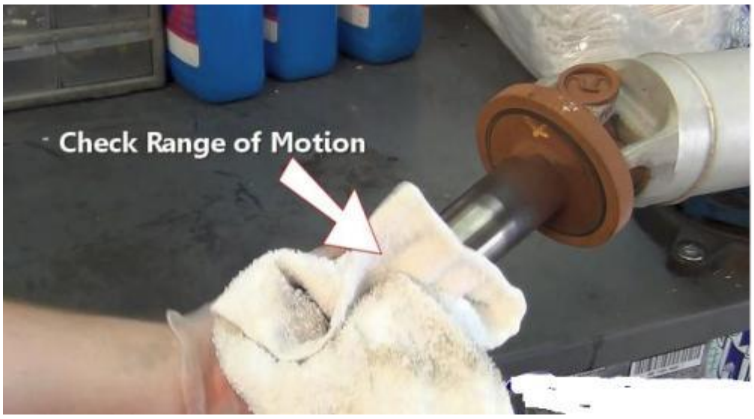


Figure 13: Check Range of motion

6**. Reinstall Driveshaft**

Before re-installing the driveshaft apply a small amount of grease to the yoke. This will help lubricate the output shaft seal in the transmission or transfer case.

Figure 14: lubricate a driveshaft

There is a dust boot along with the rear seal which is incorporated within the transmission or transfer case tail housing seal. This transmission or transfer case output shaft is where the driveshaft connects.

Figure 15: Output shaft

Care must be taken when reinserting the driveshaft yoke as not to damage the seal. Gently guide the yoke into place over and onto the output shaft.

Figure 16: Insertion of Yoke in driveshaft

7. Reinstall Flange Bolts

Once the front yoke is installed pull the driveshaft back into place while inserting a mounting bolts by hand to avoid cross threading.

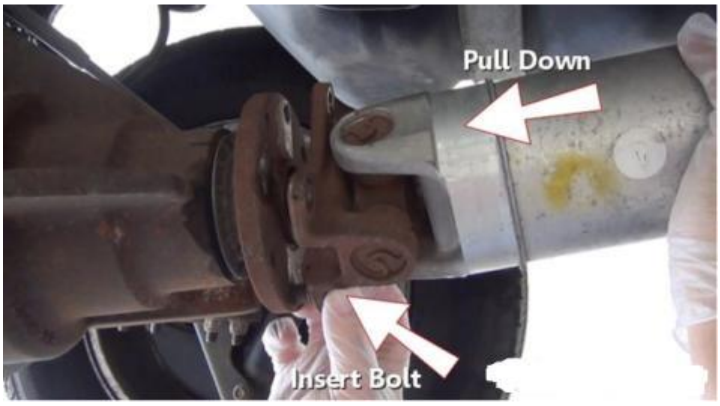


Figure17: Installation of flange bolts

Finish installing the mounting bolts while making sure the alignment marks are together.

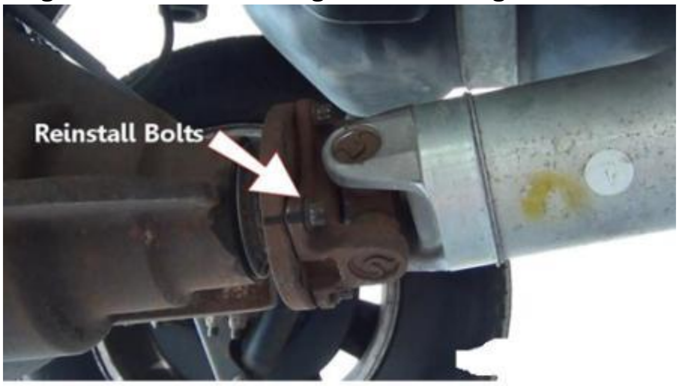


Figure 18: reinstallation of Bolts

Tighten the bolts evenly and in a cross pattern to factory specs which is usually 55-65 foot pounds of torque. If any fluid was lost during the job check and refill the transmission or transfer case after the shaft has been reinstalled and you are all set.

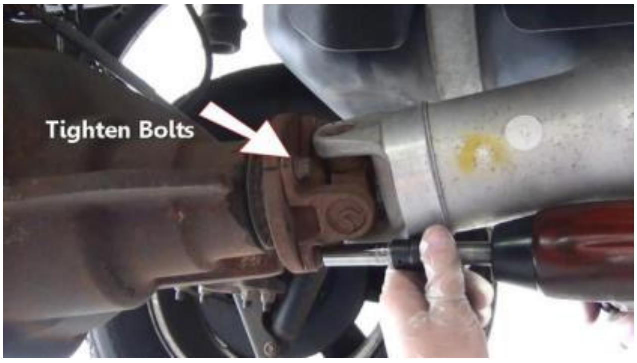


Figure 18: Tightening bolts

- Topic 2 : Procedures of removing half shaft

Step 1

Park the vehicle on solid, flat ground so the vehicle does not move around while you are working. Raise the rear of the car or truck with a jack, then support the vehicle on a set of jack stands under either the frame or axle housing.

Step 2

Locate the retaining bolts on the rear of the drive shaft where it connects to the axle housing. The shaft will connect to the pinion yoke (the yoke on the rear differential) with either two straps and four bolts or a flat flange with four bolts. In either case, remove the retaining bolts from the pinion yoke with a wrench. Pull the drive shaft away from the rear differential slightly and lower the rear to the ground for now.

Step 3

Move to the front of the drive shaft. The front of the shaft may be mounted on a flange or may slide into the rear of the transmission with a slip yoke. If your shaft has the slip style yoke, just slide it out. If it is bolted on, remove the retaining bolts with a wrench.

Pull the front of the drive shaft away from the transmission of transfer case, then remove the drive shaft from under the vehicle.

- ✓ Wheel and tire removal

See LO 1.3.TOPIC 4

- ✓ Drum and disc brake removal
- ✓ Drum brake removal:
  - Part 1 of 4: Prepare the vehicle
  - Part 2 of 4: Remove the brake shoes
  - Part 3 of 4: Install the brake shoes and drums
  - Part 4 of 4: Install the brake drums and replace the wheel

Figure 19: Drum brake removal

Drum brakes are a very common braking option used on many vehicles today. While disc brakes have become the standard for use on the front and rear axles of many vehicles, drum brakes are still very commonly used. However, they are usually found on the rear axle of a vehicle, and usually also function as the parking brake for the vehicle.

While both disc and drum brakes are commonly found across all types of vehicle platforms, and are both safe and reliable braking options, they do differ significantly in design and operation. **Drum brakes** use friction-lined brake shoes inside of a drum, as opposed to brake pads over a disc brake rotor. This design allows them to have a longer service life, as well as a lower cost of manufacturing than found with disc brakes - in exchange for the straight-ahead braking power and heat dissipation of a disc brake system. This is why most vehicles with drum brakes will usually have disc brakes in the front and drums in the rear, as most of a vehicle's braking force is exerted onto the front wheels during braking.

While drum brakes do have a completely different layout and mode of operation than disc brakes do, they are usually no more difficult to service, and often require only a basic set of hand tools and a drum brake adjustment tool to get the job done. In this step-by-step guide, we will go over how to service a typical drum brake system, including how to disassemble and replace the drums, shoes, and hardware, as well as how to properly adjust the drag of the brake shoes inside of the drum.

Materials Needed:

- Aerosol brake cleaner
- Brake shoes
- Digital micrometer
- Drum brakes
- Drum brake adjustment tool
- Dust mask
- Jack
- Jack stands
- Needle nose pliers
- Oil drain pan
- Ratchet and socket assortment
- Safety glasses
- Tire chocks (or blocks of wood)
- Drum brake tool kit
- Free repair manuals
- Protective gloves
- Safety glasses

Figure 20: Loosen the lug nuts of the wheel

Step 1: Loosen the lug nuts of the vehicle. Before raising the vehicle, loosen the lug nuts of both rear wheels.

It will be much easier to loosen them with the weight of the entire vehicle on the wheels.

Remove any wheel hubcaps or center wheel covers that may be covering the lug nuts.

Figure 21: Jack stand to support the vehicle

Step 2: Secure the vehicle on jack stands. Once the lug nuts are loosened, raise the rear of the vehicle and secure it on jack stands.

Since you will be working on the rear of the vehicle, the parking brake cannot be used to secure the vehicle. Thus, it becomes very important to secure the front wheels, using tire chocks or wood blocks, to prevent the vehicle from rolling.

Once the wood blocks are in place, slowly lower the vehicle onto the jack stands.

Part 2 of 4: Remove the brake shoes


Figure 22: wheel brake removal

Step 1: Remove the wheel. This will expose the brake drum.

- **Warning**: When servicing drum brakes, brake dust can be released into the air and can become a potential health hazard. Working in a well-ventilated area and using a dust mask will help prevent accidental inhalation of any hazardous brake dust.

Step 2: Remove the brake drum. The brake drum can usually be removed by moving it back and forth, while pulling it away from the hub.

If the brake drum doesn't move or appears to be stuck, use a bit more force and make sure that the parking brake is disengaged - it will lock the brake drums in place if it is set.

Some vehicles will also use screws to hold the drums in. If this is the case, simply remove them before attempting to remove the drum. Make sure to use the correct screwdriver so that there is no damage to the screw head during removal.


Figure 23: Clean the wheel hub.

Step 3: Clean the drum brake assembly. Once the drum is removed, you should be able to see the inner workings of the drum brake assembly: the shoes, springs, and wheel cylinder.

Before proceeding with disassembly, place the oil drain pan underneath the drum brake assembly, and then thoroughly spray the entire assembly with brake cleaner.

Liberally spray down any areas that are especially dirty, or places where brake dust has built up.

Excessive brake dust inside of the drum can cause problems like noise, vibration, and uneven wear.

- **Tip**: It would also be a good recommendation to take a picture of the drum brake assembly at this time, to have a quick visual reference of what it should look like during reassembly.

Figure 24: use a micrometer to measure shoes wear.

Step 4: Inspect the brakes. Before you dig into replacing your brake shoes, you'll want to measure and inspect the brake components.

- Brake shoes - You can measure the old shoes with a digital micrometer set to read in inches. If they have a thickness of anything less than 1/16th of an inch, the brake shoes should be replaced.
- Brake drums - Inspect the drum for scoring, cracking, or grooving.
- Brake fluid leaks - While you're inspecting the shoes and drums, you'll also want to check the wheel cylinders. If they are leaking brake fluid then they should be replaced.

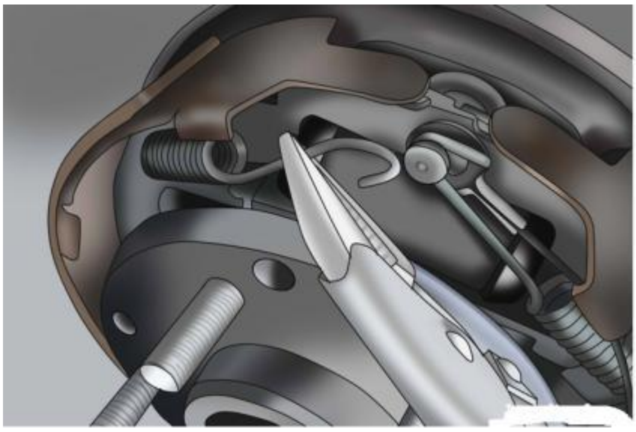


Figure 25: Disassemble the brake drum assembly

Step 5: Disassemble the brake drum assembly. Remove the brake shoe retaining springs by pulling them free using needle nose pliers.

Many vehicles will use multiple sets of springs to tension the brake shoes. It is often easiest to remove the topmost spring first, which will loosen the overall tension and make the lower springs easier to remove.

Figure 26: Brake shoes removal

Step 6: Remove the brake drum shoes. The drum brake shoes are tensioned with springs, but often times secured in place with pins and washers.

Remove any pins and washers by pulling them free using the needle nose pliers. Once all of the pins have been removed, pull the drum shoes free.

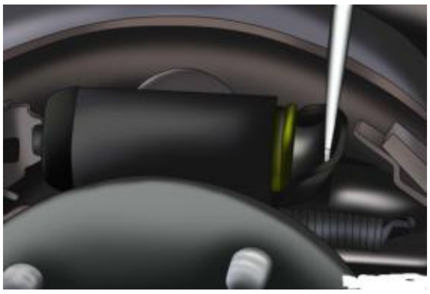


Figure 26: check a wheel cylinder leakage

Step 7: Look for any leaks. With the drum shoes and springs removed, locate and closely inspect the wheel cylinder for any signs of leakage.
Leakage at the wheel cylinder would indicate a leakage of brake fluid, and a compromise to the efficiency and safety of your vehicle's braking system.
If any leakage or damage to the wheel cylinders is found, it is recommended to replace the brake wheel cylinders as soon as possible.
Once the wheel cylinder has been closely inspected and verified to be okay, proceed to reassembly.

Figure27: The parking brake cable retainer clip removal

Step 8: Remove the parking brake cable retainer clip. Remove the parking brake cable retainer clip by prying it up with a flathead screwdriver or twisting it with a pair of pliers.

- Note: Some replacement shoes come with a new clip and some don't. Be careful removing the clip if your shoes don't come with a new one - you will need to reuse the clip when you install the replacement shoes.

Part 3 of 4: Install the brake shoes and drums

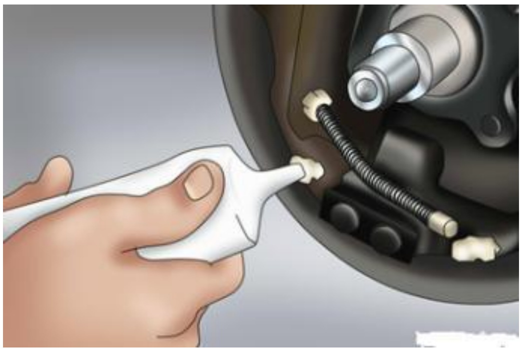


Figure 28: Clean the backing plate with brake cleaner

Step 1: Clean and lubricate the backing plate. Clean the backing plate with brake cleaner.
Then, apply disc brake lubricant to the the bosses, anchor of the pin, and parking brake actuating lever pivot surface.

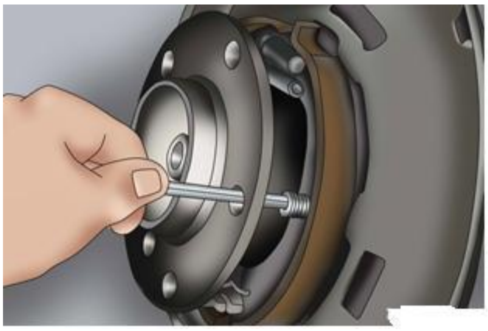


Figure 29: Installation of the parking brake lever and retaining clip

Step 2: Install the parking brake lever and retaining clip. Slide the pin through the new shoe and reinstall the parking brake retaining clip.

Figure 30: Installation the adjusting screw assembly and adjusting screw spring

Step 3: Install the adjusting screw assembly and adjusting screw spring. After putting the parking brake lever and retaining clip, install the adjusting screw assembly and spring.

Figure 31: To secure the new brake shoes onto the hub

Step 4: Secure the new brake shoes onto the hub. Begin reassembly by reinstalling the new brake shoes onto the hub, and securing them into place with the new pins and washers that should be included in your hardware kit.

Many hardware kits will also include a new adjuster component that is often secured to the bottom of the brake shoes; replace this component as well if it is included in the kit.

Figure 32: Reinstallation the tensioning springs

Step 5: Reinstall the tensioning springs. With the brake shoe secured in place, reinstall the tensioning springs in the reverse order that you removed them, from bottom to top.
The entire interior drum brake assembly should be completely reassembled at this point.

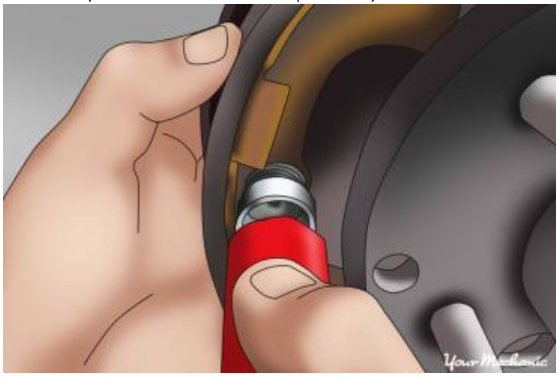


Figure 33: Installation of the hold down pins and springs.

Step 6: Install the hold down pins and springs. You should now install the hold down pins and springs of the brake drum assembly.

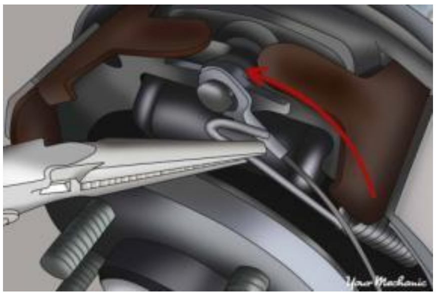


Figure 34: Installation the return springs

Step 7: Install the return springs. Install the return springs by attaching the spring to its proper location on the brake.

Figure 35: Adjust the brakes so the brake shoes expand

Step 8: Adjust the brakes so the brake shoes expand. Adjust the brakes using a screwdriver or dedicated brake spoon.

You will want to expand the shoes until the drum can just barely be turned by hand.

Then, back off the adjusting screw 12 notches. If the shoes are still dragging, back off the adjusting screw a couple more notches.

Set the wrench to the desired reading and turn it until it clicks. Torque specifications can be found in the repair manual for your vehicle.

Part 4 of 4: Install the brake drums and replace the wheel

Step 1: Prepare the new drum brake. Many drums will become coated in a thin oily film to prevent them from rusting during shipping and storage.

If that is the case, be sure to liberally spray the drums with brake cleaner to remove any of the film that may be present before installing them.

Figure 36: **Installation of the drum brake over the brake shoes**

Step 2: Install the drum brake over the brake shoes. Once the drum is clean and ready to install, slip it over the brake shoes and install it onto the hub.
If there is any difficulty sliding the drum on, it may be possible that the brake shoes need to be adjusted so that the drum can fit correctly.
Adjust the brake shoes by turning the adjuster, or by using the adjuster tool, one increment at a time until the drum slides over the brake shoes and onto the hub properly without excessive resistance.

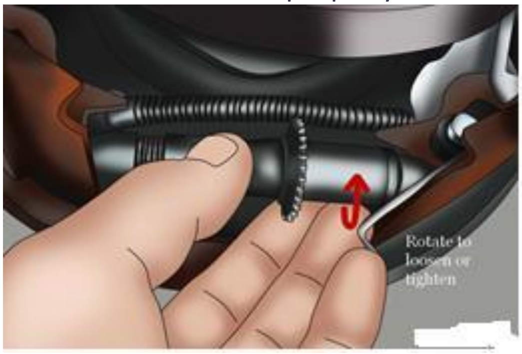


Figure 37: Make final adjustments to the brake drum

Step 3: Make final adjustments to the brake drum. At this point the drums should be fully reassembled, and will just require a final adjustment.
A final adjustment is very important. Loosely adjusted shoes will not work correctly and may even result in problems with the parking brake, while excessively tight shoes will cause excessive drag that can overheat and damage the drums and shoes.
Locate the adjuster access port, which is usually on the inside of the hub. This port grants access to the brake adjuster.

- Note: Some vehicles will require you to turn the drum a certain way to gain access to the port, while others will not have a port at all, requiring you to remove the drum every single time you make an adjustment.

Use the drum brake adjusting tool to turn the adjuster and loosen or tighten the shoes. You may also need to use a flathead screwdriver to turn the adjuster if a brake adjuster tool is not handy.
Carefully adjust the tension in small increments, until there is minimal to zero drag on the inside of the drum when you turn it by hand.

Figure 38: Installation of the wheel and tire

Step 4: Install the wheel and tire. Put the wheel and tire back on the vehicle and tighten the lug nuts until they are snug - but don’t tighten them all the way.

Step 5: Remove the jack stands. Jack up the vehicle in the same location as before. Remove the jack stands and then lower the jack slowly until the car is on the ground.

Step 6: Remove the wheel chocks.

Figure 39: Torque the wheel lug nuts to specification

Step 7: Torque the wheel lug nuts to specification. Use a torque wrench and refer to your owner's manual for the correct specification.

Step 8: Replace the brake shoe and drums of the other rear wheel. Follow the previous steps to replace the brake drum on the other rear wheel.

Once the final adjustment has been made, put the wheel back on, and tighten the lug nuts.

Step 9: Test your brakes. Pump the brakes using your brake pedal to redistribute hydraulic pressure into the system. Also check to make sure that the parking brake is operating correctly and does not feel excessively loose.

At this point, you can test drive the vehicle on the road to make sure that the brakes is operating normally. If the brake pedal feels loose or too hard to push, you should stop and make adjustments or have the brakes inspected and repaired by a mechanic.

All things considered, servicing your drum brakes is a relatively straightforward affair, and is not much more complicated to perform than most disc brake services. Best of all, servicing them yourself can be a great way to save on expenses.

- ✓ Axle shaft bolts removal

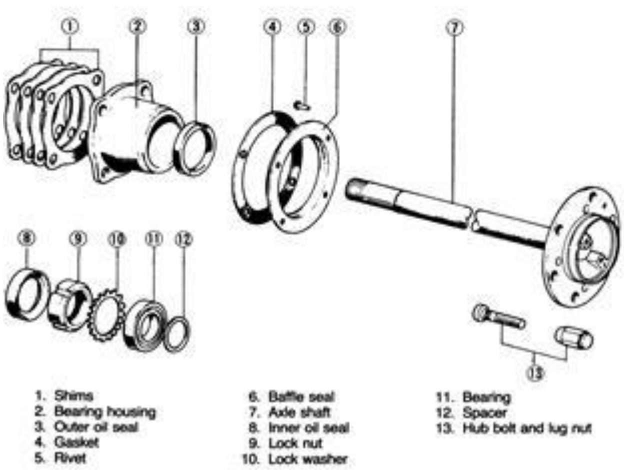


Figure 40: Disassembled axle shaft with its bolts

- ✓ Axle shaft removal

Figure 40: Axle shafts

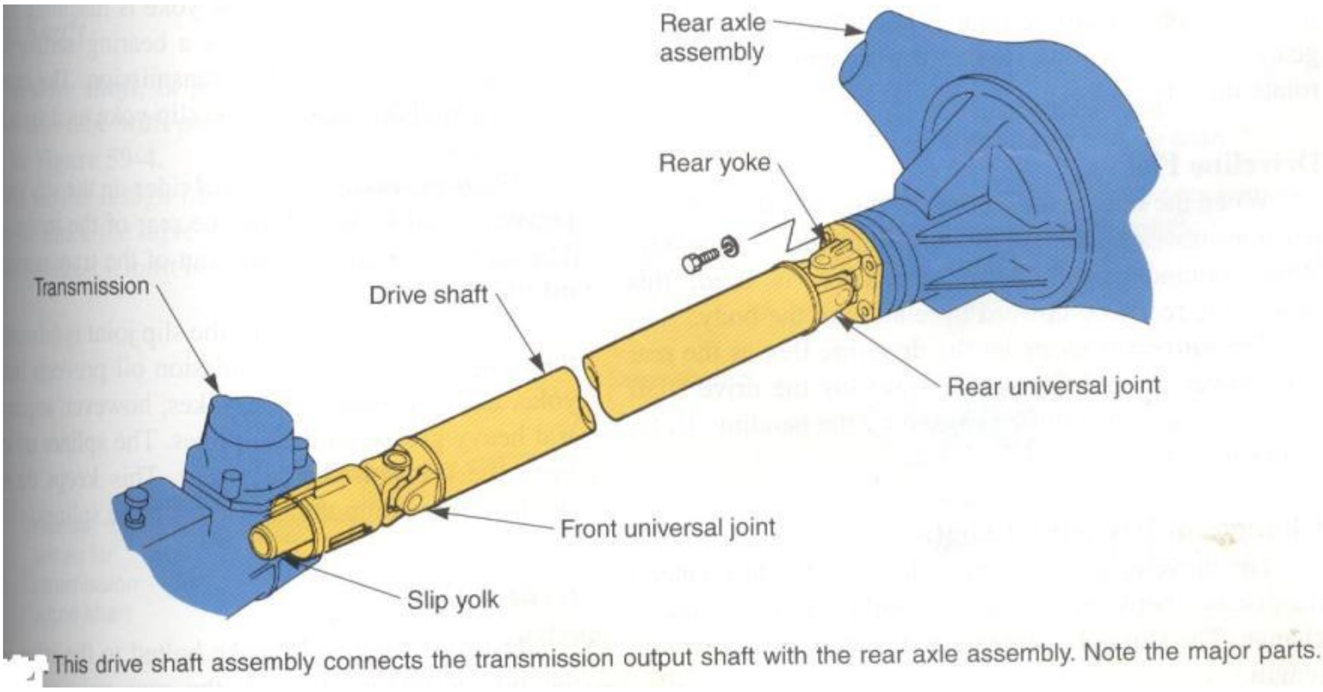


Figure 41: Drive shaft assembly

LO 1.5 – Dismount manual gearbox mountings and starter motor

- <u>Topic 1 : Dismounting manual gearbox mountings</u>

Remove the large bolts that hold the **transmission** to the **engine** block, and the small bolts that hold the dust shield in the bottom front of the **transmission**. **Remove** the two bolts that hold the clutch slave cylinder onto the bell housing. Twist the speedometer cable from its mount at the rear extension housing

- ✓ Withdrawing speedometer drive cable and pinion assembly
- ✓ Using a ramp jack, support the gearbox and remove rear mounting platform attachment bolts and nuts
- ✓ Removing the two mounting bolts and nuts. Swing the steady strap forward and clear of rear extension
- ✓ Raising the gearbox and remove the mounting

➢ **Gearbox lowering**

- ✓ Placing a drip tray under gearbox
- ✓ Unscrewing and removing bolts

- ✓ Extension housing and thrust washer withdrawal

➢ Dismounting starter motor

- ✓ Always disconnect the battery before removing the starter motor, which is often awkwardly placed low down on the engine. You may have to raise the car on axle stands and work from below.
- ✓ Disconnect the battery (earth terminal first) to avoid an accidental short circuit.
- ✓ Remove the nut that holds in place the heavy lead connecting the starter to the battery. With an inertia-type starter take care not to twist the terminal post as you are unscrewing the nut.
- ✓ Hold the locknut on the post with an open-ended spanner.

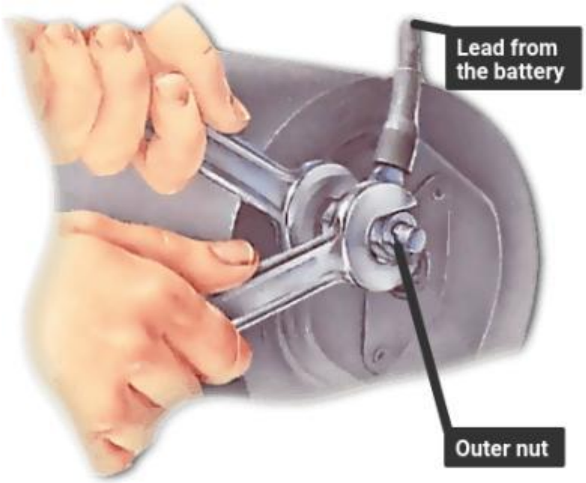


Figure 42: Hold the terminal-post but with a spanner while you unscrew the outer nut securing the lead from the battery.

LO 1.6 – Dismount manual gear shifting linkages and attachments

- **Topic1 : Identification of different types of gear linkages**

Spur Gear

Figure43: **Spur Gear**

Spur gears transmit power through shafts that are parallel. The teeth of the spur gears are parallel to the shaft axis. This causes the gears to produce radial reaction loads on the shaft, but not axial loads. Spur gears tend to be noisier than helical gears because they operate with a single line of contact between teeth. While the teeth are rolling through mesh, they roll off of contact with one tooth and accelerate to contact with the next tooth. This is different than helical gears, which have more than one tooth in contact and transmit torque more smoothly.

Helical Gear

Figure 44: **Helical Gear**

Helical gears have teeth that are oriented at an angle to the shaft, unlike spur gears which are parallel. This causes more than one tooth to be in contact during operation and helical gears are capable of carrying more load than spur gears. Due to the load sharing between teeth, this arrangement also allows helical gears to operate smoother and quieter than spur gears. Helical gears produce a thrust load during operation which needs to be considered when they are used. Most enclosed gear drives use helical gears.

Double Helical Gear

Figure 45: **Double Helical Gear**

Double helical gears are a variation of helical gears in which two helical faces are placed next to each other with a gap separating them. Each face has identical, but opposite, helix angles. Employing a double helical set of gears eliminates thrust loads and offers the possibility of even greater tooth overlap and smoother operation. Like the helical gear, double helical gears are commonly used in enclosed gear drives.

Herringbone Gear

Figure 46: **Herringbone Gear**

Herringbone gears are very similar to the double helical gear, but they do not have a gap separating the two helical faces. Herringbone gears are typically smaller than the comparable double helical, and are ideally suited for high shock and vibration applications. Herringbone gearing is not used very often due to their manufacturing difficulties and high cost.

Bevel Gear

Figure 47: **Bevel Gear**

Bevel gears are most commonly used to transmit power between shafts that intersect at a 90 degree angle. They are used in applications where a right angle gear drive is required. Bevel gears are generally more costly and are not able to transmit as much torque, per size, as a parallel shaft arrangement.

Worm Gear

Figure 48: **Worm Gear**

Worm gears transmit power through right angles on non-intersecting shafts. Worm gears produce thrust load and are good for high shock load applications but offer very low efficiency in comparison to the other gears. Due to this low efficiency, they are often used in lower horsepower applications.

Hypoid Gear

Figure 49: **Hypoid Gear**

- **Topic3 : Gear shifting linkages and attachments removal**

✓ Shift lever

Figure 49: Shift Level

✓ Gear shift mechanism assembly

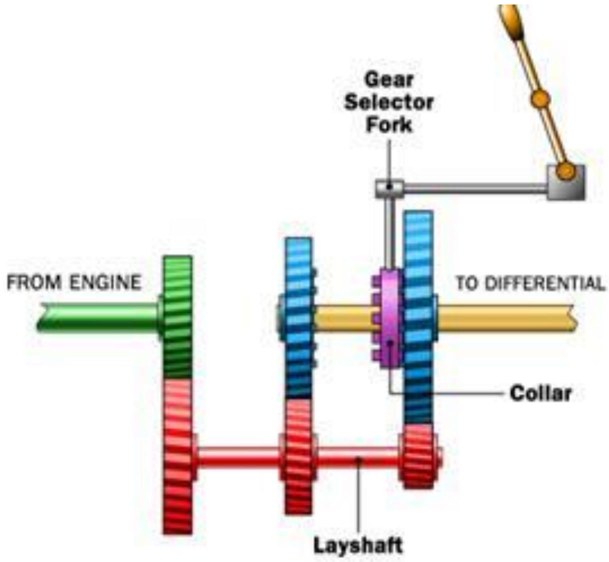


Figure 50: Gear shift mechanism assembly

✓ Boot and console assembly

Figure 51: Boot and console assembly

✓ Adjusting screw cable

Figure 52: Adjusting screw cable

✓ Ball

Figure 53: Ball

✓ Selector cable assembly

Figure 54: Selector cable assembly

✓ Selector rod

Figure 55: selector rod

✓ Grommet cable assembly

Figure 56: grommet cable assembly

✓ Bracket

Figure 57: Bracket

✓ Stabilizer

Figure 58: Stabilizer

Learning Outcome 1.7 – Dismount clutch control components and housing

- Topic 1 : Identification of different clutch

Following are the different types of clutches using in automobile industries.

- Friction clutch. Single plate clutch. Multiplate clutch.
- Centrifugal Clutch.
- **Semi**-centrifugal clutch.
- Conical spring clutch or Diaphragm clutch. Tapered finger type.
- Positive clutch. Dog clutch.
- Hydraulic clutch.
- Electromagnetic clutch.
- Vacuum clutch.

components Location of clutch control components

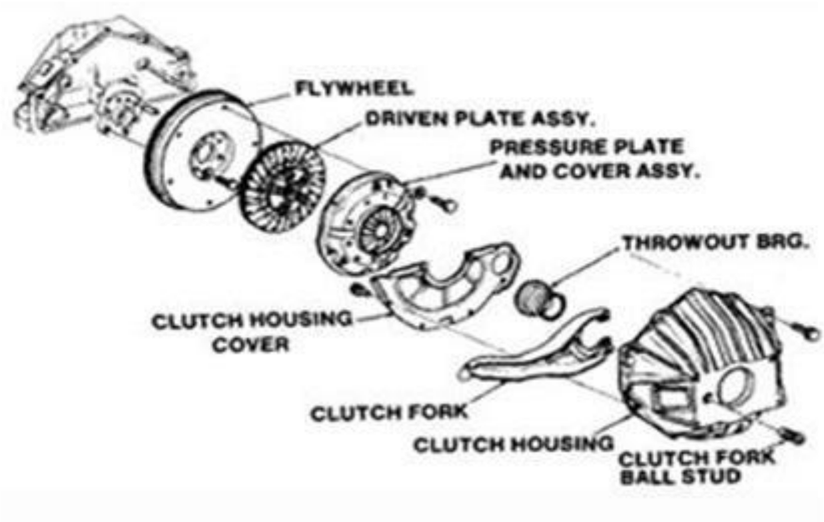


Figure 59: Clutch components location

Clutch control components removal

- ✓ Slave cylinder

Figure 60: Slave cylinder

- ✓ Clutch cable

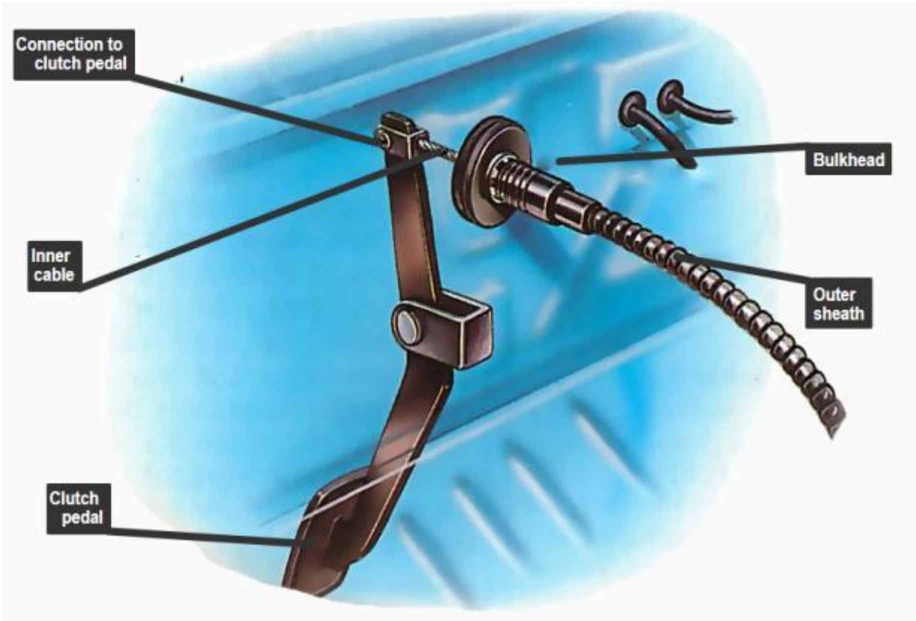


Figure 61: Clutch cable

Clutch housing removal

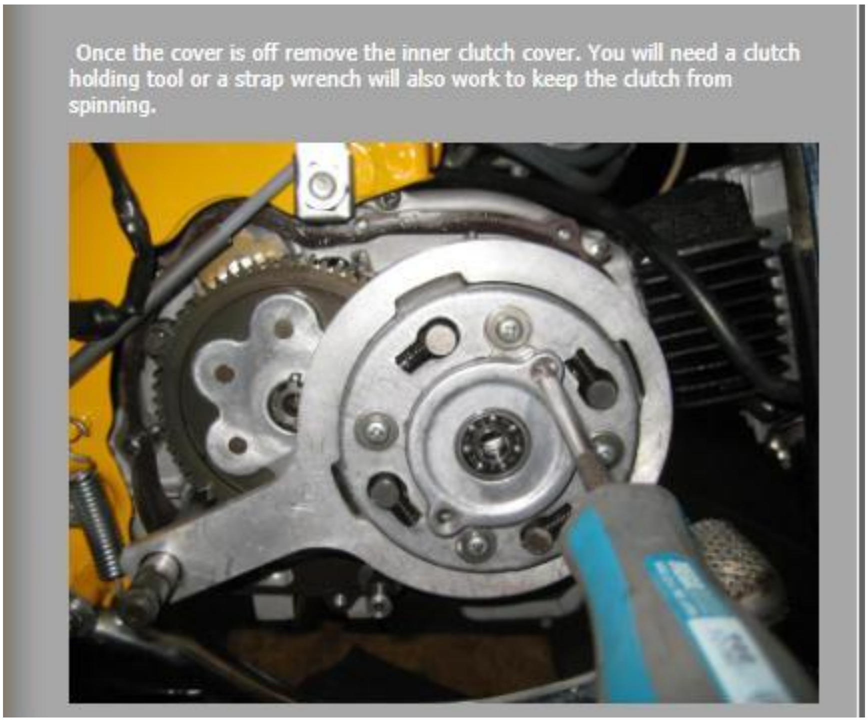


Figure 62: Clutch housing removal

LO 1.8 – Dismount final drive with differential

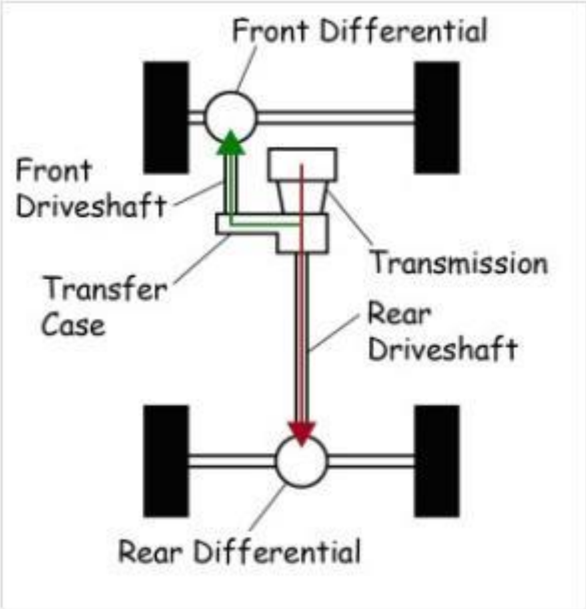


Figure 63: Final drive with differential

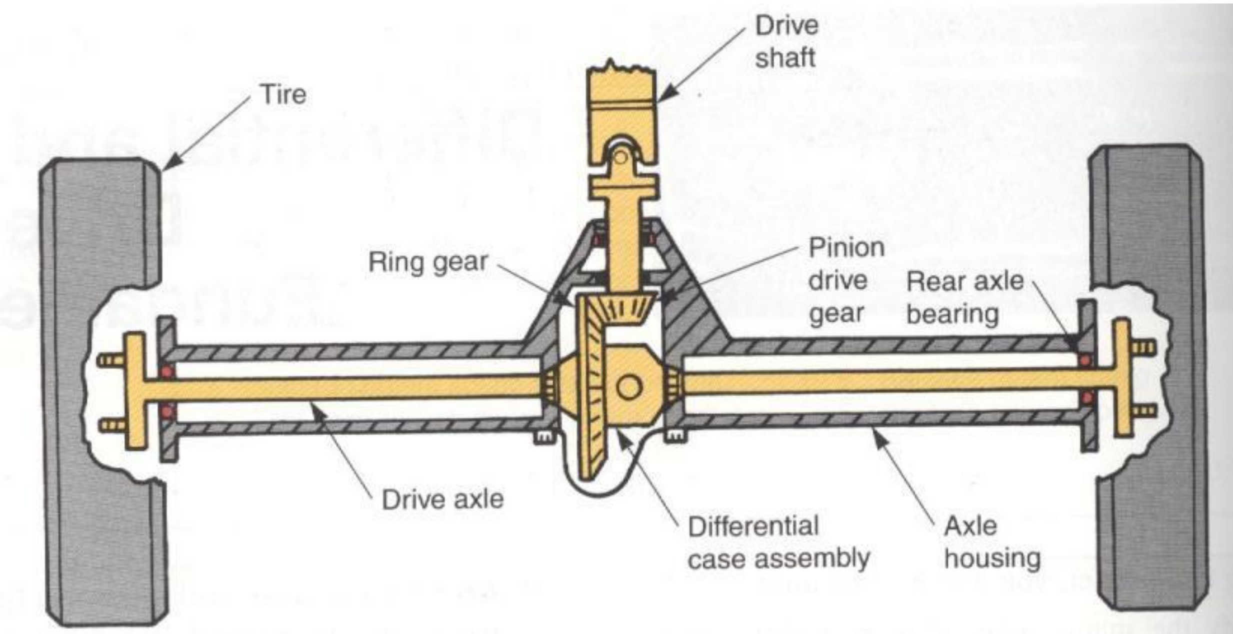


Figure 64: Final drive with differential assemblies

Topic 1: Final drive with differential dismounting procedures

1) Lift up vehicle and remove wheels.
2) Drain differential oil from rear axle housing referring to **Rear Differential Gear Oil Inspection and Change: Rear**.
3) Remove rear brake drums and pull out right and left rear axle shaft referring to **Rear Axle Shaft and Wheel Bearing Removal and installation: Rear**.
4) Before removing propeller shaft, give match marks (1) on companion flange (2) and propeller shaft (3) as shown.
5) Remove differential carrier bolts (1) and differential assembly.

Dismount differential components

- ✓ Bevel gear

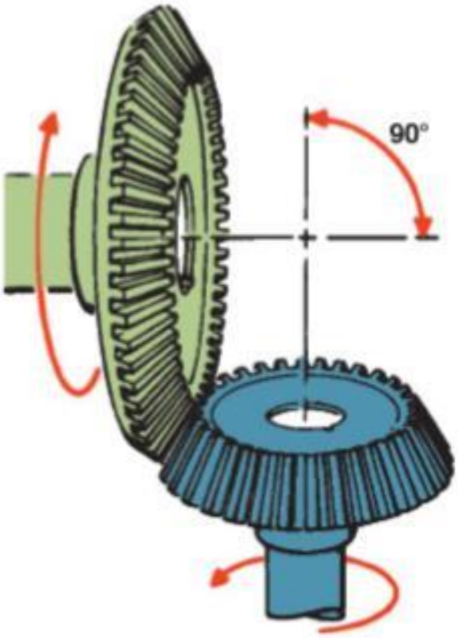


Figure 65: Bevel gear

Topic 2: Final drive with differential dismounting

Figure 66: Differential dismounting

- As we do with all dismantling and reassembly exercises clear off a bench **use the jig provided**, work methodically, and lay out your parts.
- As with all the practical exercises on the course, they form the basis for the practical exams at the end of the module.
- Take time with this exercise, it is not just a matter of dismantling and reassembling the unit.
- Read through the extract from the workshops manual to get used to the terminology used as well as learning to read any technical information or instructions.

The purposes of this exercise are that you:

- Disassemble the unit,
- Name and state the function of each part,
- Reassemble the unit,
- Adjust the pinion preload and backlash on the unit.

Figure 67: Differential on the bench to be repaired.

Figure 68: Differential on the bench to be greased

When reassembling the unit, do so as if you were leaving it **ready for service**. This means:

- **Greasing** all bearings and gears as you fit them.
- Using **oil** on all components as you reassemble them.
- **Adjusting** the crown wheel carrier bearings so that they have the correct **pre-load**, and also that the crown wheel to pinion **backlash** is also correct.
- When the crown wheel carrier bearings are adjusted, the **locking levers** are correctly fixed.

Locking the Crown wheel Carrier Bearings Once They are Correctly Adjusted:

Figure 69: Locking the crown wheel

Figure 71: Differential dismounted

Use the correct tool provided in order to preload the Crown wheel carrier bearings. These bearings must be preloaded, but the position of these bearing also controls the position of the crown wheel, and thus the crown wheel to pinion backlash. When the bearings are correctly set, knock out the roll pin from the locking lever.

Figure 72: Differential lock lever


Figure 73: use proper tool to remove roll pin lever

Remove the lever, and put the point of it into a groove in a gap in the carrier bearing adjuster ring.

Return the top of the lever to its mounting position, and re-insert the roll pin. Now the bearing is properly adjusted and the adjuster is locked up.

Learning Unit 2 – Disassemble final drive with differential

LO 2.1 – Identify components of final drive with differential

DIFFERENTIAL

A. Functions

- Balances speed discrepancies between the drive wheels.
- Distributes torque in equal proportions to the drive wheels.

Balancing speed discrepancies between the drive wheels.

When a vehicle is driving through a bend/curve, the outside wheels must cover a greater distance than the inside wheels. Different road surfaces also cause discrepancies in the distance covered. The wheels on one axle therefore rotate at different speeds.

The differential balances the speed discrepancies between the drive wheels. The outside drive wheel during cornering rotates faster at the same rate that the inside drive wheel rotates more slowly.

Distributing torque in equal proportions to the drive wheels.

The differential transmits equal torque to both drive wheels even if, for example during cornering, one drive wheel is rotating faster than the other.

The amount of transmitted torque is determined by the drive wheel which has the poorer adhesion on the road surface.

B. Types

- Bevel-gear differential. This is accommodated together with the final drive in a single housing (differential).
- Worm gear differential (Torsen differential). This is installed, for example, in all-wheel-drive vehicles as a transfer box between the powered axles and has an automatic locking effect.

Bevel-gear differential

The bevel pinion is connected for example with the propeller shaft and drives the crown wheel, which is bolted to the differential housing. The differential bevel gears are mounted so that they can rotate in the differential housing. The differential bevel gears mesh with the axle-shaft gears, which are connected with the axle shafts.

Operating principle

Straight-ahead driving. Both drive wheels and axle shaft gears rotate at the same speed. The differential bevel gears do not rotate. They act as drivers and transmit the drive torque in equal proportions to the left and right axle-shaft gears.

One wheel spins, the other is stationary. The axle shaft gear of the spinning wheel causes the rotation of the differential bevel gears, which circulate on the stationary axle-shaft gear.

The speed discrepancy is balanced by the fact that the spinning wheel rotates twice as fast as the crown wheel.

Torque distribution is effected in equal proportions to the axle-shaft gears and is directed at the drive wheel with the poorer adhesion. Propulsion of the vehicle is not possible.

Cornering (example: left-hand bend. **Figure 74).**The outside drive wheels cover a larger distance and rotate faster than the inside wheels.

This is made possible by the differential bevel gears, which balance speed discrepancies between the left and right axle-shaft gears.

Here the differential gears which are mounted in *he differential housing rotate about their axes.

Figure 74: shows the directions of rotation of the shafts and bevel gears on a left-hand bend.

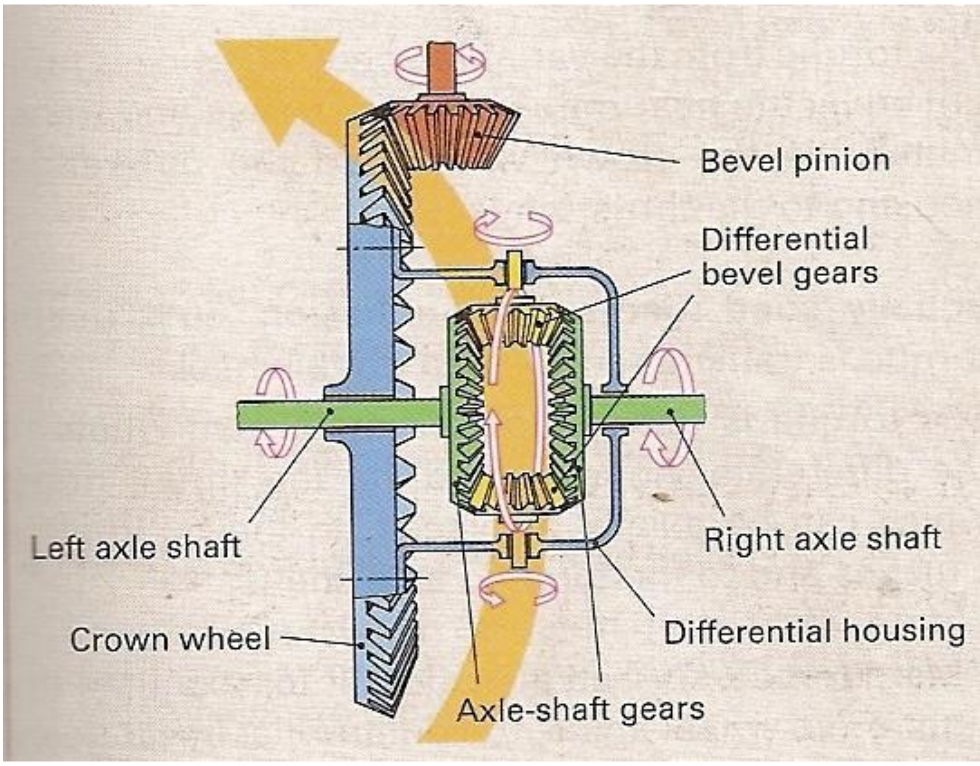


Figure 74: Bevel gear differential

The inside left drive wheel rotates more slowly at the same rate that the outside right drive wheel rotates faster. The speed discrepancy is balanced by the differential bevel gears.

Each drive wheel receives equal torque.

C. Differential locks

A distinction is made between:

- Interwheel locks and
- Longitudinal locks

1. **Interwheel lock.** This locks speed balancing between the drive wheels of one axle.

An Interwheel lock allocates more torque to the drive wheel of an axle which has the better road surface adhesion (traction).

Example: If for instance a drive wheel spins on an icy road surface or soft ground, this wheel transmits insufficient motive force to the road surface to propel the vehicle.

The differential has a disadvantageous effect here because the other drive wheel with good road surface adhesion is allocated the same torque. More torque is allocated to the drive wheel with the better road-surface adhesion thanks to the differential lock. The allocated torque is dependent on the traction and the locking value of the installed differential lock.

Locking value

The locking value **S** indicates how much torque discrepancy is possible between the left and right drive wheels on a powered axle or between two final drives of the front and rear axles of all-wheel-drive vehicles.

$$S = \frac{\text{Differential, torque}}{\text{Sum total, torque}} . 100\%$$

The locking value **S** is given in %. It refers for example to the load torque applied to the crown wheel.

Example, locking value 40%: Here the drive wheel with the better traction can transmit 40% more torque than the enter drive wheel.

2. **Longitudinal lock.** This locks speed balancing between the wheels of two powered axles. A longitudinal lock allocates more torque to the drive wheels of the axle which have the better road-surface adhesion (traction).
   Example:I f, for instance on an all-wheel-drive vehicle, the wheels on a powered axle spin, the wheels on the powered axle with the better traction are allocated more torque in accordance with the locking value of the installed differential lock.

- **Topic 1 : Identification of final drive with differential components**

1. **Bevel gear final drive**
   A bevel-gear final drive consists of a bevel pinion and crown wheel.
   A distinction (Fig. 74) is made between bevel-gear final drives.
   - With **non-offset axes** and
   - With **offset axes** (hypoid drive).

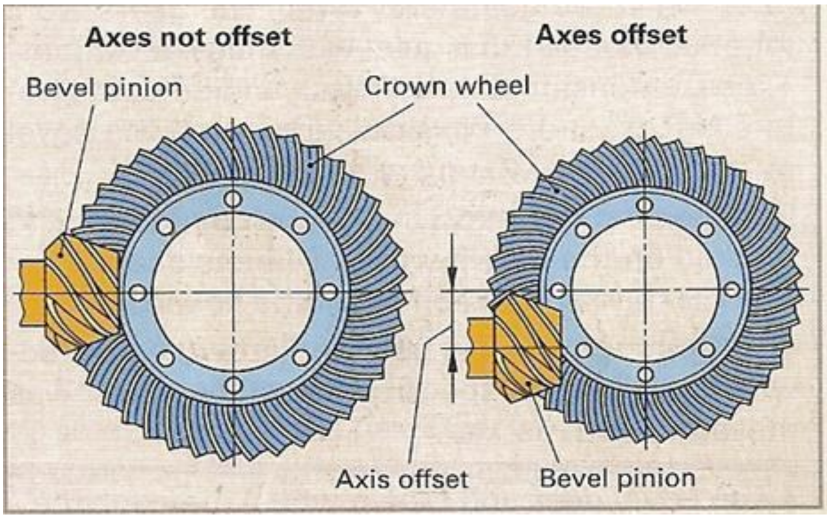


Figure 75: Final drive with offset and non-offset axes (hypoid drive).

Advantages of hypoid drive:

- **Increased smooth running** because a greater number of teeth meshes.
- **Higher load capability** because the diameter and the tooth widths of the bevel pinion are larger.
- **Takes up less space** because the crown wheel while being subject to the same load has a smaller diameter.

Thus, the propeller shaft can be mounted in a lower position in vehicles with front engines and rear-wheel drive. The propeller-shaft tunnel and the centre of gravity are lower.

As a result of the axis offset, greater friction movements occur during rolling contact between the touching tooth flanks than is the case with non-off- set axes. This makes it necessary to use particularly pressureresistant hypoid oils.

Two different types of toothing may be used: Gleason toothing or Klingelnberg toothing.

Gleason toothing (Fig.76)

- The tooth flanks of the crown wheel form parts of the arc of a circle.
- The tooth backs become narrower from the outside inwards.
- The tooth heights become smaller towards the inside.

Klingelnberg toothing (Fig.76)

- The tooth flanks form parts of a spiral.
- The tooth backs maintain a constant width from the outside inwards.

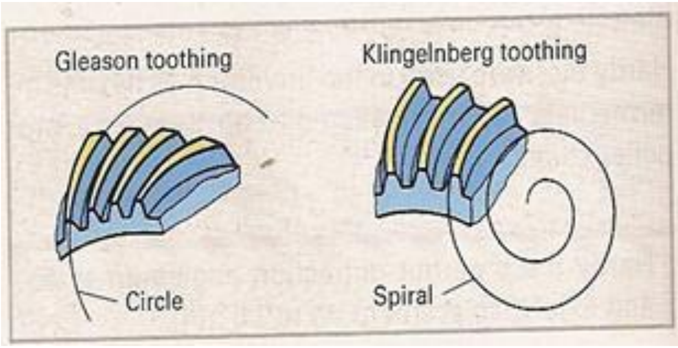


Figure 76: Gleason and Klingelnberg toothing

2. **Spur-gear final drive**

This consists of a small input spur gear and a large output spur gear. Both gear wheels have helical teeth, which are cheaper to manufacture than spiral teeth.

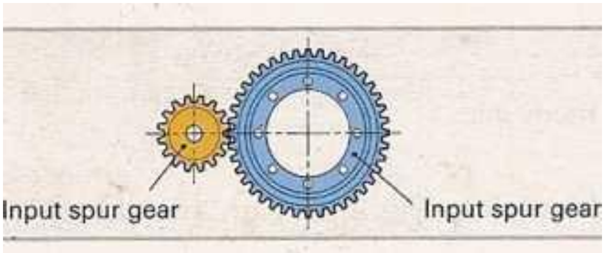


Figure 77: spur-gear final drive

WORKSHOP NOTES

The correct interaction of bevel pinion and crown wheel is essential to low-noise operation by and a long service life for the final drive. Because bevel pinion and crown wheel are matched in pairs to each other for fault-free operation, they are provided with markings by the manufacturers (Fig. 3). They are given a pair number p, which is marked on the face of the bevel gear and on the flange side at the top of the crown wheel.

R and T are design dimensions.

The dimensional deviations **r** and **t** from these design dimensions are determined by the manufacturer when the gears are run in. The gears work together at their most quiet with these deviations. These dimensional deviations **r** and **t** must therefore be taken into consideration when the bevel gear and crown wheel are adjusted.

Dimensional deviation **t** and tooth backlash **z** are marked on the crown wheel. Dimensional deviation **r** is marked on the face of the bevel pinion.

The teeth of the bevel gear and crown wheel between which the specified tooth backlash was measured are marked.

The bevel gear and crown wheel may only be replaced in pairs.

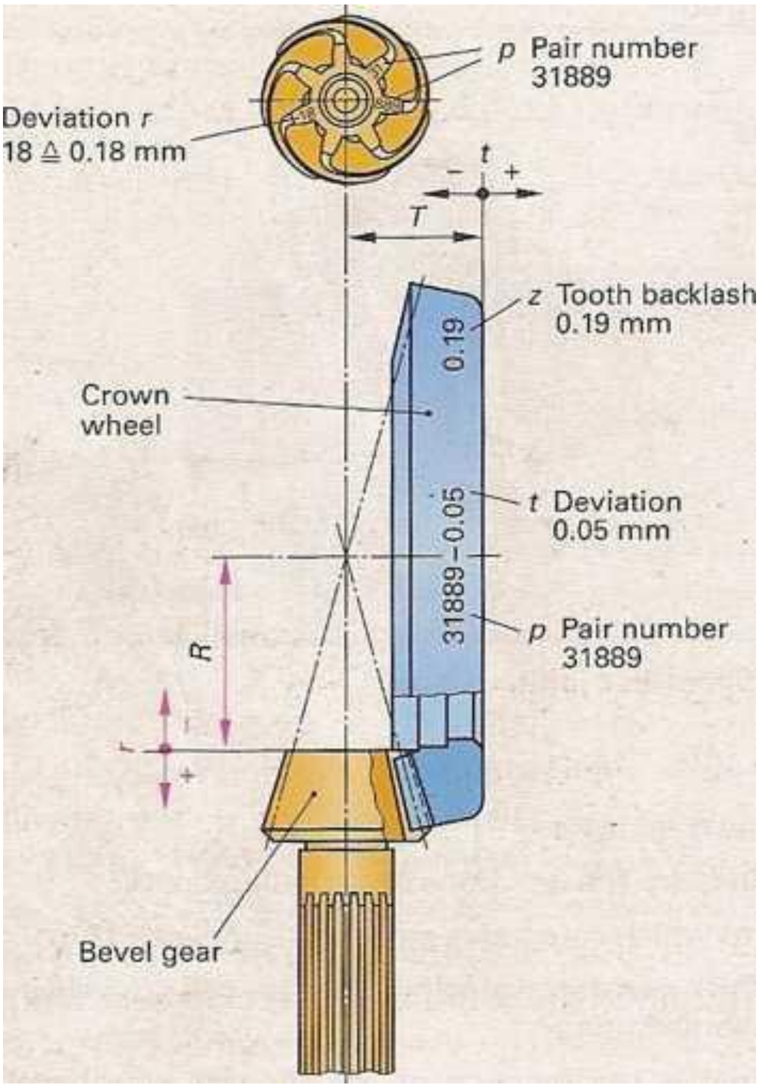


Figure 78: Bevel pinion and crown wheel

3. Crown wheel

Figure 79: Crown wheel

4. Sun gears

Figure 80: sun gear

5. Axle gears

Figure 81: axle gears

6. Differential lock

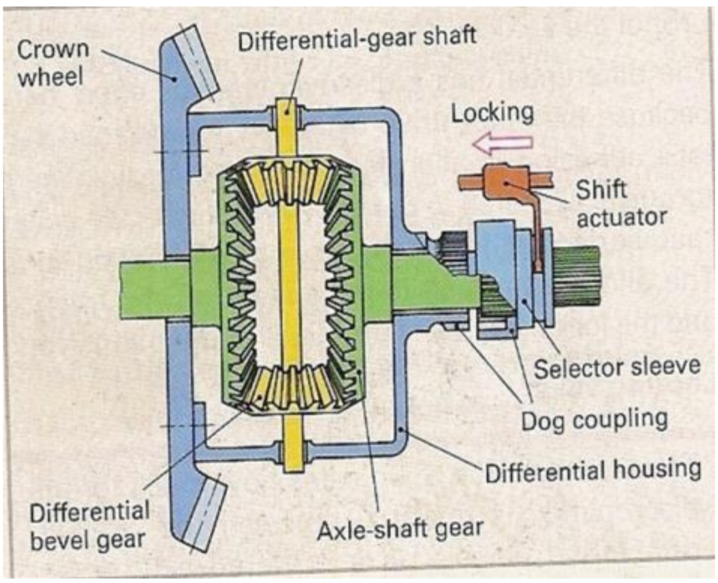


Figure 82: Shiftable Differential lock

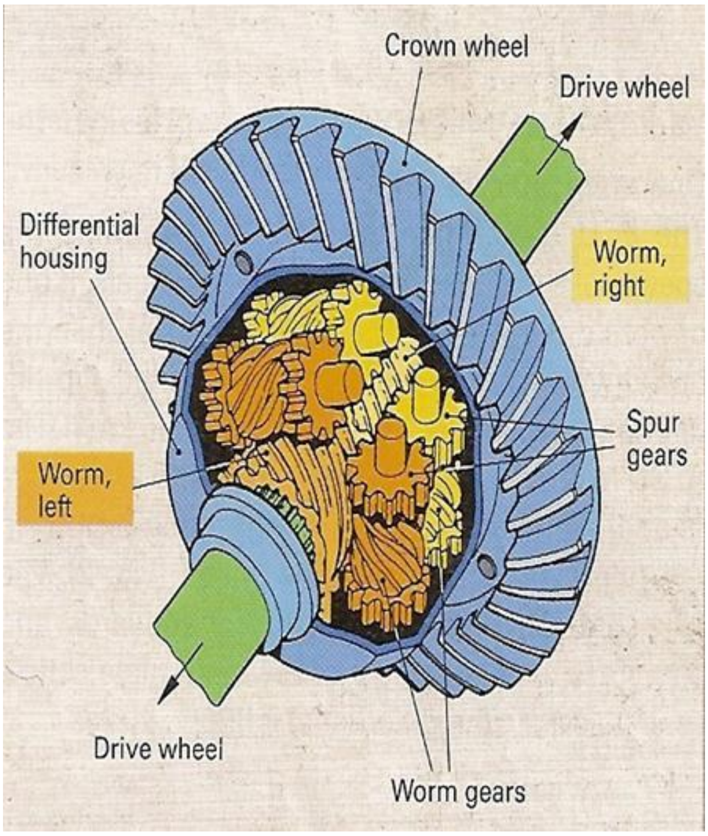


Figure 83: Torsen differential as Interwheel lock

- **Automatic limited-slip differential (ALSD)**

There is an electrohydraulic system which is used as an aid to starting and locks the differential 100% when the wheels spin. Improved traction is achieved as a result.

Design (fig.83)

The system features the following assemblies:

- Differential with ring cylinder and multi-plate clutches.
- Fluid pump, fluid reservoir, ALSD hydraulic control unit with pressure accumulator and solenoid valve.
- Wheel sensors, ALSD ECU, function and fault indicators.

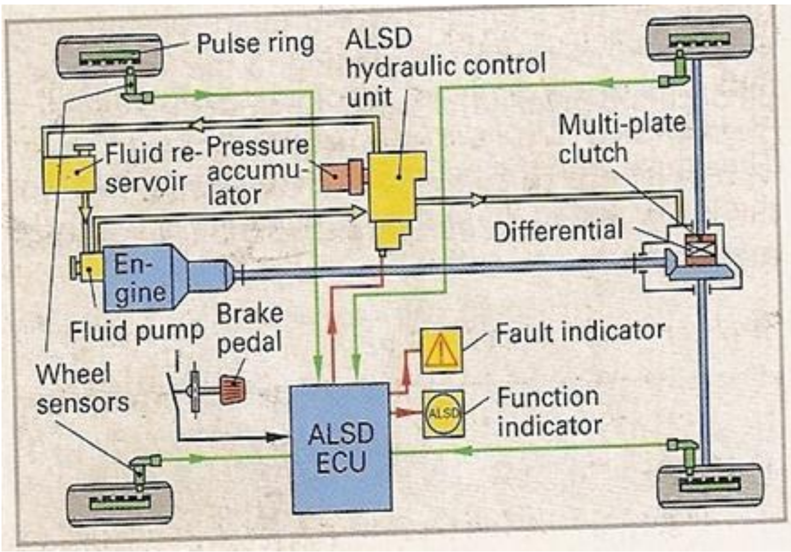


Figure 84: ALSD system overview

LO 2.2 – Disassemble final drive with differential components

Figure 85: Disassembling differential

- <u>Topic 1 : Location of differential components</u>

A car **differential** is placed halfway between the driving wheels, on the front, rear, or both axes (depending on whether it's a front-, rear-, or 4-wheel-drive car).

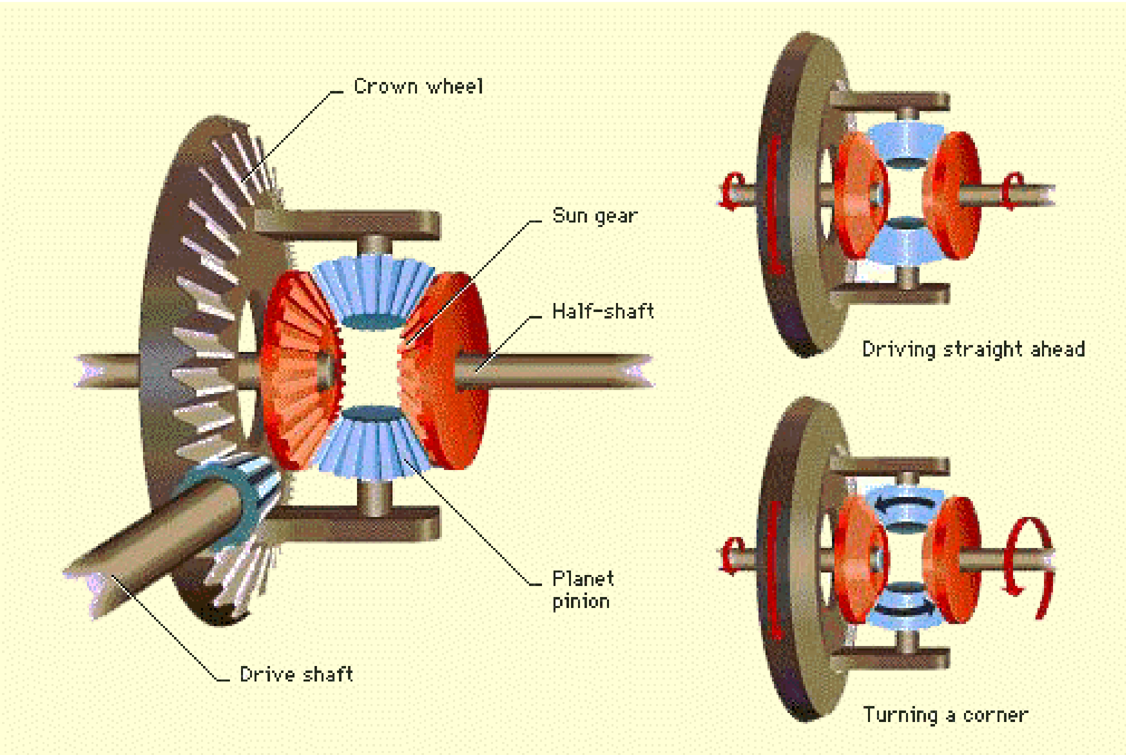


Figure 86: Differential components

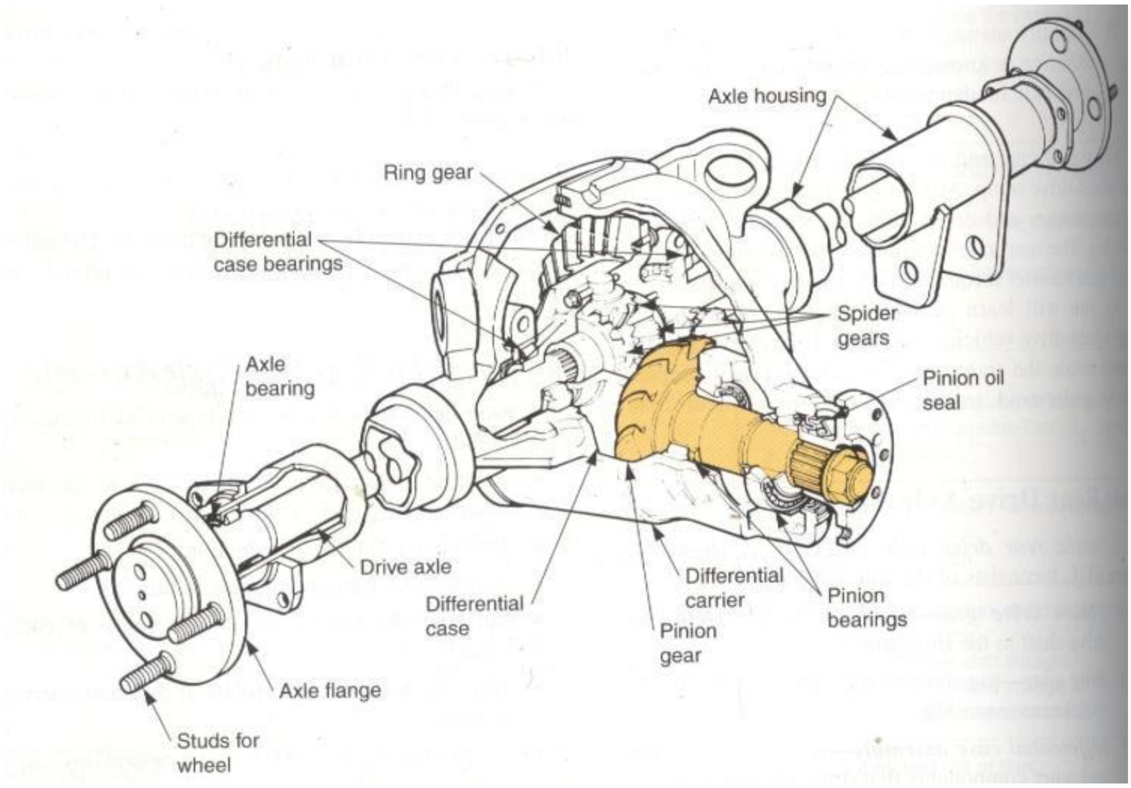


Figure 87: Cutaway shows a detailed view inside the axle housing. The relationship of parts.

- **Marking components of final drive with differential**

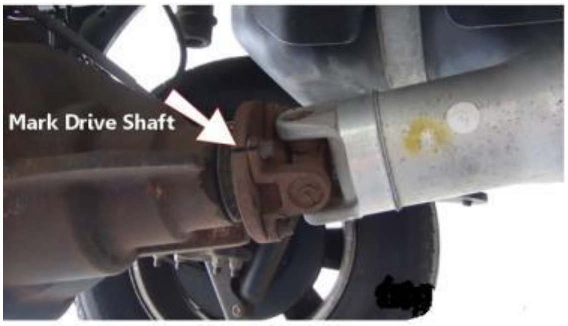


Figure 88: marking components of final drive with differential

- <u>Topic 2 : **Disassembling differential locking components**</u>

- Disassembly

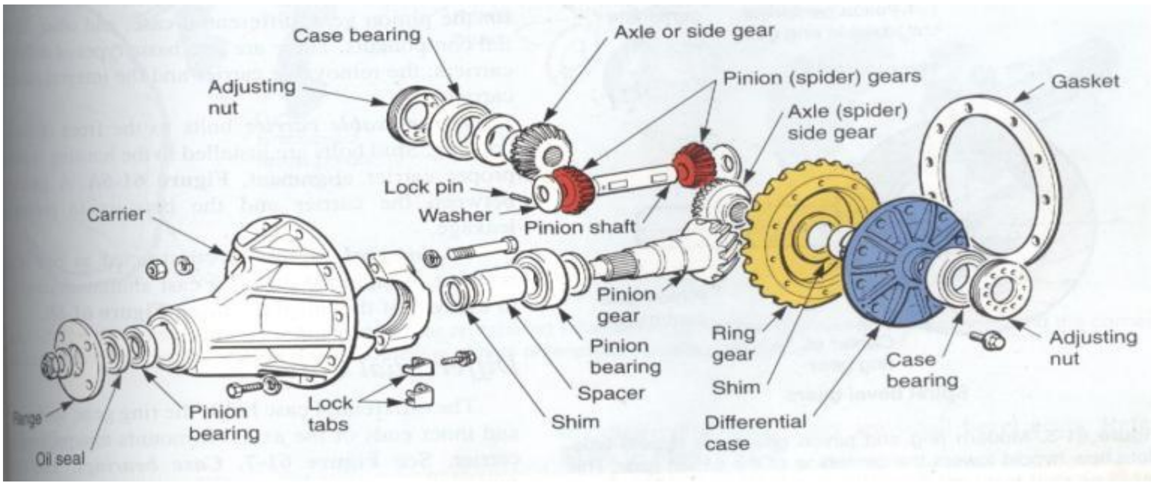


Figure 89: The exploded view shows all the major parts of a differential assembly.

The picture below shows the spreader in use. I used plenty of grease on the threads and the large washers then turned the nuts with two large crescent wrenches, one 12-inch and one 18-inch. To keep the forces balanced, I turned the nuts on both side equal amounts; two flats on one side, then the same on the other. It is possible to damage the case when doing this, so it's necessary to use only enough force to loosen the differential. I probably used more than necessary, but the case seemed OK afterward, and the carrier came out easily. Next time, if there is one, I won't be so brutal.

Figure 90: The spreader in use

Below are some pictures of the carrier. At first glance, it wasn't too bad. The internal differential gears looked OK. The bearings should be a press fit, but the left-side one, although not loose, was only a sliding fit on the carrier. That was a concern, although I later learned that this situation is common.

Figure 91: The carrier-bearing races

As I expected, the carrier-bearing races had substantial corrosion; the bearing rollers were similarly corroded. I found no date code on the bearings, but they were marked "Timken--Made in England" so they probably were originals.

Figure 92: Bearings

The right-side bearing wasn't as easy to remove. Under the edge of the bearing, the carrier has a pair of convenient notches, which allow the use of a small two-jaw puller. With some force, the bearing came off. The left side had 40 mils of shims; the right side, 35.

Figure 93: Right side bearings removal

Once the carrier was out of the way, the pinion was easy to remove. The outer bearing cone, which should be a press fit, just slid off; the inner one came out with the pinion. The bearings' outer races were more difficult, as they had to be taken out with a drift. The front bearing's race was removed easily. The rear one has a reputation for being difficult, but the use of the tool described above made the inner-race removal fairly easy.

Below, the pinion-gear races. They were not as bad as the carrier races but were still due for replacement. The second picture shows the pinion and inner bearing. The pinion was worn, not as badly as the ring gear, but (in my opinion) beyond use. In any case, it had to be replaced, as the ring gear and pinion are a matched set. Removing the inner bearing is tricky. The special tool described in the shop manual is no longer available, and a general-purpose bearing separator often won't fit. This pinion was trash, though, so in this case it didn't matter.

Figure 94: The pinion-gear races.

I removed the planetary and star gears, inside the carrier, to check the condition of their thrust washers. All were fine, but I could feel a very little backlash in the internal gears. Oddly, there is no spec in the shop manual for backlash; the manual just instructs us to minimize it by selecting thrust washers of various thicknesses. I measured the thrust washers, but their thickness was the maximum available, so it was impossible to reduce the backlash by using thicker washers.

The rest of the differential, disassembled, is shown in the second picture. The item on the far right in the second picture is the (probably) original leather pinion seal. An antiquated component if there ever were one; all the replacements these days uses elastomers.

Figure 95: The removal of planetary and star gears, inside the carrier

I bought a used unit, mainly for the ring gear, which was in much better condition. The carrier and internal gears looked better than the original ones, so I decided to use it instead of the original. The bearings came off without too much difficulty; the left-side carrier bearing was not very tight, but at least it was not a sliding fit, like the one on the original differential. I was able to remove the inner pinion bearing with an ordinary separator.

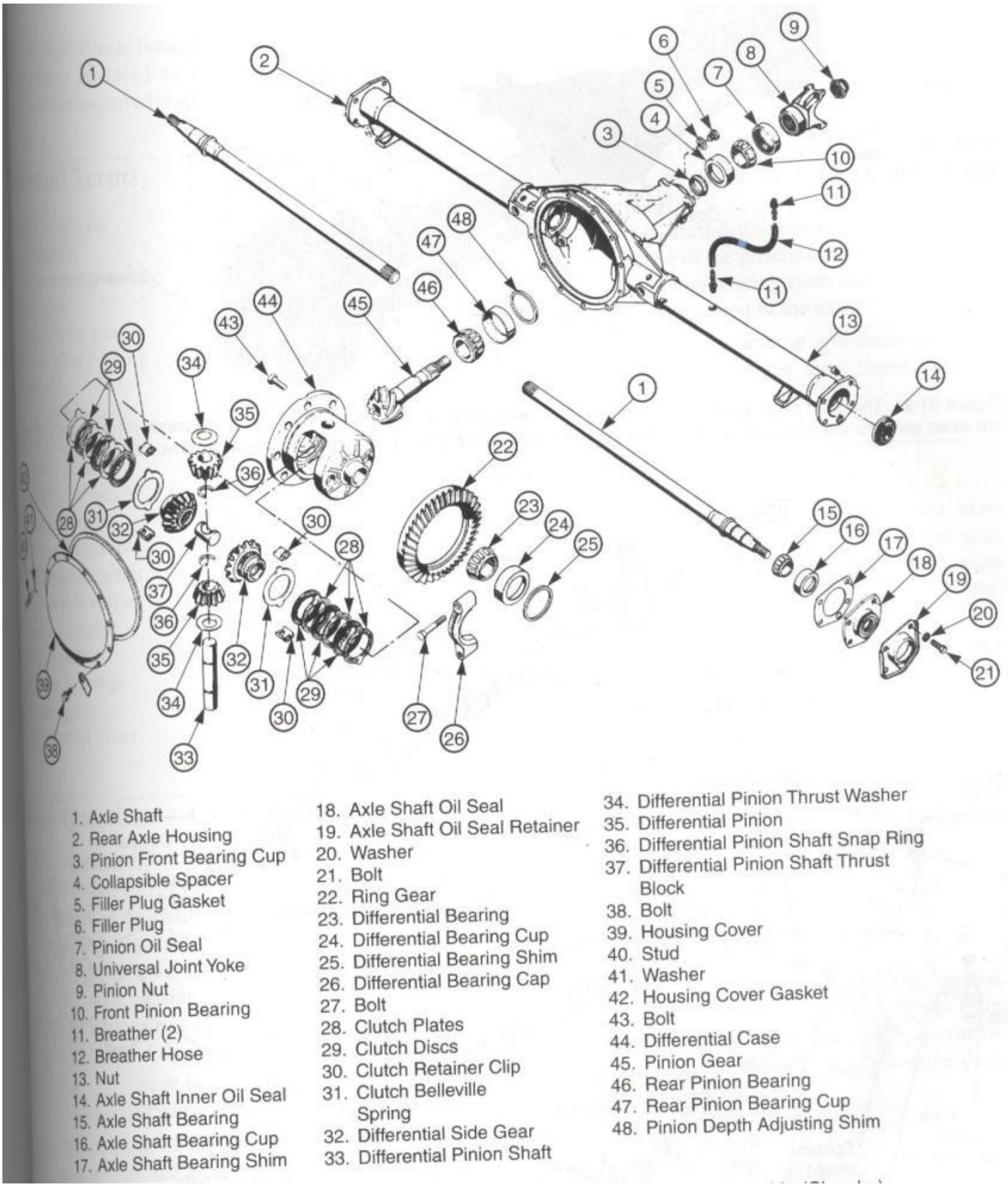


Figure 96: Disassembled view of a complete rear axle assembly

LO 2.3 –Clean and arrange components of final drive with differential

Topic 1: Cleaning and arranging components of final drive with differential

- **Cleaning methods**
  - ✓ Wet cleaning
  - ✓ Dry cleaning
- **Cleaning agents**
  - ✓ Soaps
  - ✓ Solvents
  - ✓ Chemicals
  - ✓ Acid
- **Arranging components of final drive with differential**

Figure 97: Arranged carrier bearings

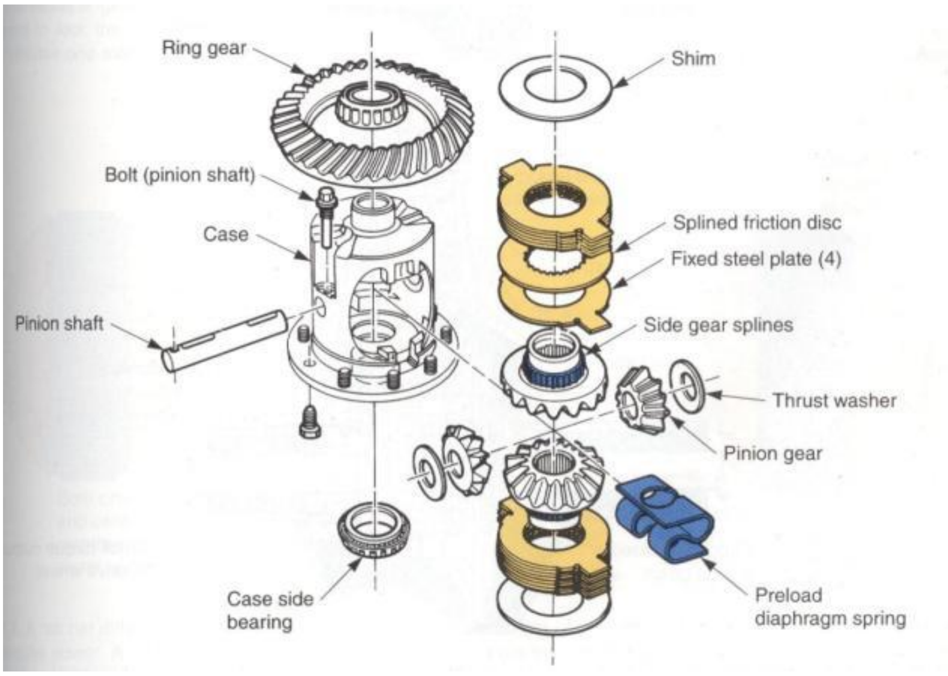


Figure 98: Arranged friction discs to the axle side gears

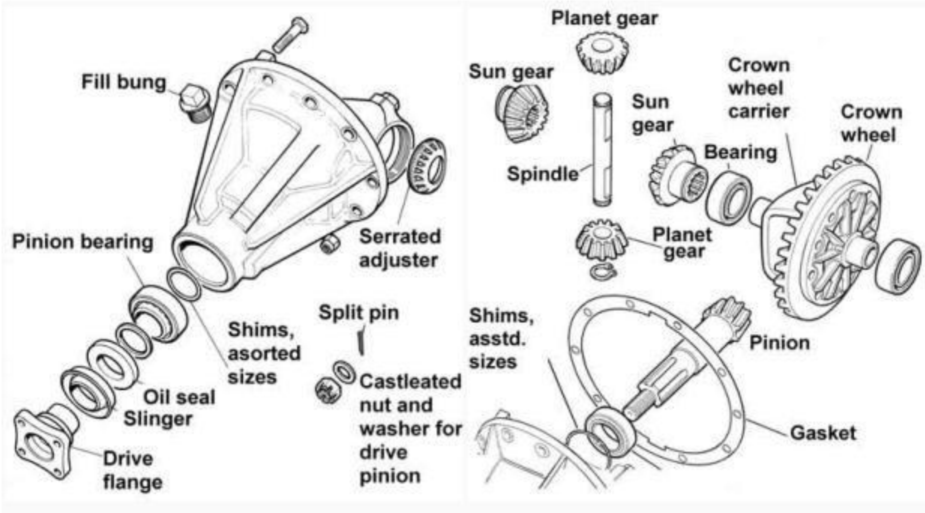


Figure 99: arranged final drive with differential

- ✓ Bevel gear
- ✓ Crown wheel
- ✓ Differential bevel gears
- ✓ Sun gears
- ✓ Axle gears
- ✓ Differential bevel gears shaft

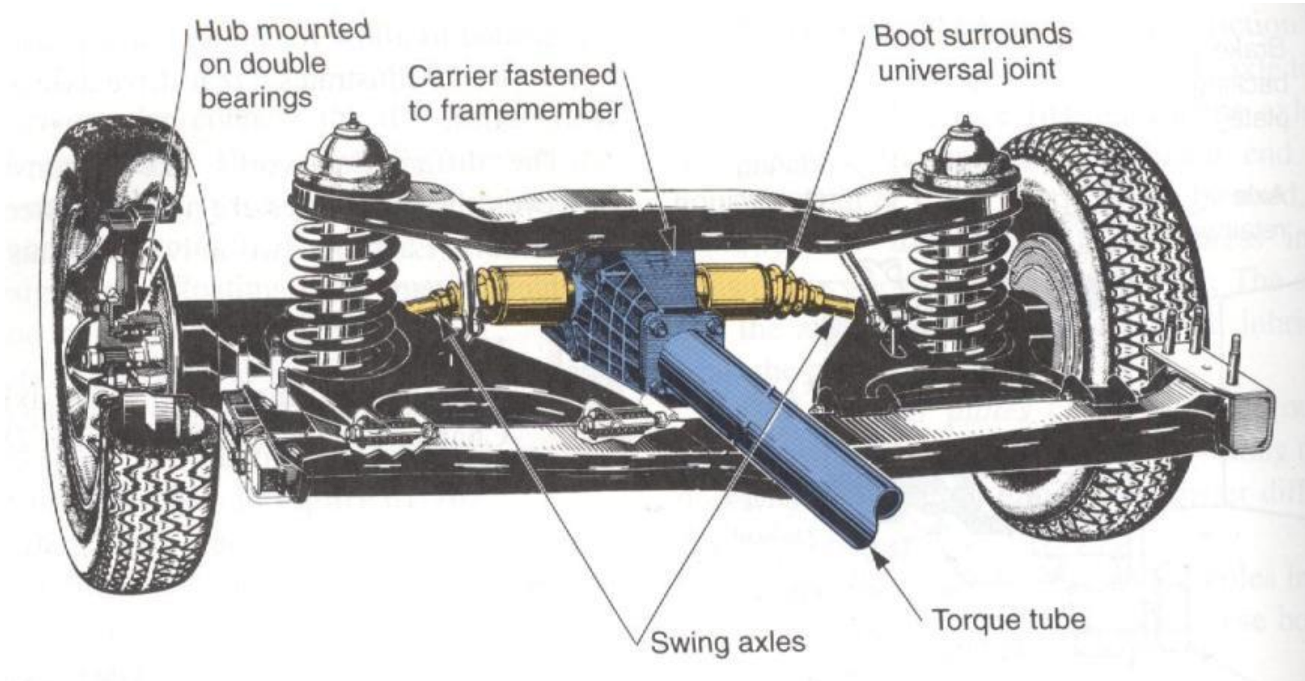


Figure 100: A swing axle has the differential assembly mounted on a frame member. Universal joints let the axles and wheel move up and down with suspension action.

Learning Unit 3 – Repair final drive with differential component

LO 3.1 – Inspect final drive with differential

INTRODUCTON

Differentials and rear drive axles are normally very dependable. However, if operated dry (without lubricant). Caused or used for prolonged service, parts can wear and damaged.

Rear differential assembly inspection (All models)

1. Bearing inspection

2. Differential carrier inspection

1. Inspect the differential carrier.

Note

Inspect the axle case installation section, the side bearing installation section, the bearing cap, and the pinion bearing race and oil seal fitting sections on the carrier assembly for cracking, damage, and wear.

- **Differential case problems**

Differential case problems frequently show up when rounding a corner. With the rear wheels turning at different speeds, any problem (damaged spider gears or a grabbing limited-slip clutch pack, for example) will usually show up as an abnormal sound (clunking or clattering) from the rear of the vehicle.

A limited slip differential (clutch-type) can sometimes make a chattering sound when turning a corner. The clutches are sticking to each other and then releasing. Many automakers recommend that the differential fluid be drained and replaced when this occurs.

- **Differential Maintenance**

Many automobile manufacturers recommend that the differential fluid be checked or replaced at specific intervals.

Notes:

Always install the correct type of differential fluid. Limited-slip differential often require a special type of fluid intended for the friction clutches.

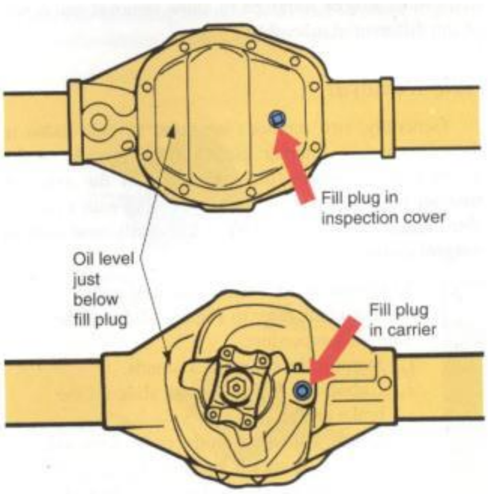


Figure 101: Check the oil level

Lubricant should be almost even with the fill hole when the oil is warm. If a drain plug is not provided, you must remove the cover or carrier or use a suction gun to remove the old oil.

Differential Service

When symptoms point to differential troubles, remove the differential carrier or rear inspection cover. Inspect the ring gear, pinion drive gear, bearings, and spider gears.

A differential ID number (identification number) is provided to show the exact type of differential for ordering parts and looking up specifications. The number may be on a tag under one of the carrier or inspection cover fasteners. It may also be stamped on the axle housing or carrier. Use the ID number to find the axle type, axle ratio, make of unit, and other information.

Differential Removal

To remove a separate carrier differential, use the following procedure:

1. Remove the drive shaft,
2. Unbolt the nuts around the outside of the carrier,
3. Place a drain pan under the differential,
4. Force the differential away from the housing,
5. Drain the lubricant into pan

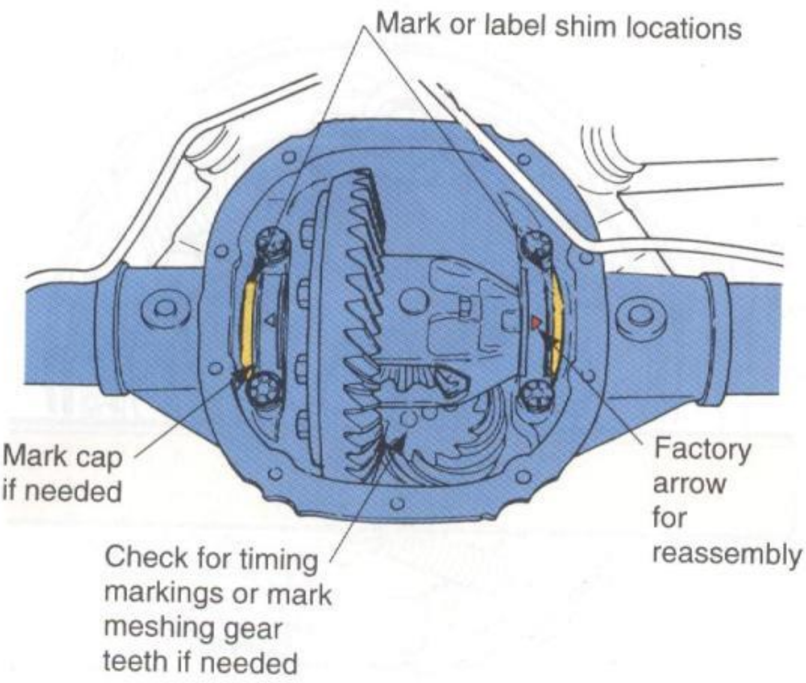


Figure 104: As you disassemble the differential, make sure you check marks and mark critical components. Most parts must be installed in the same location during reassembly.

To remove an integral differential, remove the cover on rear of axle housing. Drain the lubricant, with the cover of off, inspect and mark the individual components as they are removed. (Look at Figure 104).

- Topic 1:Differential Disassembly

Procedures for repairing a differential will vary with the particular unit. However, the following service rules relate to almost all types of differentials:

- ✓ Check for marking before disassembly, carrier caps, adjustment nuts, shims, ring and pinion gears, spider gears, and the pinion yoke and flange should be installed exactly as they are removed. If needed, punch mark, label, or scribe these components so they can be reassembled properly.

- ✓ Clean all parts carefully. Then, inspect these closely for wear or damage. **Figure 105** shows the most important parts needing inspection.
- ✓ Use a holding fixture for the differential, if available. It will make your work easier. One is shown in **figure 106.**
- ✓ Rotate the pinion and case bearings by hand while checking for roughness. Inspect each roller and race. Replace the bearing and race as a set of faulty. To install new bearings, use a press, **Figure 107**, or a puller, if required.

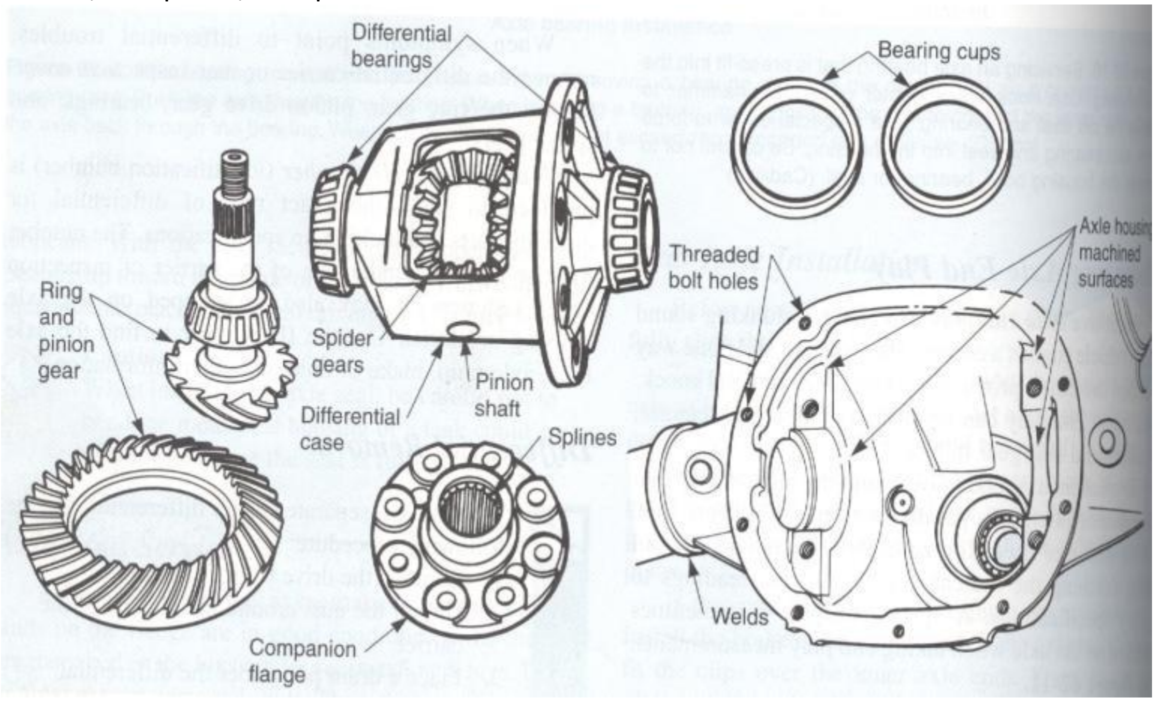


Figure 105: Inspect all differential components carefully. If you overlook even one bad part, your repair could fail.

- ✓ If the pinion gear has a collapsible spacer (device for preloading the pinion bearings), always replace it. **(See Figure 107).**
- ✓ Coat the outside of all seals with nonhardening sealer. Lubricate the seal's inside diameter. Make sure the sealing lip faces the inside of the differential. To avoid seal damage, use a seal driver to install the seal, **Figure 108.**
- ✓ When tightening the pinion yoke nut, clamp the yoke in a vise or use a special holding bar, **Figure 109.**
- ✓ Replace the ring and pinion gears as a set. Mesh or align the gear timing markings (painted lines or other marks) on the ring and pinion gears (if used0. This will properly match the teeth, which have been lapped together at the factor, **Figure 110.**

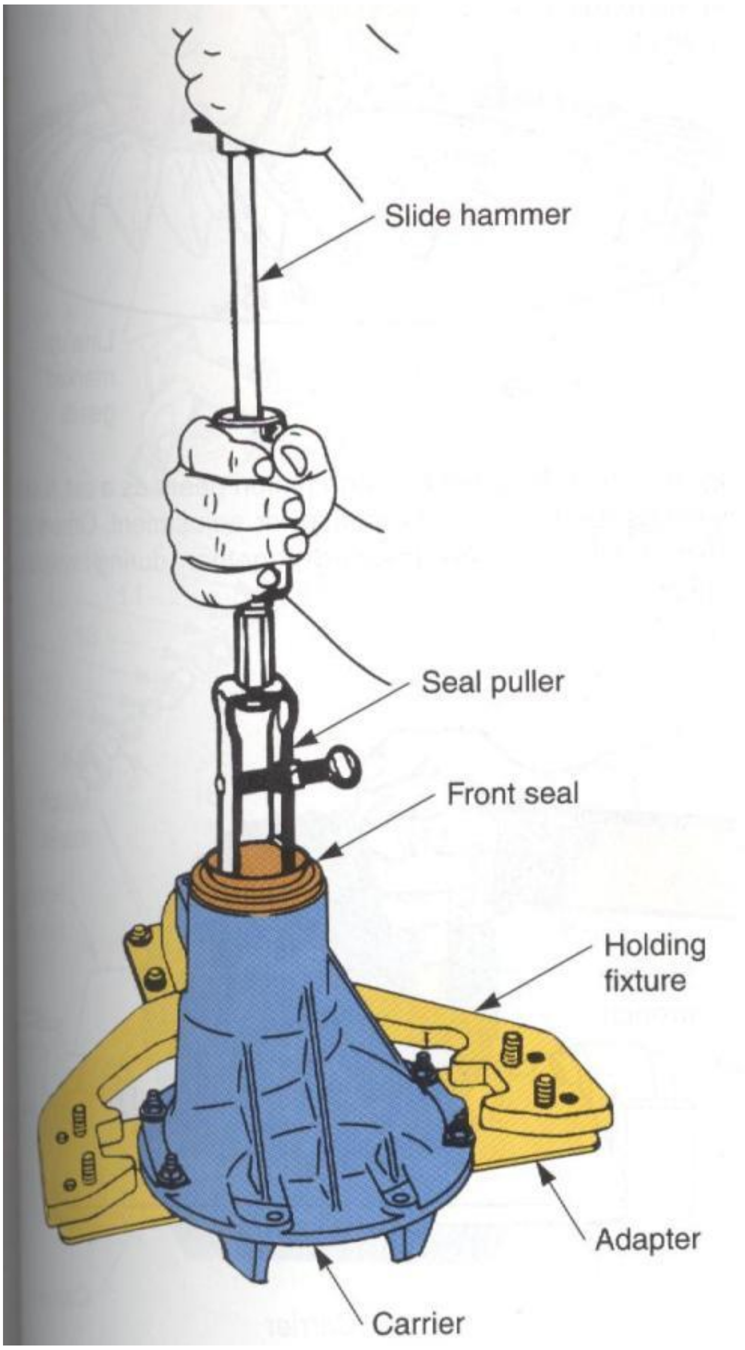


Figure 106: A differential holding fixture allows you to swivel a heavy differential carrier into different positions while holding. Here, a pinion seal is being removed.

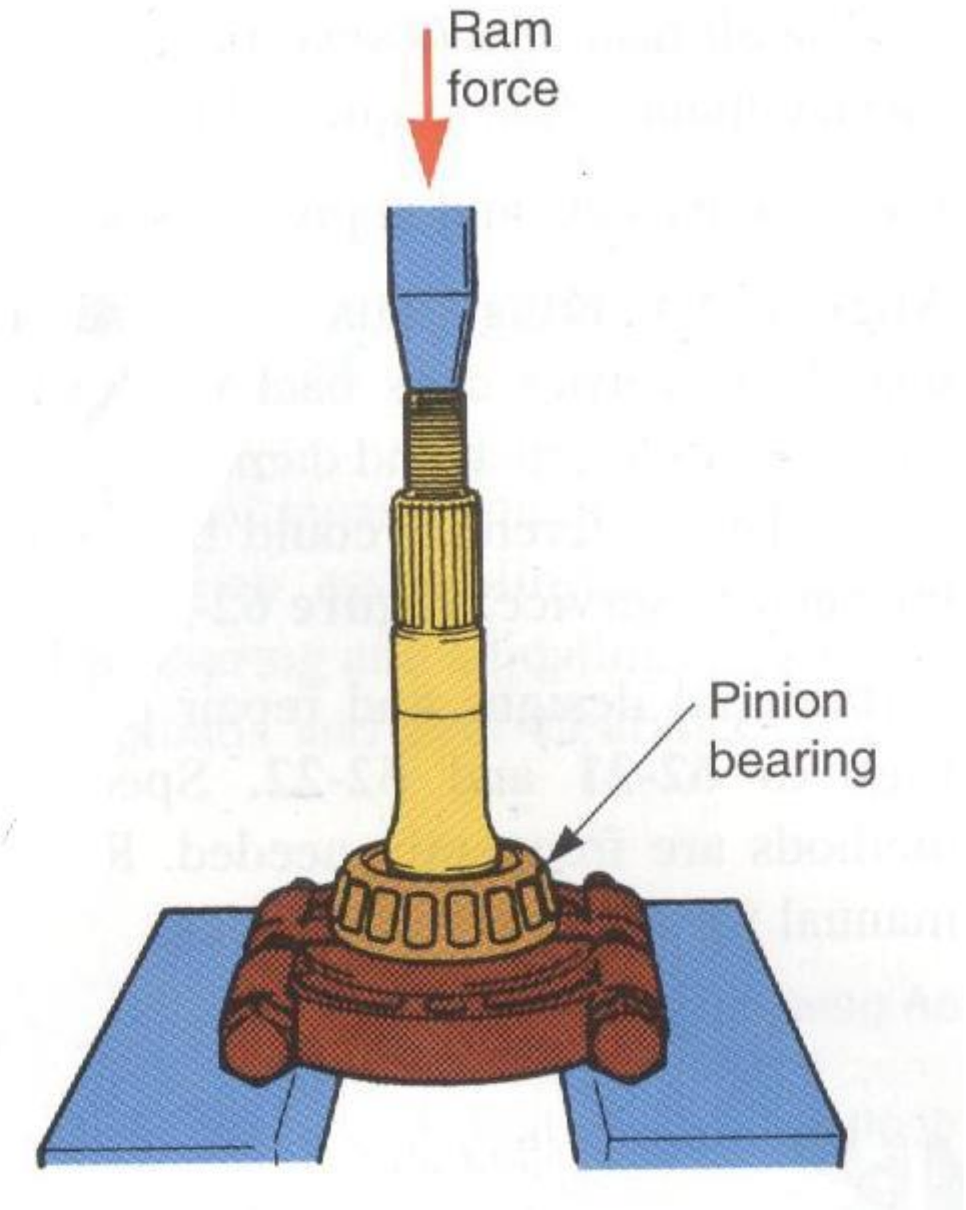


Figure 107. Use a press to remove pinion bearing. Stand back and use the recommended driving tools.

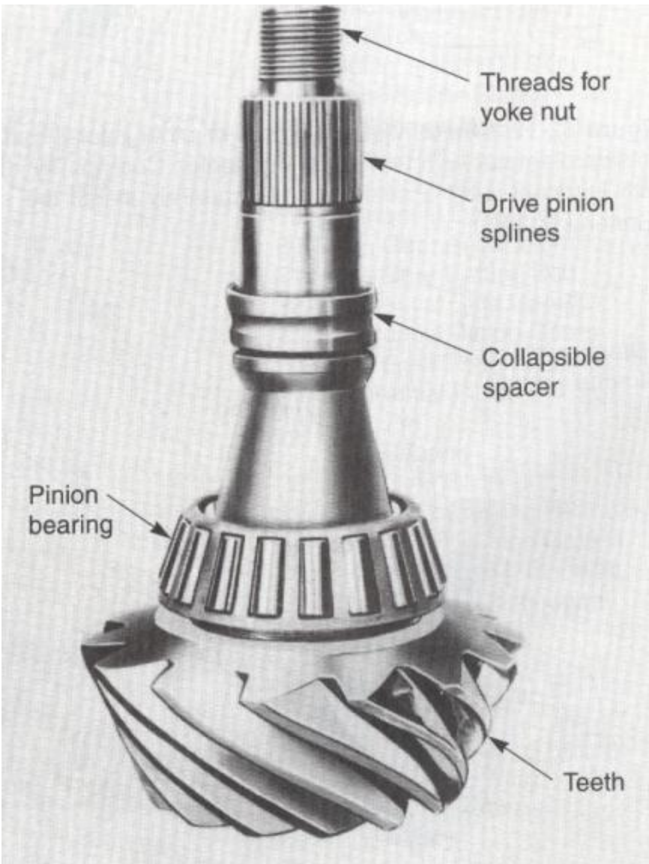


Figure 107: If the pinion gear uses a collapsible spacer, install a new one anytime the bearings are disassembled. If an old spacer is used, the bearing preload cannot be accurately attained.

- ✓ Torque all fasteners to specifications. Refer to the service manual for torque values.
- ✓ Use new gaskets and approved sealer.
- ✓ Align all markings during reassembly. If you install the carrier caps backwards, for example, the caps could crush and damage the bearings and races. The differential could fail as soon as it is returned to service, **Figure 111.**
- ✓ Differential designs and repair procedures vary, **Figure112. And 113.** Special tools and methods are frequently needed. Refer to a shop manual for detailed instructions.

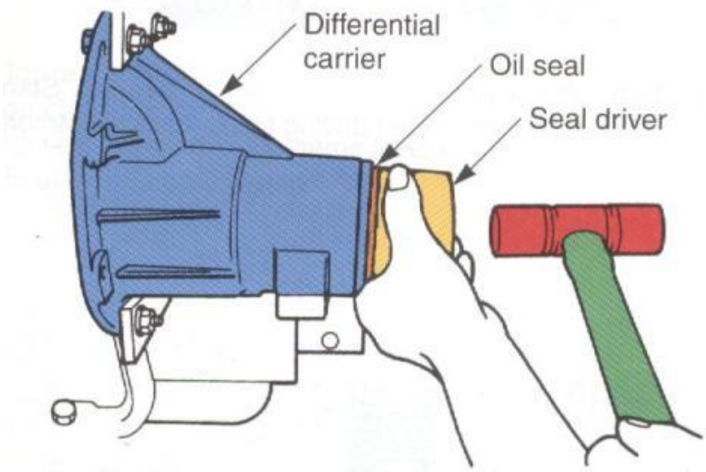


Figure 108: when installing pinion or seals, coat the outside diameter with non-hardening sealer. Coat the inside lip with lubricant. Use a seal driver to squarely install the seal.

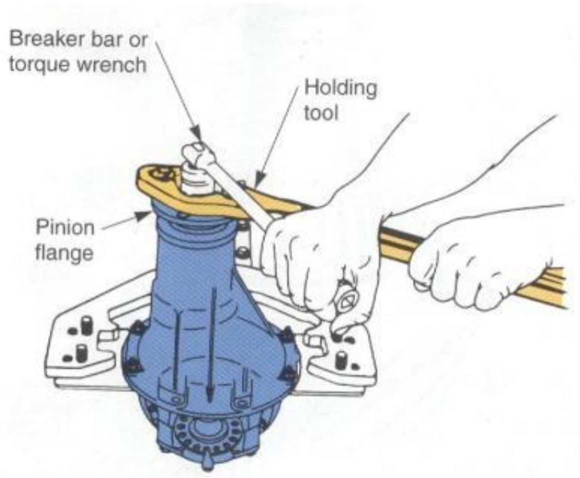


Figure 109: Using a large holding bar is the best way to keep the yoke from turning when tightening the drive pinion nut. If a collapsible spacer is used, tighten the nut in small increments and measure the preload. Without collapsible spacer, you must torque nut to specifications.

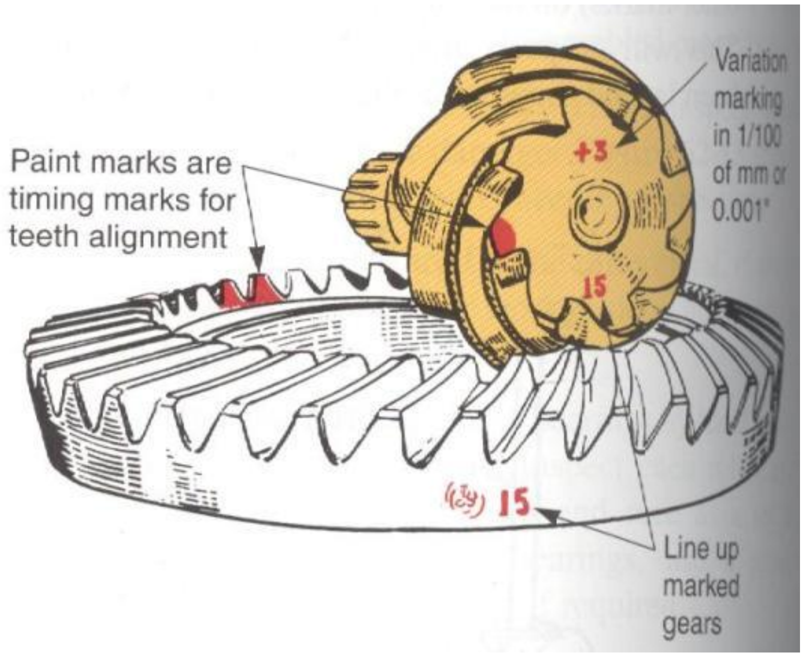


Figure 110: Replace ring and pinion gears as a set. Note the markings. Some give information for adjustment. Others show which teeth must be meshed together during installation.

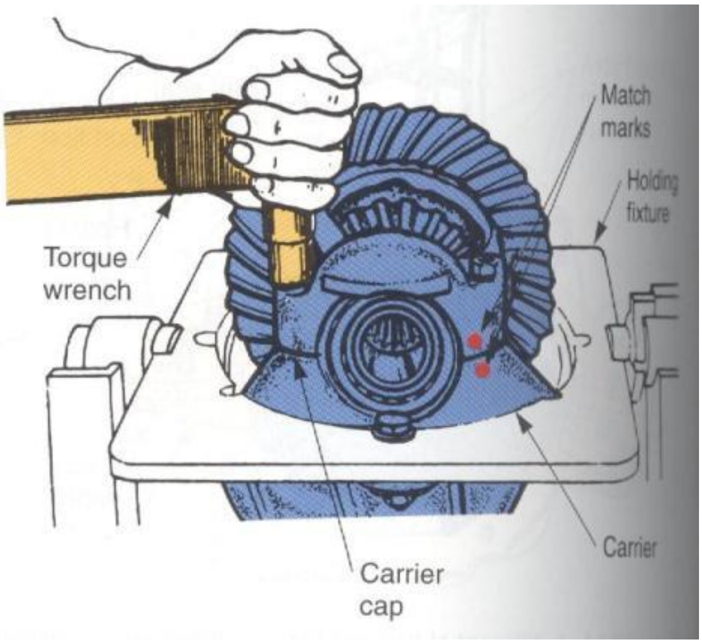


Figure 111: Make sure you align markings during assembly and torque all fasteners to specifications.

i. Place the transmission in neutral.
ii. Turn the wheel and axle with a torque wrench. Note the reading when the wheel begins to turn. This is the clutch pack or cone break-away torque, **Figure 114.**

Break-away torque is the amount of torque needed take one axle or differential side gear rotates the limited-slip differential clutches. If the break-away torque is too low (worn clutches or cones, weakened clutch or cone springs, or part damage) or too high (shimmied improperly, part damage), repairs are needed.

If a limited-slip differential needs to be serviced, replace the clutch discs and springs. See **Figure 115**

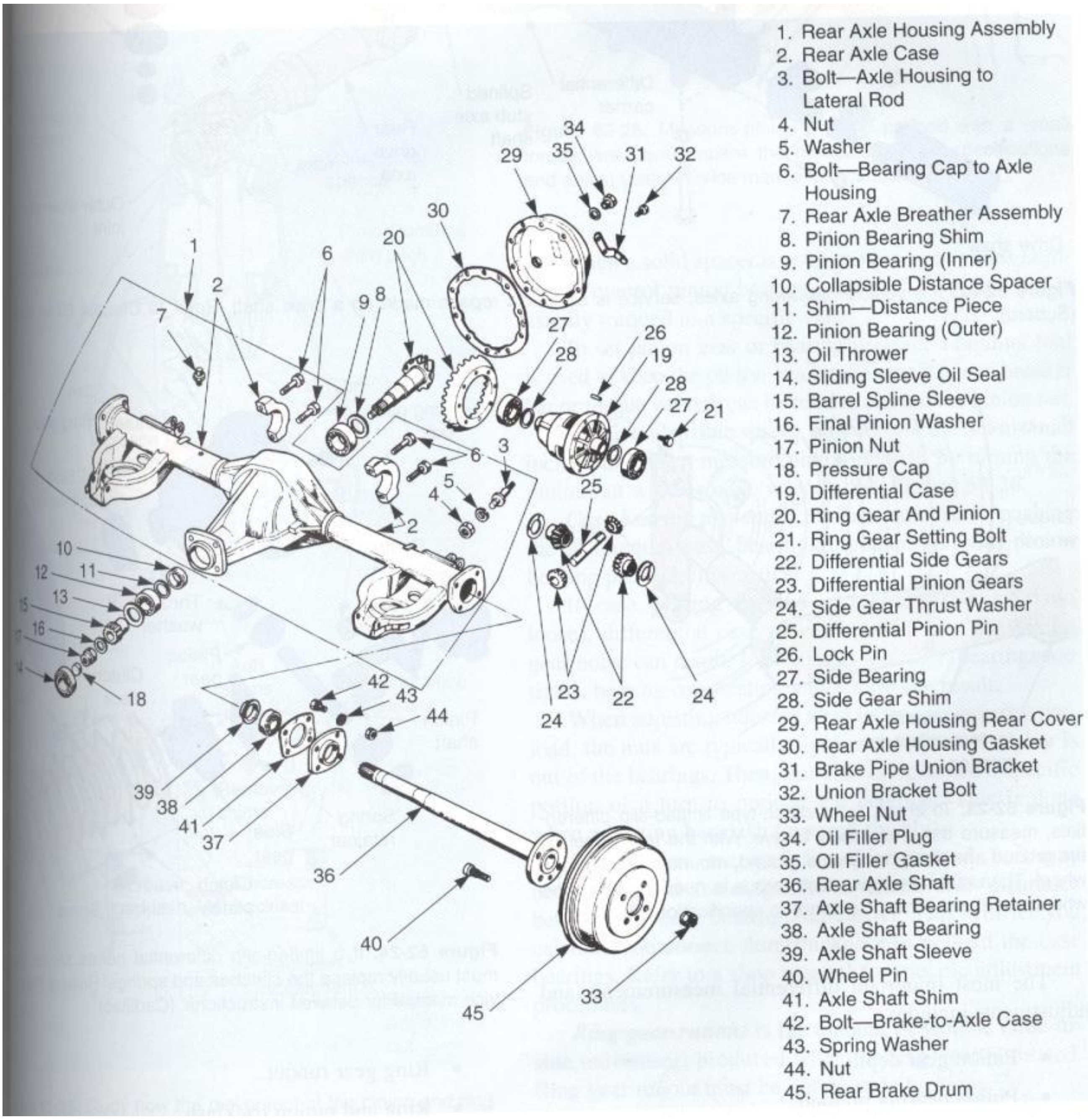


Figure 112: Use a service manual illustration like this one to help you with differential reassembly.

1. Inspect the drive pinion gear.

Note

- Inspect the drive pinion gear contact surfaces including both the drive and coast sides for chipping, cracking, peeling, pitting, and improper tooth contacts.
- Inspect the spline section of the drive pinion gear for cracking, twisting and damage.

Caution

- For the final gear, even when only the differential ring gear or the drive pinion gear is defective, both of them must be replaced as a set.

2. Inspect the ring gear.

Note

- Inspect the ring gear contact surfaces including both the drive and coast sides for chipping, cracking, peeling, pitting, and improper tooth contact.

Caution

- For the final gear, even when only the differential ring gear or the drive pinion gear is defective, both of them must be replaced as a set.

3. Inspect the bearing.

Note

- Inspect the bearing for seizure, peeling, noise, etc.
- If an abnormality is found, replace it.

  Categories of bearings:

  a) Inner bearing
  b) Outer bearing
  c) Side bearing

4. Inspecting worn-out parts by measurement

5. Inspecting differential spider gear sets as well as the side gears for abnormal wear

6. Inspecting thrust washers
7. Inspecting locking pins for wear and distortion

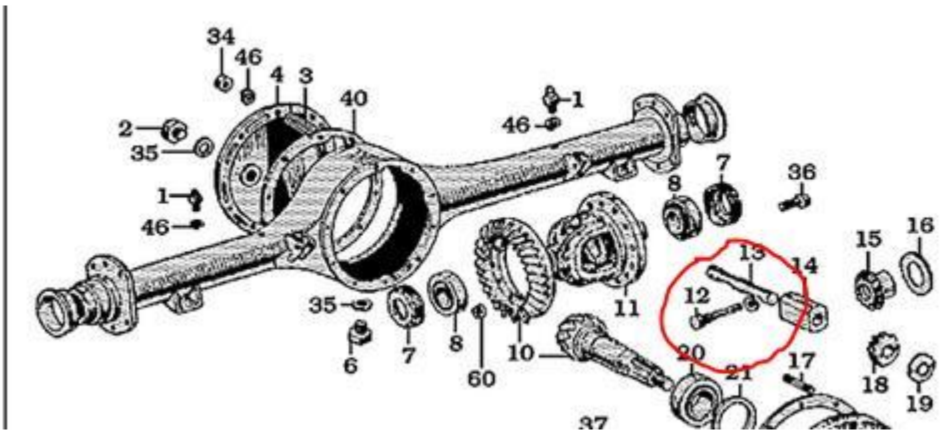


Figure 113: Inspecting locking pins for wear and distortion

8. Inspecting differential case for any damage
9. Inspecting ring gear for abnormal wear or cracking

LO 3.2 – Replace damaged parts of final drive with differential

Types of Rear Differential Repairs

Figure 114: Rear differential

Obviously, the less intrusive the repair is a rear differential oil leak before it causes other issues. Different oil leak repairs include:

- Rear differential gasket replacement. The rear differential cover is typically silicone or rubber and can deteriorate and leak. It's the easiest to repair – all that's required is removing the rear differential cover, cleaning the sealing surface, and resealing the cover. It's all done in less than an hour.
- Rear differential pinion seal. At the front of the differential is a yoke that attaches to the driveshaft. The seal around the yoke can develop a leak over time, either from nicks in the rubber or from age. This can take a bit more time to repair as the yoke needs to be removed, the seal pried out, and a new seal driven into place without damaging it.
- Differential side seals. These seals prevent the diff fluid from leaking onto your rear brakes. It's more intrusive because the axle shafts must be removed. The old, leaking seals are pried out and new ones are carefully installed before the whole assembly is put together.

Other rear differential repairs might be:

- Rear differential bearing replacement. There are side bearings and a pinion bearing which can pit or deteriorate, causing your rear differential noise. These bearings are part of a rear differential overhaul, taking three to five hours to complete.

- Topic 1 : Gear ring replacement
  - When we replace a gear and pinion or turn an existing gear around, we use dial indicators to achieve proper run out. The better the alignment, the more years of service you can expect from your equipment - making alignment the most crucial part of this process.
  - During the ring gear and pinion install process, we make sure that the tires are tight and don't have excessive slipping. Once this has been verified, we install the gear and perform a radial and axial alignment and lock down once the proper alignment has been achieved.
  - Then we weld down the mounting brackets or the spring plates to the shell surface. We then final align the pinion by using feeler gauges and then final align the drive components with either dial indicators or laser alignment based on the customers' requirements.

- Topic 2 : Planetary gear set replacement

When teeth on the gears have chipped or worn badly, they must be replaced to eliminate the noise and potential for failure. These 'hard parts' are the costliest components, and repairs can only get one step worse.

- Topic 3 : Differential case replacement

If the gears have 'grenaded', the case might not be salvageable. That's when a complete rear differential replacement comes in – housing, gears, bearings, seals, and all.

- Topic 4 : Differential components lubrication

Lubricant should be almost even with the fill hole when the oil is warm. If a drain plug is not provided, you must remove the cover or carrier or use a suction gun to remove the old oil.

LO 3.3 – Adjust final drive with differential

Rear axle assembly problems usually show up as abnormal noises. It is critical that procedures are used when trying to find the source of these noises. Further problems (worn wheel bearings, universal joints, or transmission gears) can produce symptoms similar to those caused by faulty rear drive axle components.

To begin diagnosis, gather information. Determine when the noise or condition occurs when accelerating, coastinging at certain speed, or rounding corners. Use common sense and your understanding of operating principles to narrow down the possible sources.

Road test the vehicle on a smooth road surface. Listen for changes in the noise under different driving conditions. **Figure 115** lists some typical problems you might find.

- **Eliminate other problem sources**

After your road test to verify the complaint, use your knowledge of noise diagnosis to determine which components Should be checked further. If the noise could possibly be tire related, increase inflation pressure in the tires as described in a service manual. If the abnormal noise changes, the tires may be at fault.

If the sound originates from the middle or front of the car, listen for noises in the transmission or transaxle. Also, check for bad front wheel bearings.

- **Problem Isolation**

A stethoscope (listening device) can often be used to isolate the source of a differential or rear axle bearing problems. Raise the vehicle on a lift. Ask another technician to start the engine, place the transmission in gear, and accelerate to 30mph (48 km/h).

Touch your stethoscope on the ends of the axle housing and on the housing near the carrier bearings. The area producing the loudest noise contains the faulty parts.

Warning

When using a stethoscope to listen for rear axle noise, stay away from the spinning tires and driveline. Serious injury could result if you touch these parts.

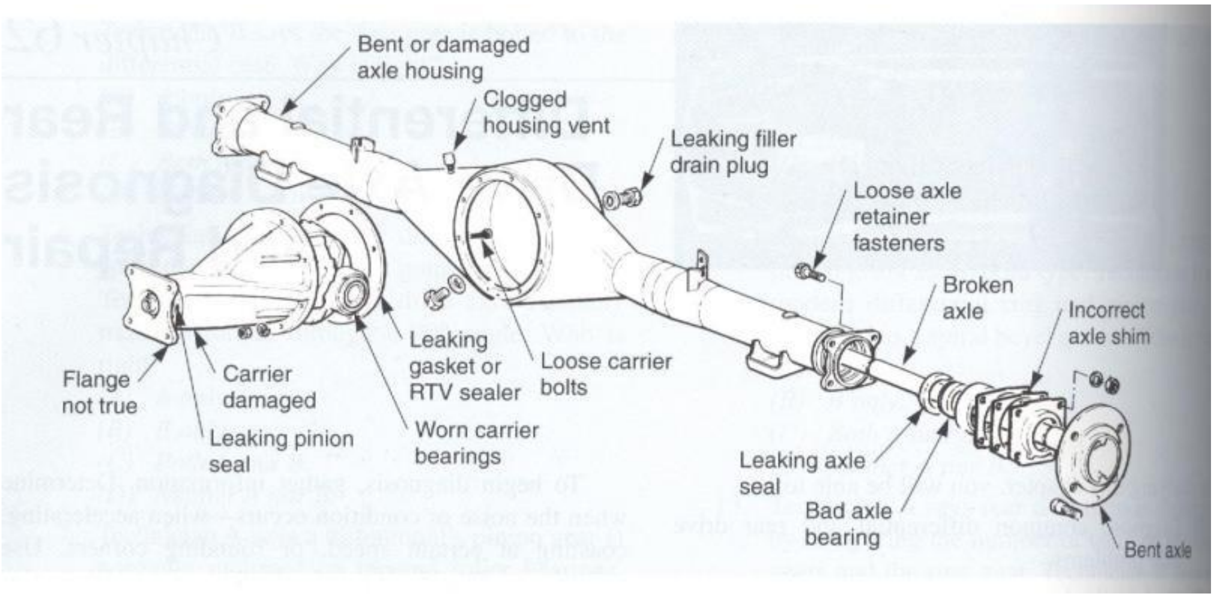


Figure 115: These are typical problems that can develop in a rear axle assembly

Limited-Slip Differential Service

Limited-slip differential repair may be required after prolonged service or after damage from abuse or lack of maintenance. The clutch discs can wear, losing much of their frictional quality. This can make the differential act like a conventional unit.

A limited-slip differential (clutch and cone types) should be tested as follows:

iii. Bolt a special tool to the wheel. The tool mounts over the lug studs so that a torque wrench can be used to rotate the axle.
iv. Raise the tire off the shop floor.

Differential Measurements and Adjustments

There are several measurements and adjustments that must be made when assembling a differential. When "setting up" (measuring and adjusting) a differential, correct bearing preloads, and gear clearances are extremely critical.

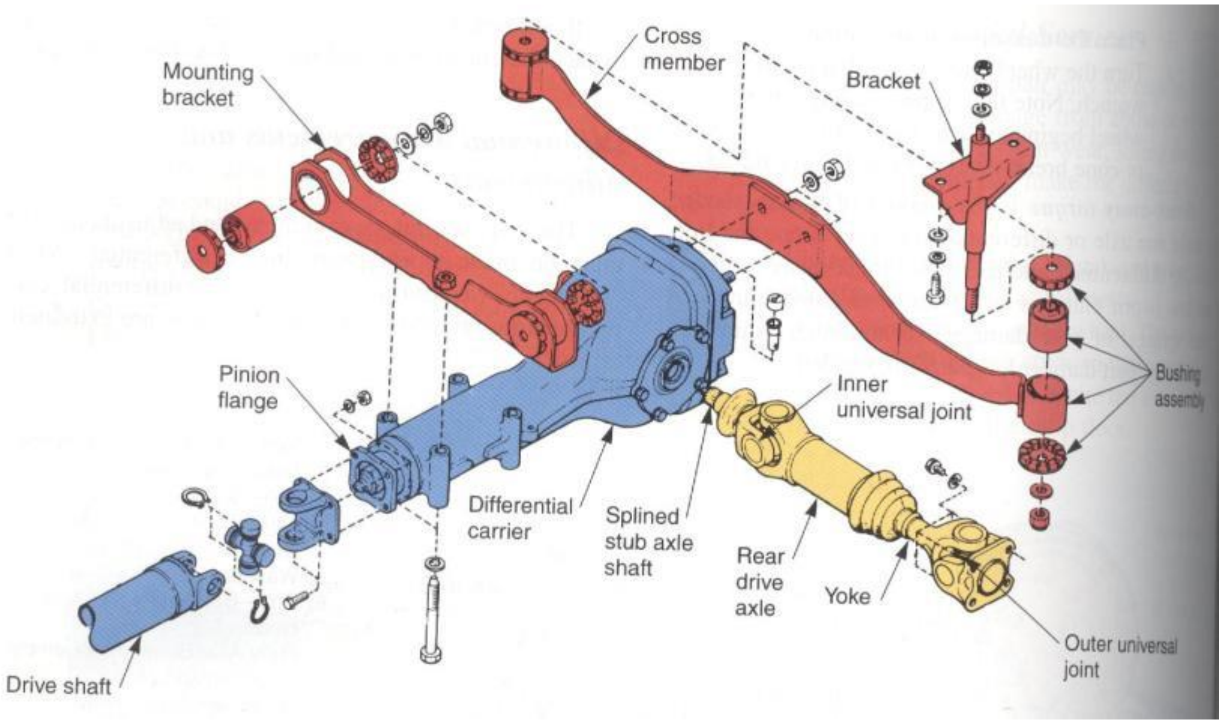


Figure 116: If a vehicle has swing axles, service is similar to repairs made on a drive shaft.

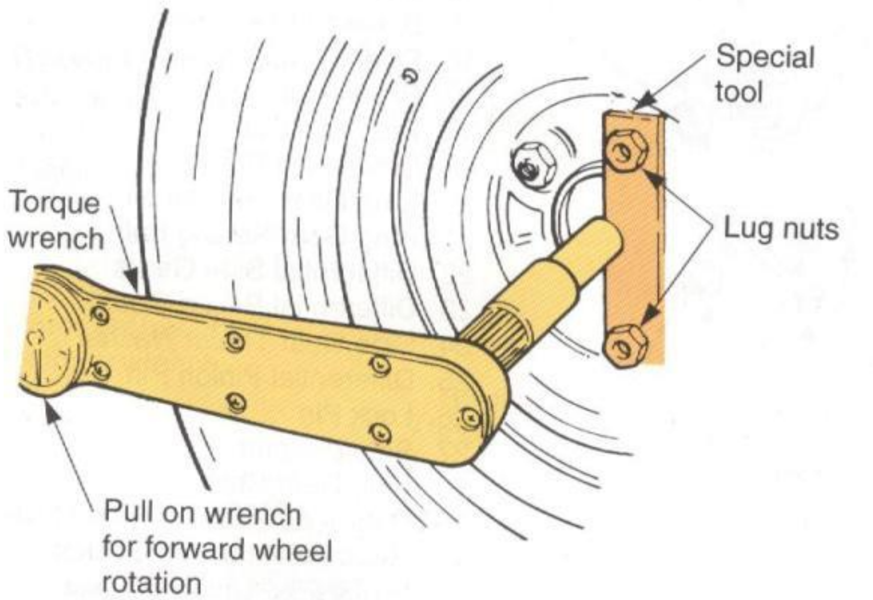


Figure 117: To check most clutch-type limited-slip differentials, measures the break-away torque. With the test wheel off the ground and the other on the ground, mount the tool on the wheel. Then measure how much torque is needed to turn the wheel and slip clutches. Compare to specifications.

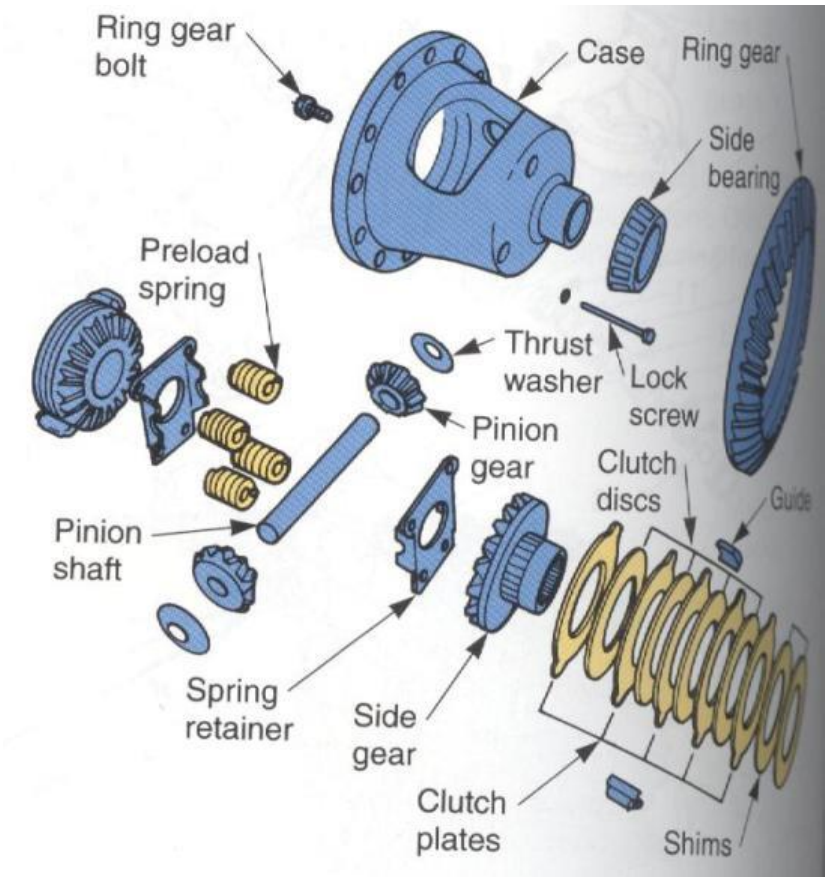


Figure 118: If a limited-slip differential needs service, you must usually replace the clutches and springs. Refer to the service manual for detailed instructions.

The most important differential measurements and adjustments include:

- Pinion gear depth.
- Pinion bearing preload.
- Case bearing preload.
- Ring gear runout.
- Ring and pinion contact pattern

i. **Pinion gear depth** refers to the distance the pinion gear extends into the carrier. Pinion gear depth affects where the pinion gear teeth mesh with the ring gear teeth. Pinion gear depth is commonly adjusted by varying shim thickness on the pinion gear and bearing assembly. Figure 116 illustrates how shims affect pinion gear depth in both removable and integral carriers.

ii. **Pinion bearing preload** is frequently adjusted by torquing the pinion nut to compress a collapsible spacer. The more the pinion nut is torqued, the more the spacer will compress to increase the preload (tightness) of the bearings.

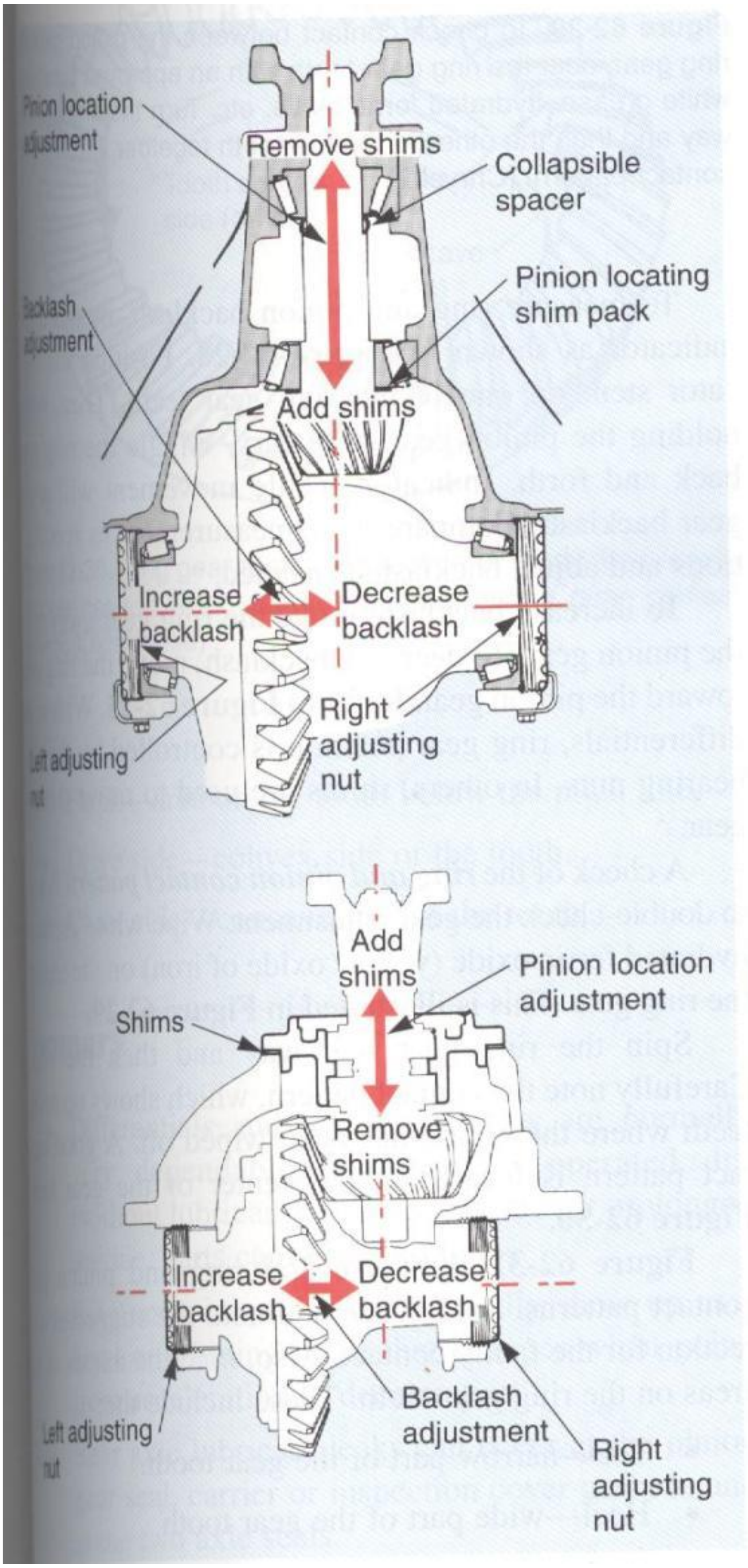


Figure 119: Study how the movement of the pinion and ring gears adjusts differentials. Shim thickness change affects each differently.

When a solid spacer is used, pinion gear shims commonly control pinion bearing preload. The pinion nut is usually torqued to a specific value.

To set pinion gear or bearing preload, a holding tool is used to keep the pinion gear stationary. Then, a breaker bar or torque wrench can be used to tighten the pinion nut.
With a collapsible spacer, only tighten the nut in small increments. Then measure pinion preload by turning the pinion preload by turning the pinion nut with a torque wrench. **See Figure 117.**

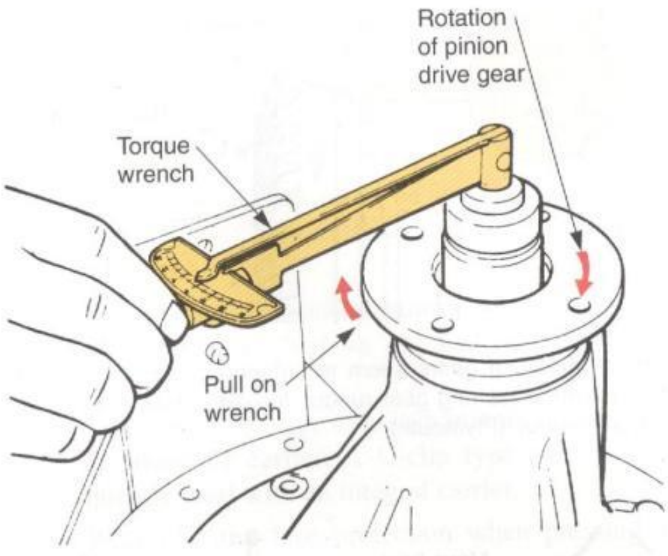


Figure 120: Measure pinion bearing preload with a small torque wrench. Compare the measurement to specifications and adjust using service manual directions.

iii. **Case bearing preload** is the amount of force pushing the differential case bearings together. As with pinion bearing preload, it is critical.
If case bearing preload is too low (bearings too loose), differential case movement and ring and pinion gear noise can result. If preload is too high (bearings too tight), bearing overheating and failure can result.
When adjusting nuts are used to set case bearing preload, the nuts are typically tightened until all the play is out of bearings. Then, each nut is tightened a specific portion of a turn to preload the bearings. This is done when adjusting backlash (covered shortly).
When shims are used to adjust preload, you may need to use a feeler gauge to check side clearance between the case bearing and carrier. This will let you calculate the correct shim thickness to preload the case bearings.

iv. **Ring gear runout** is the amount of wobble (side-to-side movement) produced when the ring gear is rotated. Ring gear runout must be within specifications.
To measure ring gear runout, mount a dial indicator against the back of the ring gear. The indicator stem should be perpendicular to the ring gear surface. Then, turn the ring gear and note the indicator reading. See **Figure 121.**

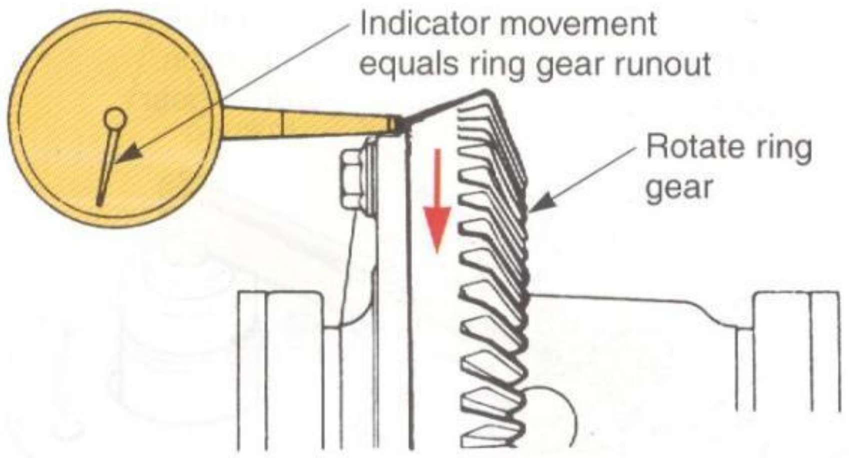


Figure 121: If gears seem to tighten up and loosen when turned, measure ring gear runout Indicator needle movement equals runout.

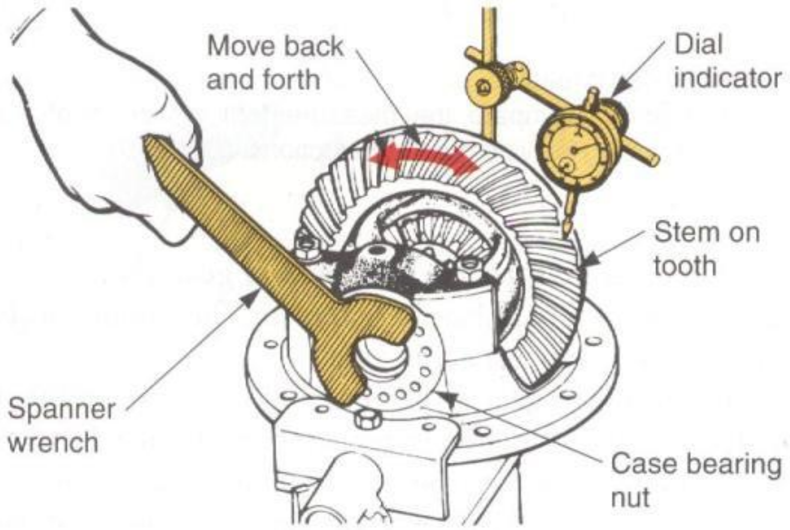


Figure 122: After setting pinion bearing preload and depth, adjust backlash and case bearing preload. This unit is adjusted by turning nuts. The indicator is mounted with the direction of gear rotation, touching the outer end of the tooth. Hold the pinion stationary and move the ring gear back and forth while watching the indicator.

If ring gear runout is excessive, check the ring gear mounting and the differential case runout. If the ring gear mounting is not a problem, replace either the ring gear (and pinion) or the case needed.

v. **Ring and Pinion backlash** refers to the amount of space between the meshing teeth of the gears. Backlash is needed to allow for heat expansion and lubrication.
As the gears operate, they produce friction and heat. This makes the gears expand, reducing the clearance between meshing teeth. Without sufficient backlash, the ring and pinion teeth could jam into each other as they reach operating temperature. The gears could fail in a short time. Too much ring and pinion backlash could cause gear noise (whirring, roaring, or clunking).

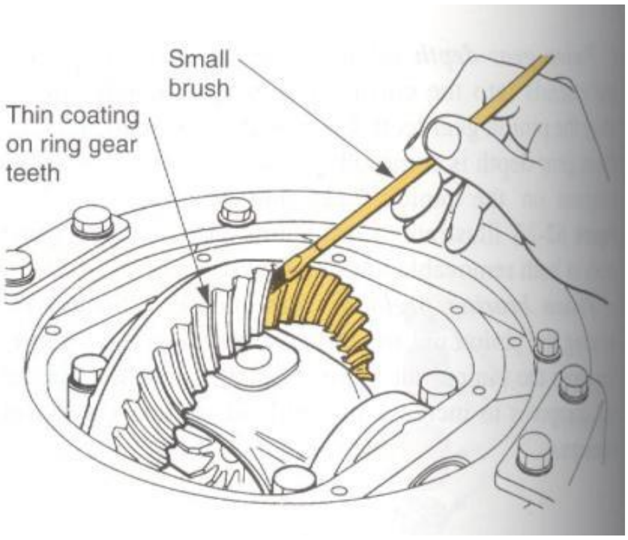


Figure 123: To check contact between the pinion gear and ring gear, coat the ring gear teeth with an approved substance; white grease, hydrated ferric oxide, etc. Turn the ring gear one way and then the other to rub the teeth together, producing the contact pattern.

To measure ring and pinion backlash, mount a dial indicator as shown in **Figure 122.** Position the indicator stem on one of the ring gear teeth. Then, while holding the pinion gear stationary, wiggle the ring gear back and forth. Indicator needle movement will reveal gear backlash. Compare your measurement to specifications and adjust backlash as needed.

To increase backlash, move the ring gear away from the pinion gear. To decrease backlash, move the ring gear toward the pinion gear. Refer to **Figure 119,** with some differentials; ring gear position is controlled by the case bearing nuts. In others, shims are used to move the ring gear.

A check of the ring and pinion contact patter is used to double-check the gear adjustment. Wipe white grease or hydrate ferric oxide (yellow oxide of iron) on the teeth of the ring gear. This is illustrated in **Figure 123.**

Spin the ring gear one way and then the other. Carefully note the contact pattern, which shows up on the teeth where the grease has been wiped off. A good contact pattern is located in the center of the gear teeth, **Figure 124.**

Figure125 shows several ring and pinion gear contact patterns. Study each and one note the suggested correction for the faulty contact. Also, note the names of the areas on the ring gear teeth. These include the:

- ✓ Toe- narrow part of the gear tooth.
- ✓ Heel- wide part of the gear tooth.
- ✓ Pitch line- imaginary line along the center of the tooth.
- ✓ Face- area on the tooth above the pitch line.
- ✓ Flank-area on the tooth below the pitch line.
- ✓ Drive side- convex side of the tooth.
- ✓ Coast side-concave side of the tooth.

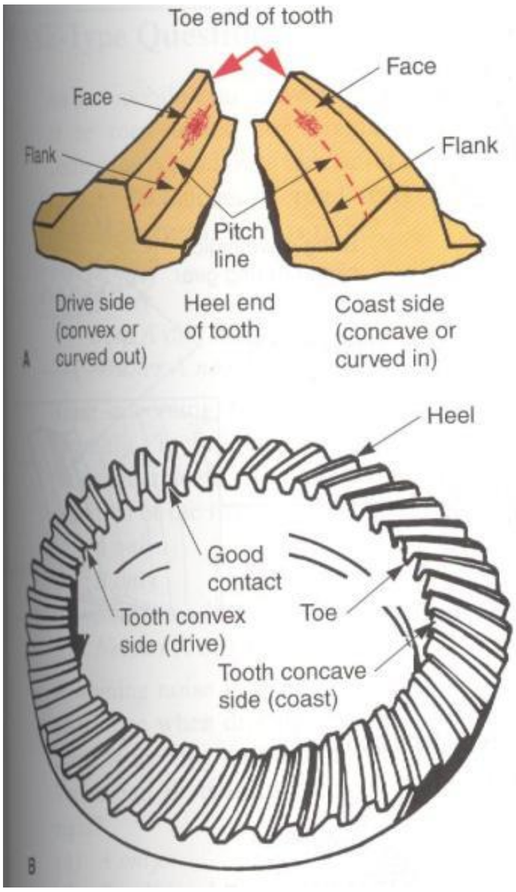


Figure 124. Ring gear teeth nomenclature.

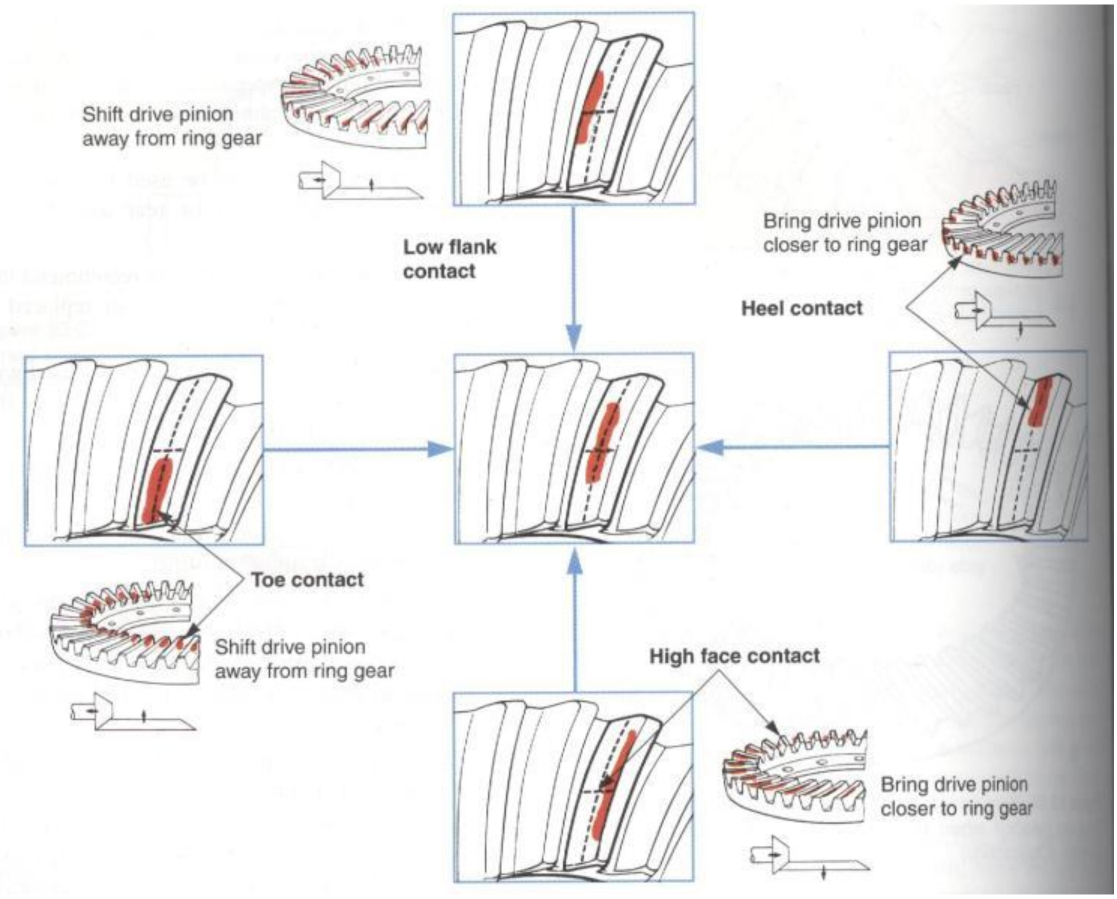


Figure 125: The area where grease is rubbed off the ring gear indicates contact point. It must be centrally located on the teeth.

LO 3.4 – Lubricate final drive with differential

- Hypoid gear types usually use 75W to 90W gear lube
- Limited-slip differentials use a special fluid
- Some applications require ATF
- Some transaxles use a different lubricant for the transmission and the differential

Figure 126: differential lubrication

- Location of oil plugs :
  i. Fill plug
  ii. Drain plug
- Gearbox and transfer box components lubrication
  i. Oil viscosity grade
  ii. Oil level

LO 3.5 – Reassemble final drive with differential components

- **Topic 1: Reassemble final drive with differential components, measurements**

Bearing Recess Depth

Dimensions in the above drawing are from the center of the carrier, but it's impossible to measure that center directly. Instead, the mounting surfaces for the carrier-bearing caps are used as a datum, but there is no guarantee that those surfaces are centered with the bearing, and thus the carrier. To find the offset, we measure the distance from that datum to the bottom of the bearing's mounting surface and compare it to the known radius of the bearing. The difference between those values--the recess depth minus the bearing radius--is the datum's offset.

This is done with a dial micrometer and the special tool I made, an accurately machined and measured crossbar. This measurement is tricky: it is essential to make it precisely at the center of the recess. The bar thickness is measured with a micrometer and subtracted from the raw measurement to obtain the recess depth.

I found that it's just as accurate, and easier, to hold the caliper while making the measurement. The clamp shown in the picture below is one way to do it, but it often just gets in the way.

Figure 127: measuring clamp with Vanier caliper

I determined that the datum was 0.006 inches below carrier center on the left and 0.008 on the right.

Mostly out of curiosity, I measured the depth of the bearing caps. I obtained 0.005 inches over the center depth on the left and 0.007 on the right. The caps were marked with a cryptic symbol, as shown below; the left one, marked "∇6" is at the top, and the right one, marked "∇7" is at the bottom. It seems that the caps may have been selected in assembly to match the depth of the bearing mount, minus one or two mils, so the bearing could be clamped tightly. If so, this provides a clue as to how far the bearing mount is below the center of the bearing.

Carrier Bearings and Carrier Float

The next measurement is the side-to-side carrier float without bearing shims. That value, plus 0.003 inches for preload, is the total thickness of the two carrier-bearing shim packs.

I began by pressing my new bearings, without shims, onto the carrier. They will have to come off again, probably more than once, to install the shims.

Figure 128: Use press to install carrier float

Measuring the carrier float seems simple; just install it, without shims, set up a dial micrometer, and slide the carrier back and forth. It's actually not quite that easy, as an accurate measurement requires that the bearings be loaded at each end of the movement, and that there be no motion perpendicular to the carrier's axis. To guarantee that, I installed the bearing caps and tightened the mounting screws only finger tight, then backed them off about 1/8 turn. That allowed the bearings and races to slide back and forth without restriction but also without any vertical motion. I used a couple of screwdrivers to move the carrier and bearing, and to provide sufficient load on the bearing. With the carrier fully to one side of the housing, and with the bearing loaded, I zeroed the micrometer; then I moved the carrier to the other side, loaded the other bearing, and noted the change measured by the micrometer. As with all measurements, I did this a couple times to make sure it was right. I obtained a measurement of 0.063 inches.

Figure 129: Carrier bearing measurements

While I had the carrier in place and the bearings loaded, I checked the runout at the ring-gear flange. It was less than 0.001 inch; the spec is 0.002.

Pinion Setup

Once the carrier float has been determined, the pinion can be installed and set up. The first task is to set the pinion depth, which is adjusted by shims under the inner pinion-bearing race; the second is to adjust the preload.

To set up the pinion, the inner bearing cone is first pressed onto the pinion gear assembly; that's straightforward. It is important in this bearing-installation operation, and all others, to make certain that the bearing or race is pressed ALL the way to its stop. It's easy to stop a few mils short. Then, the bearing eventually moves all the way to the stop, and all previous measurements and shim adjustments are worthless. Getting those last couple of mils can require a lot of force, so it's best to use a hydraulic press for installing bearings.

Figure 129: Pinion set up

Figure 130: The pinion gear assembling

Pressing the inner race into the housing has a reputation for being difficult, and it must be inserted and removed a few times in setting up the pinion. Part of the problem is the shop manual's implication that a screw-operated bearing setter is adequate for pressing the race into the housing. While the original special tool might have been adequate, the general-purpose tools available today are not. It really requires a hydraulic press.

The race gets cocked easily while being pressed into place; it is difficult to get it to go in perfectly straight. The best method, I found, is initially not to worry about straightness, but, as soon as the race starts to tilt, to move the force to the high side. That straightens the race. Once it is straight, even force can again be applied, and the bearing goes into place fairly easily. The housing is large and awkward, and it is cumbersome to lift onto and off the press, but I don't think there is any other workable way to insert this race.

Only the inner race has shims under it; the shims for preload go between the outer bearing cone and the spacer. With the use of the tool described above, pressing out the inner race, to insert shims, was easy. To insert the tool, I first had to remove the outer race. The outer race was not particularly difficult to insert and remove, though.

Figure 131: use press to set up shims and outer bearing cone

I have a nice set of micrometers, which I bought while working on my MGTD. I used them, among other things, to measure the pinion thickness, another important quantity, and 1.286 inches in this case.

Figure 132: Micrometers for measuring

I measured the pinion depth in a manner similar to the bearing recess depth, using the dial caliper to measure from the top of the crossbar to the pinion. **The pinion depth must be measured with full preload on the bearings.** To set the preload, the outer bearing, I installed the pinion flange, washer, and nut, leaving out the spacer that normally sits between the two bearings. I then tightened the flange nut enough to load the bearings to the specified value. That preload was surprisingly great; the pinion seemed uncomfortably tight. I found that, when the preload was correct, tightening the nut a little more did not change the pinion depth.

The preload is correct when the torque required to move the pinion is 15-18 pound inches (without the oil seal, of course), a value outside the range of most torque wrenches. So, I made my own high-tech inch-pound torque wrench, shown below. The sockets were weighed on a digital scale and are within a couple percent of one pound. Note that the yardstick is centered on the pinion nut, so it has no effect on the torque.

Figure 133: High-tech inch-pound torque wrench

It was a simple calculation to determine the distance from the carrier center to the bearing-contact surface of the pinion gear, dimension 2 in the figure.

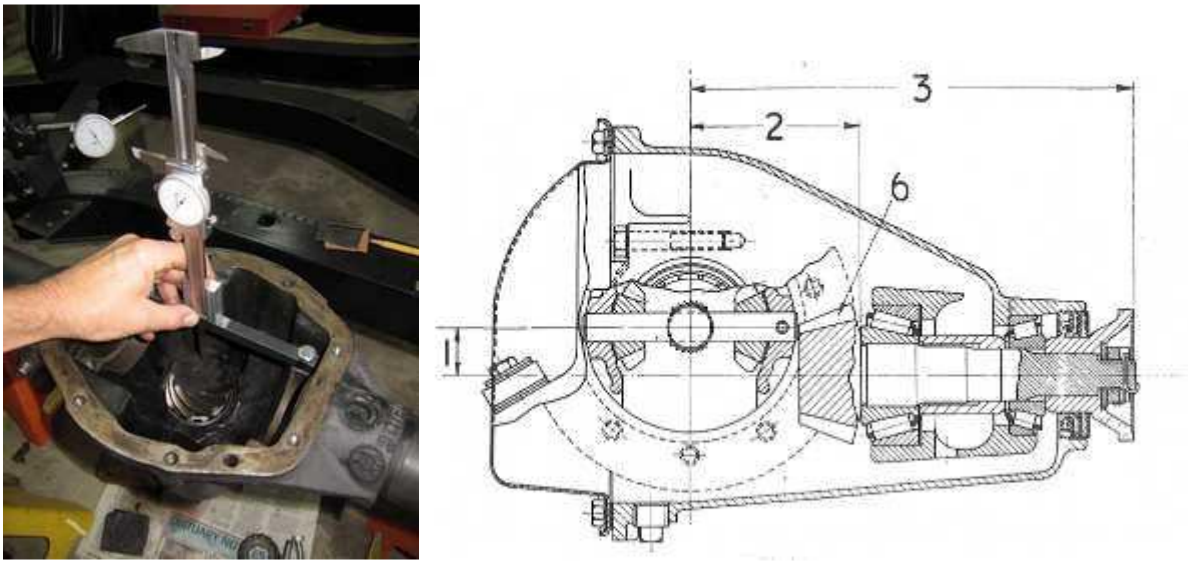


Figure 134: To determine the distance from the carrier center to the bearing-contact surface of the pinion gear.

The correction for the raw measurement, in my case, was as follows:

Bar thickness: -0.489
Datum to carrier center: +0.007 (average of the two sides)
Pinion thickness: +1.286

Adding these gave a +0.804 inch correction. For example, suppose the above measurement was 2.630 inches. Adding 0.804 gives a value of 3.434 for dimension 2, which is 3-6 mils high. Removal of a 5-mil spacer should change dimension 2 to 3.439.

After a few changes of pinion and preload shims, I eventually got the pinion within spec. I ended up with a 45-mil stack of pinion shims and 43 mils of preload shims. The pinion depth was 3.438 inches (3.437-3.440 spec) and 15 lb-in of torque (15-18 spec). Setting up the pinion was one of the most tedious automotive tasks I've ever done.

Carrier Assembly

Since I didn't remove the differential gears, and the bearings had already been installed (temporarily, for the carrier-float measurements), assembling the carrier involved only installing the ring gear. It is important to make sure the ring-gear mounting surface is clean and free of debris, as tolerances are tight. I reused the old bolts, as they are a special type, hardened (equivalent to modern grade 8), with a short unthreaded shank that locates the gear on its mounting surface. Similar bolts would have been difficult to find, as most available grade-8 bolts of the required length are fully threaded. I did use new, grade-8 lock washers, however. Uniform torque on those bolts is probably important; the manual specifies 35-40 lb-ft.

Carrier Setup

Now to set up the carrier. Here's where I encountered some problems.

The first task was to measure the carrier float between its full left position and fully meshed position. This is called the "full mesh" distance in the shop manual; it is measured with the carrier bearings in place but without shims. I measured 47 mils with no shims under the bearings. I removed the left bearing, added 42 mils of shims, aiming for 5 mils of float and therefore backlash, and pressed the bearing back onto the carrier.

Figure 135: Measuring carrier bearing

The backlash can be measured without installing the right-side shims; it is necessary only to push the carrier all the way to the left, thus loading the left bearing. When I measured the backlash, however, it was 10 mils. I rechecked the float, and it was 8 mils instead of the expected 5. What was going on?

Figure 136: The total float measurement

The most likely explanation is that the bearing wasn't fully pressed onto the carrier when the measurement was made. If that was the case, the total float measurement would also be erroneous, but it can't be premeasured without removing the pinion or the ring gear. It would have been a cold day in hell before I did that. Anyway, I changed the left shim stack to 46 mils, and measured 6 mils of backlash (the spec is 4-6 mils). So far, so good. But the measurement I needed to set the right stack, and thus the preload, was suspect. What to do?

I installed the carrier, loaded it to the left, and measured the right-side gap with feeler gauges. I measured 28 mils. Adding all this implies that the float originally was something like 74 mils instead of the 63 I measured. I have a hard time believing that this was caused by the bearings not being fully home; I think I would have noticed 11 mils of gaps between the bearings and carrier. Perhaps the measurement was really 73 mils, but I read 63. I've done dumber things.

Knowing the gap, I set the right-side stack to 31 mils. I tested it by trying to insert the carrier; it went in a little way and jammed, as I would have expected.

Figure 137: Use press to insert the carrier.

I hauled out my case spreader, spread the case, and dropped the carrier into position. I installed new bolts for the bearing caps. Finally, I rechecked the backlash and measured 5 mils. Done! Below is the finished differential.

Figure 138: A hauled out my case spreader, spread the case, and dropped the carrier into position. I installed new bolts for the bearing caps. Finally, I rechecked the backlash and measured 5 mils. Done! Below is the finished differential.

- Topic2 : Reassembling differential locking components

Figure 139: Insertion of differential lock

Figure 140: Use the correct tool provided in order to preload the Crown wheel carrier bearings. These bearings must be preloaded, but the position of these bearings also controls the position of the Crown wheel, and thus the Crown wheel to pinion backlash. When the bearings are correctly set, knock out the roll pin from the locking lever.

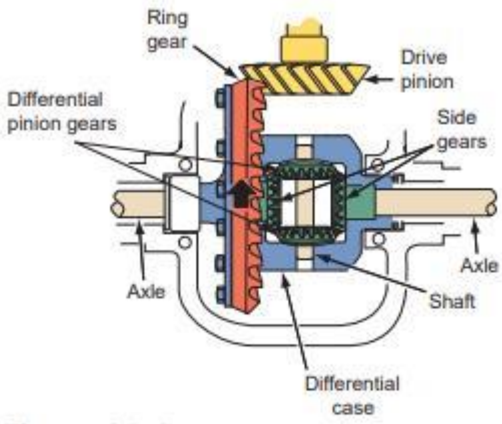


Figure 141: The components of a typical final drive unit.

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 gear set 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 gear sets have no timing marks. These gears are hunting gears and do not need to be timed. **Nonhunting** and partial **nonhunting** gears must be timed.

Learning Unit 4 – Remount and test final drive with differential

LO 4.1 – Remount final drive with differential

- Topic1 : Remounting final drive with differential

  - **Reassembly Tips:**

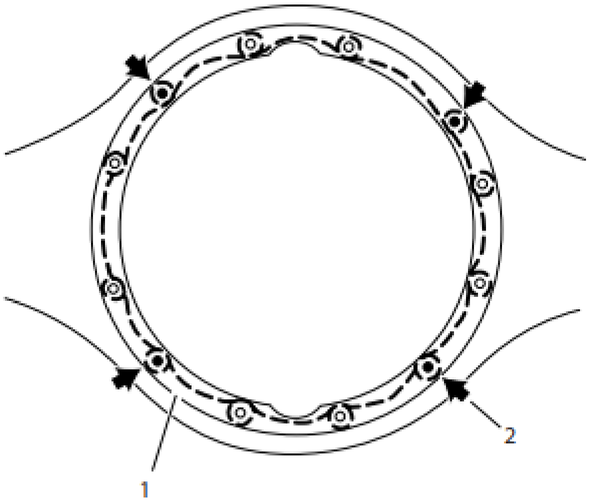
    a. Always clean the mounting and sealing surfaces before assembly
    b. Always replace ring and pinion gears in sets
    c. Use pilot studs to align the ring gear to the case
    d. Check the gears for timing marks and properly align if necessary

Reverse removal procedure for installation, noting the following.

- **Install Differential Carrier (Forward/Rear)**

IMPORTANT: Before installing carrier assembly, inspect and thoroughly clean interior of axle housing using an appropriate solvent and clean rag.

1. Apply Spicer approved RTV compound on axle housing mating surface as shown in the illustration. Completely remove all old gasket material prior to applying new material. Compound will set in 20 minutes. Install carrier before compound sets or reapply.



1 — Apply silicone gasket in this pattern
2 — Common stud locations

Figure 142: Apply Spicer approved RTV compound on axle housing mating surface

TIP: To assist in installing complete differential carrier use two pieces of threaded rod (M16 X 1.5) threaded into carrier capscrew holes. Rod should be approximately 6” long. Use these to pilot the carrier into the housing.

2. Install carrier to housing, lock washers, capscrews and nuts.

Torque to proper specification. Torque to 230–270 lbs. ft. (312–366 N•m).

3. After 11/02/98, axle housing covers are welded in place. If you have a bolt-on cover, install rear housing cover/output shaft assembly. See page 76. Torque all fasteners to proper specifications. Torque to 85–103 lbs. ft. (115–140 N•m). Install inter-axle driveline making sure yokes are in phase.
4. Install axle shafts and axle stud nuts (if used, also install lock washers and tapered dowels).
5. Add axle lubricant. Fill to bottom of filler hole.
6. Rear Only: Connect inter-axle driveline, making sure all yokes are in phase. Lubricate U-joints.

7. Front Only: Connect main driveline, making sure all yokes are in phase. Lubricate U-joints.
8. Front Only: Connect differential lockout airline.

LO 4.2 – Remount clutch control components and housing

Clutch control components remounting

- ✓ Clutch cable
- ✓ Slave cylinder

- Topic1. Clutch housing remounting

To remove the clutch case cover from its adapter sleeves, take a mallet and carefully hit all around until it comes loose.

Important: only use a screwdriver to lever out the cover if the cover and the housing feature corresponding gaps or recesses.

Never attempt to drive the screwdriver between the sealing surfaces as this will cause irrevocable damage!

If it's absolutely impossible to remove the lid, you probably forgot to undo a screw! Usually the seal adheres to one of the two surfaces and rips apart.

Always replace the seal.

Then carefully use sealing agent remover or brake cleaner and a seal scraper to remove any residue without damaging the sealing surfaces.

Use a new seal during re-installation.

Also remember to keep the adapter sleeves safe.

LO 4.3 – Remount manual gear shifting linkages and attachments

- Topic1 : Remounting assemblies
  - ✓ Grommet cable assembly
  - ✓ Selector cable assembly
  - ✓ Boot and console assembly
  - ✓ Gear shift mechanism assembly
- Topic2 : Gear shifting linkages and attachments remounting
  - ✓ Stabilizer
  - ✓ Bracket
  - ✓ Selector rod
  - ✓ Ball
  - ✓ Adjusting screw cable
  - ✓ Shift level

There are two types of shift linkages used on manual transmissions. They are the EXTERNAL ROD and the INTERNAL SHIFT RAIL. They both perform the same function. They connect the shift lever with the shift fork mechanism.

The transmission shift lever assembly can be moved to cause movement of the shift linkage, shift forks, and synchronizers. The shift lever may be either floor mounted or column mounted, depending upon the manufacturer. Floor-mounted shift levers are generally used with an internal shift rail linkage, whereas column-mounted shift levers are generally used with an external rod linkage.

LO 4.4 – Remount manual gearbox mountings and starter motor

- Starter motor remounting
- Remounting manual gearbox mountings
- ✓ Fixing gearbox mountings
- ✓ Remounting the two mounting bolts and nuts
- ✓ Remounting rear mounting platform attachment bolts and nuts
- ✓ Remounting speedometer drive cable and pinion assembly
- Gearbox remounting :
  - a) Extension housing and thrust washer remounting
  - b) Bolts fixing
  - c) Remove drip tray under gearbox.

LO 4.5 – Remount propeller shaft, joints and half shafts

- Topic 1 : Procedures of remounting half shaft
- ✓ Axle shaft remounting

Figure 143: Axle shaft

- ✓ Axle shaft bolts remounting

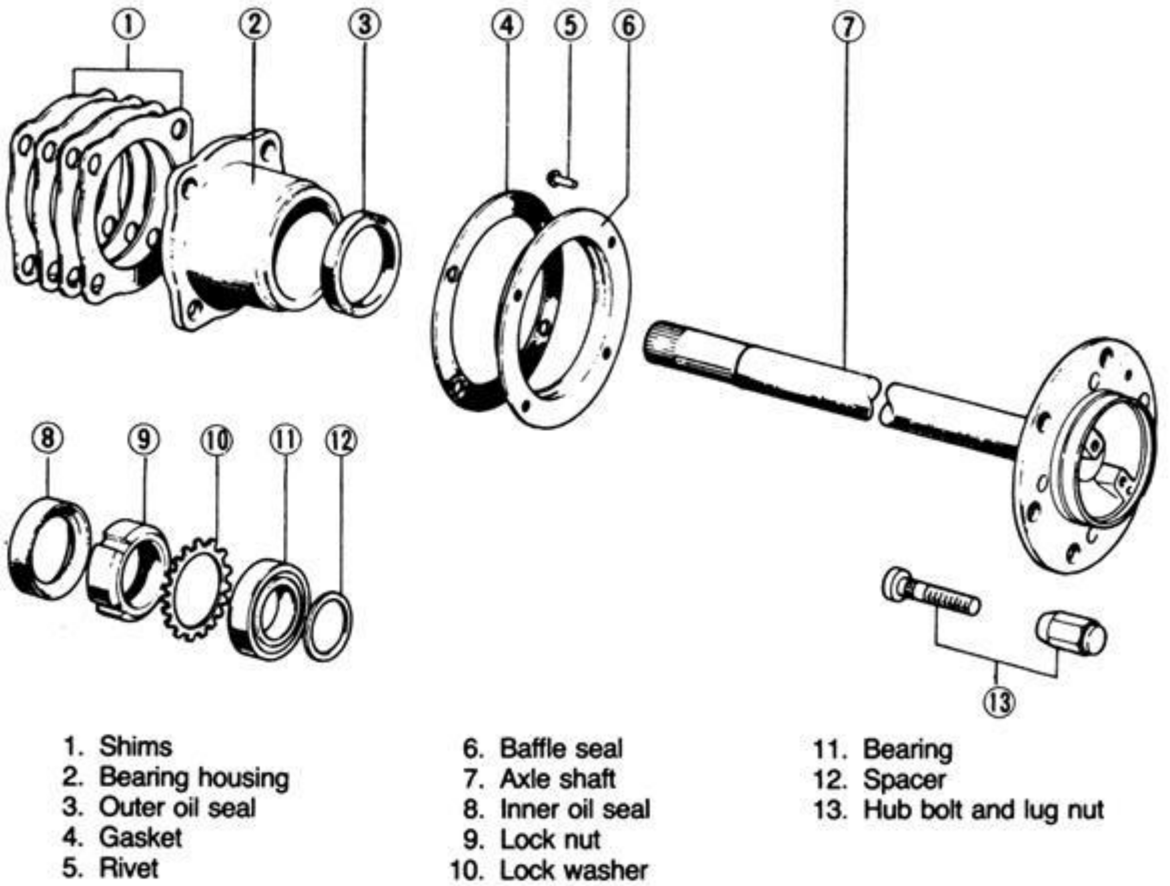


Figure 144: Axle shaft bolts

Figure 145: Axle shaft bolts

✓ <u>Drum and disc brake remounting</u>

Step 1

Remove the Brake Drum: After the wheel has been removed use a small chisel with a hammer to remove the bearing dust cap. On some cars the drum will just slide off or be held on by thin sheet metal clips which will need to be removed prior. If the drum is stuck continue down this guide for removal instructions.

Figure 146: Dust cup removal

Remove the bearing dust cap and the axle bearing retainer nut will be exposed.

Figure 147: Dust cup removal

Choose the correct size socket usually 22mm to 24mm and remove the axle bearing retainer nut. This can be done using a breaker bar.

Figure 148: Axle bearing nut removal

Gasp the drum and with a twisting and pulling motion remove it from the car. Turning the drum helps release the unit from the axle and the brake shoes.

Figure 149: Brake drum removal

On a non-bearing style of brakes there will be two methods to remove the drum. Normally a brake drum will just lift off of the axle flange but rust can sometimes make the drum stuck. To remove a stuck drum use WD40 and spray it between the axle flange, lugs studs and the drum and let it sit for about 15 minutes.

Figure 150: Spray on drum disc

The first way to remove the brake drum is too insert two bolts which are usually 8mm x1.25 and then tighten them equally which will push the drum outward for removal.

Figure 151: Bolt insertion

The second way is to be used if no bolt holes are available, or if you don't have the bolts. Use a hammer and strike the drum between the lug studs. This will "shock" the drum from the axle flange. Use caution when using the hammer so you do not hit the wheel studs. This is the best method of removing the stuck brake drum.

Figure 152: Wheel and tire remounting

- <u>Topic 2 : Procedures of remounting propeller shaft and joints</u>

✓ <u>Propeller shaft remounting</u>

B. How to Assemble Propeller Shaft

Installing the cross joint :

- Install the cross joint by matching the mounting marks
- Filling grease on the cross joint until the full
- Install new seal
- Install the bearing cup. bearing housing position, the holder bearing cups and the cross joint shaft must be straight and then pressed, little by little and check whether the cross joint can spin well, When little hard, push with the beat at the end of the yoke.
- Check the position of bearing housings on the stand, must be straight.
- Install new snap rings with axial clearances 0.02 mm.

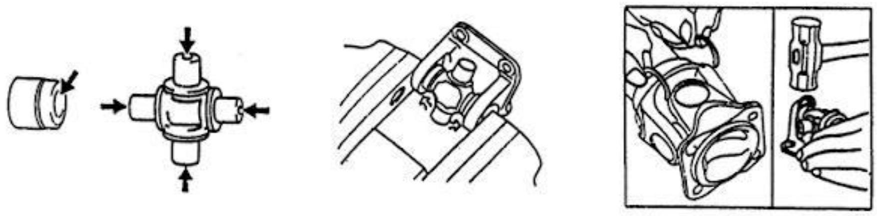


Figure 153: Installing the cross joint

- Installing back the propeller shaft to the car:
  - Check the signs of mounting
  - Tighten the bolts with a torque wrench (tightening torque refer to the manual).
  - Finally give lubrication to the cross joint and sleeve joint with grease pump.

✓ Remounting propeller shaft flange

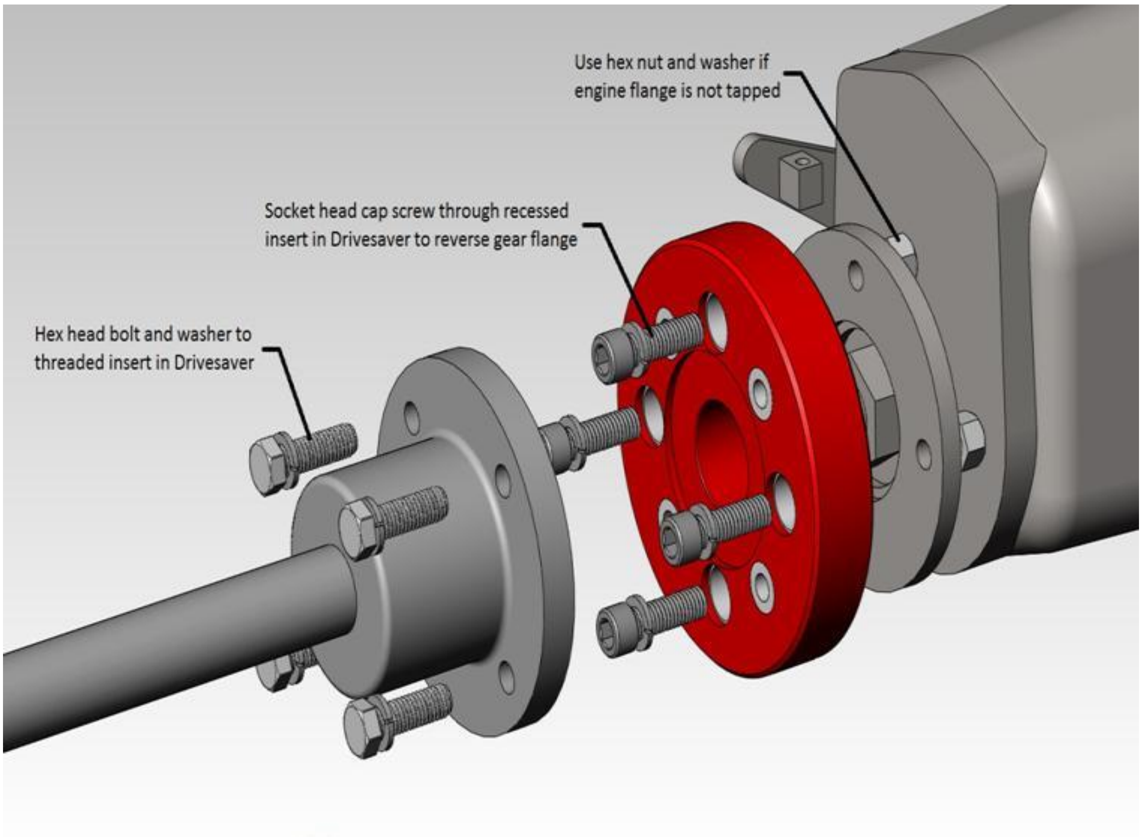


Figure 154: Remounting propeller shaft flange

✓ Remounting propeller shaft bolts

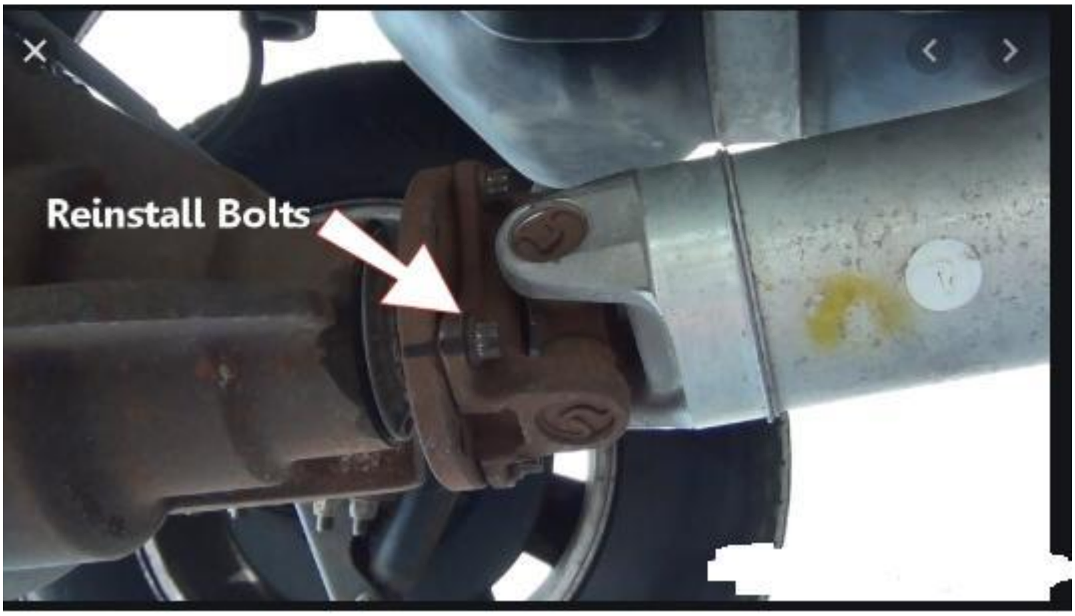


Figure 155: Reinstall bolts

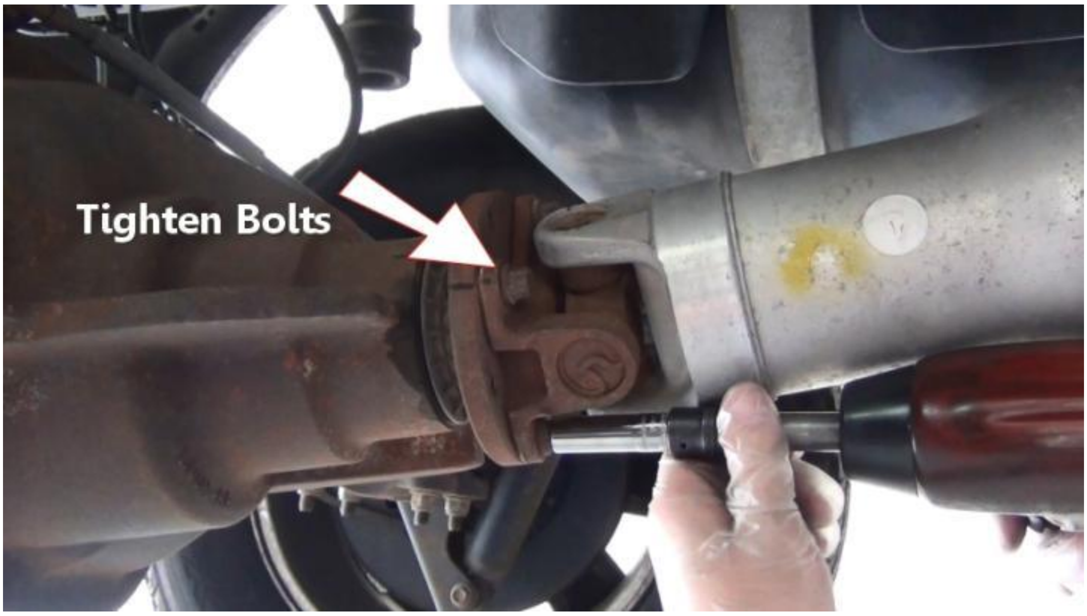


Figure 156: Tighten bolts

LO 4.6 – Remount wheels and tires

- Topic 1 : Wheels and tires remounting

Install a fresh rubber valve stem, again taking care to not damage the wheel.

Lubricate the inboard and outboard bead areas.

Place tire on wheel and with a lever securely in place, twist the tire bead over the top rim flange by hand.

You may need to use the changer's mechanical lever to complete this step.

Install a new valve core.

Identify the maximum air pressure for the tire. You will need that information to properly seat both beads using air pressure.

Seat both beads using air pressure and a gentle lift of the tire up into the top rim flange.

Find the proper inflation pressure for the tires on the vehicle placard located in the driver's door jamb or the vehicle owner's manual. Inflate the tire to that pressure. For uniformity, deflate and then inflate again.

Figure157: From 1 to 10: Procedures of Wheels and tires remounting

✓ <u>Screwing bolts of tires to the axles</u>

Figure 158: Screwing bolts

LO 4.7 – Refill and test final drive with differential

- <u>Topic 1:Noise Definitions</u>

✓ **"Chuckle"**

a) A rattling noise that sounds like a stick in the spokes of a bicycle wheel
b) It is normally heard during coasting
c) Its frequency will change with vehicle speed
d) It is usually caused by damaged gear teeth

✓ **"Knocking"**

a) Sounds similar to chuckle, but is usually louder
b) Can occur in all driving phases
c) Is usually caused by gear tooth damage on the drive side or loose ring gear bolts

✓ **"Clunk"**

a) A metallic noise often heard when an automatic transmission is shifted into drive or reverse
b) May be heard when the throttle is applied or released
c) Is usually caused by excessive backlash somewhere in the drive line

✓ **"Gear Noise"**

a) The howling or whining of a ring gear and pinion
b) Can occur under various conditions and speeds
c) Is usually caused by an improperly set gear pattern, gear damage, or improper bearing preload

✓ **Bearing "rumble"**

a) Sounds like marbles rolling around in a container
b) Is usually caused by a faulty wheel bearing

✓ **Bearing "whine"**

a) A high-pitched, whistling noise
b) Is usually caused by faulty pinion bearings

✓ **"Chatter"**

a) Can be felt as well as heard
b) Is usually caused by excessive preload
c) On limited-slip differentials, it is caused by using the wrong type of lubricant

✓ **Some Causes of Vibrations**

a. Out-of-round or imbalanced tires
b. Improper drive line angles
c. Damaged pinion flange
d. Faulty universal joint
e. Bent drive pinion shaft

✓ **Common Sources of Axle Assembly Leaks**

a. Damaged pinion seal
b. Leakage past the threads of the pinion nut
c. Leakage past the carrier assembly stud nuts
d. Leaking gaskets
e. Housing porosity
f. Defective ABS sensor O-ring

✓ **Diagnosing Limited-Slip Concerns**

i. Locate the specification for break-away torque
ii. With one wheel on the floor and the other one raised, use a torque wrench to check the torque required to turn the wheel
iii. If the torque is less than specified, the differential must be checked

✓ **Fluid Level Check**

a. Make sure the proper fluid is being used
b. The vehicle must be level
c. The axle assembly must be at normal operating temperature
d. The fluid level should be even with the bottom of the fill plug opening

✓ **Replacing a Pinion Seal**

a) Remove the pinion flange
b) Remove the seal using a slide hammer
c) Lubricate the new seal before installation
d) Use a seal driver to install the new seal
e) Follow the manufacturer's recommendation for tightening the pinion flange nut

- Topic 2 : Refilling final drive with differential

A final note is that all differential fluids possess a particular odor that may or may not appeal to your senses. Sulphur compounds used in extreme pressure lubricants smell either like rotten eggs or worse depending on additive concentration. A good call is to wear clothes you can throw away and not get any gear oil anywhere you don't want to smell it for a while. This applies in particular to the interior of the vehicle. If for some odd reason you like the smell of rotten eggs, you'll absolutely love the smell of gear oil. If not, then take the proper precautions to avoid the lingering reminder of a gear oil change.

Step-by-step guide to changing differential oil

Step 1: Secure the vehicle on jack stands or ramps. Locate the differential drain bolt. Loosen and remove.

Figure 159: Locate the differential drain bolt. Loosen and remove

Step 2: Allow time for the gear oil to completely drain. Replace the drain bolt. Wipe any excess gear oil from the case.

Figure 160: Replace the drain bolt. Wipe any excess gear oil from the case.

Step 3: Locate and remove the gear oil fill bolt.

Figure 161: Use a pump to refill gear oil.

Step 4: Use a pump to slowly add the recommended type of gear oil to the differential.

Figure 162: Add a recommended gear oil.

Step 5: Add the recommended amount of gear oil to the differential, or until gear oil starts to dribble out of the fill hole.

Figure 163: Reinstall and tighten the fill hole bolt

Step 6: Reinstall and tighten the fill hole bolt. Wipe off any excess gear oil from the case.

- ✓ Oil level

Check the fluid level with your finger.

The gear oil in the rear differential should reach the bottom of the service port hole. Insert one finger into the open service port. Bend your finger downward slightly to see if it comes into contact with gear oil

- If your finger touches gear oil, there is enough fluid inside.
- If the fluid level doesn't reach the service port, it is low.

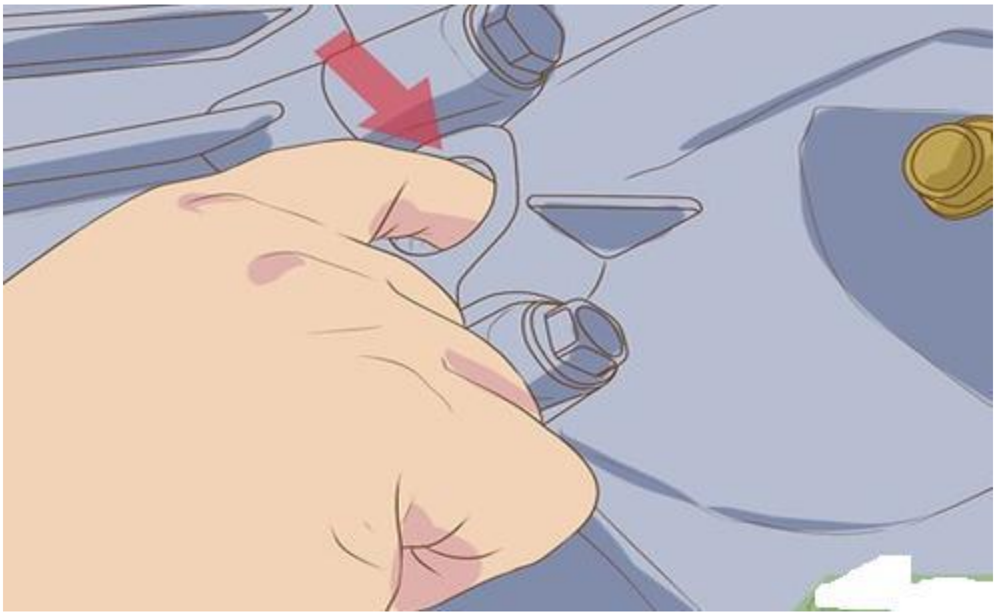


Figure 164: Use your finger to check oil level

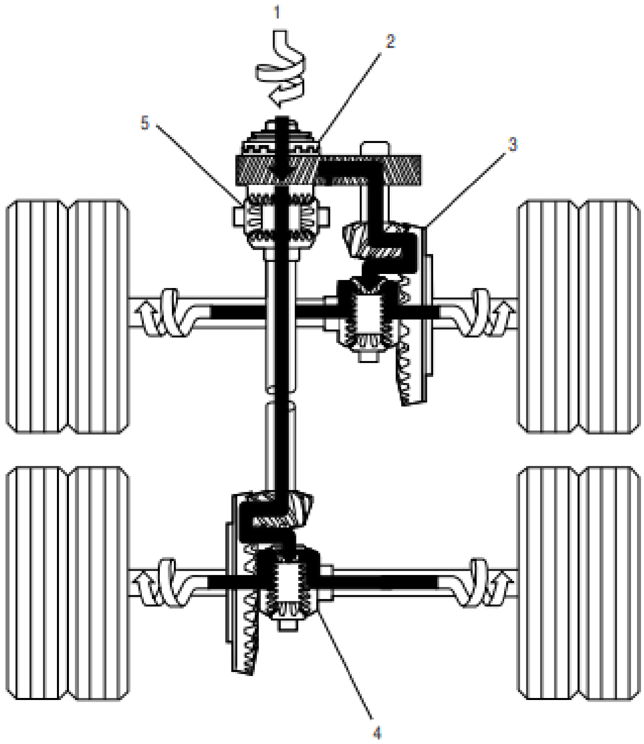
- ✓ Leakage checking

Figure 165: Check the rear differential for leakage

- Topic 3 : Road testing
  - ✓ Jump out
  - ✓ Poor synchronization
  - ✓ Abnormal noise
  - ✓ Vibrations
    - ➢ Loose or missing chassis bolts
    - ➢ Chassis cracks/porosity
  - ✓ Sticking

(Inter-Axle Differential is not operating) Lockout should only be engaged when both axles are rotating at the same speed. Operation should be limited to low-traction situations and should be disengaged when normal traction returns. Failure to do so will result in poor handling and damage to the axle components.

Note: Varied road surface conditions can result in unequal torque distribution between the two axle assemblies. **CAUTION:** Prolonged operation with the lockout engaged can damage axle and driveline components.

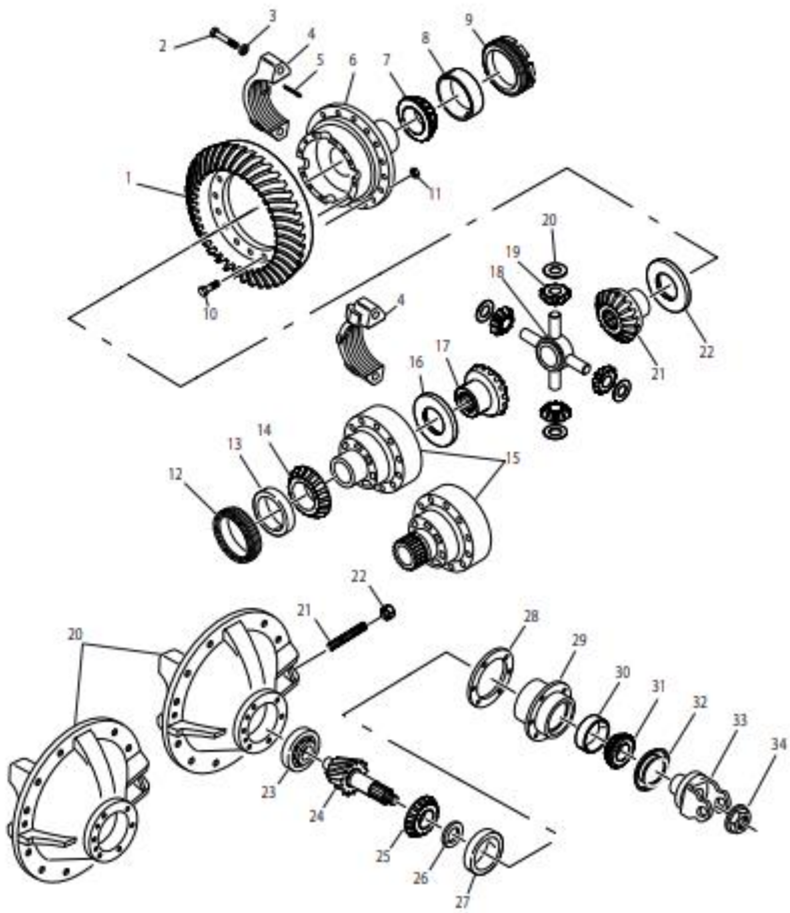


1 — Input torque
2 — Lockout engaged
3 — Forward axle torque is transmitted from the helical side gear through the pinion helical gear, drive pinion, ring gear, wheel differential and axle shafts.
4 — Rear axle torque is transmitted from the output shaft side gear through the output shaft, inter-axle driveline, drive pinion, ring gear, wheel differential and axle shafts.
5 — Input torque (power flow) from the vehicle driveline is transmitted directly to the helical side gear and the output shaft. A positive drive is provided to both axles for maximum traction under adverse road conditions.

Figure 166: Lockout should only be engaged when both axles are rotating at the same speed.

Rear Drive Axle

(Parts Exploded View)



1 — Ring gear
2 — Carrier cap bolt
3 — Flange half carrier cap
4 — Flange half differential case
5 — Flange half bearing cone
6 — Flange half bearing cup
7 — Flange half bearing adjuster
8 — Plain half bearing adjuster
9 — Plain half bearing cup
10 — Plain half bearing cone
11 — Plain half differential case
12 — Side gear thrust washer
13 — Plain half carrier cap
14 — Side gear
15 — Side pinion
16 — Side pinion thrust washer
17 — Wheel differential spider
18 — Side gear
19 — Side gear thrust washer
20 — R-head carrier or rear carrier
21 — Thrust bolt
22 — Thrust bolt jam nut
23 — Pinion pilot bearing
24 — Pinion
25 — Inner pinion bearing cone
26 — Pinion bearing spacer
27 — Inner pinion bearing cup
28 — Pinion cage shim
29 — Pinion cage
30 — Outer pinion bearing cup
31 — Outer pinion bearing cone
32 — Pinion seal
33 — Pinion yoke
34 — Pinion nut
35 — R-head carrier with thrust bolt

Figure 167: Exploded view of rear drive axle.

- Topic 4: Rear axle Diagnosis

Rear Axle Diagnosis

Condition	Possible Causes	Correction
[illegible]se during straight [illegible]ead driving.	1. Insufficient lubricant.	1. Fill housing to correct level.
	2. Worn improper lubricant.	2. Drain. Flush and fill with correct lubricant.
	3. Differential case bearings.	3. Replace bearings.
	4. Worn drive pinion shaft bearings.	4. Replace pinion bearings.
	5. Worn ring and pinion.	5. Replace ring and pinion.
	6. Excessive backlash.	6. Adjust backlash.
	7. Insufficient backlash.	7. Adjust backlash.
	8. Excessive ring and pinion backlash.	8. Adjust backlash.
	9. Insufficient ring and pinion backlash.	9. Adjust backlash.
	10. Pinion shaft or differential case bearings improperly preloaded.	10. Preload as specified by the manufacturer.
	11. Excessive ring gear runout.	11. Remove ring, clean, and check flange runout. Reinstall and check runout. Replace ring or case as needed.
	12. Loose ring gear fasteners.	12. Torque fasteners.
	13. Unmatched ring and pinion.	13. Install a matched ring and pinion set.
	14. Loose differential case bearing cap fasteners.	14. Torque fasteners.
	15. Warped housing.	15. Replace housing.
	16. Loose pinion shaft companion flange retaining nut.	16. Torque flange nut.
	17. Incorrect tooth (ring and pinion) contact pattern.	17. Adjust as needed.
	18. Loose wheel.	18. Tighten wheel lugs.
	19. Wheel hub loose on tapered axle.	19. Inspect, if not damaged, torque retaining nut.
	20. Wheel hub key (on tapered axle) sheared.	20. Install new key.
	21. Worn wheel (axle) bearing.	21. Replace axle bearing and seal.
	22. Bent axle.	22. Replace axle.
	23. Worn wheel hub or axle keyway.	23. Replace axle or hub as needed.
	24. Dry pinion shaft seal.	24. Replace pinion shaft seal.
	25. Loose universal joint retainers.	25. Tighten universal joint retainers.
	26. Damaged universal joint.	26. Replace universal joint.
	27. Worn or broken front-wheel drive front suspension parts.	27. Repair or replace as necessary.
	28. Worn or broken transaxle unit.	28. Repair or replace as needed.
[illegible]se when rounding a [illegible]e.	1. Worn or broken differential pinion gears.	1. Replace gears.
	2. Worn differential pinion shaft.	2. Replace pinion shaft.
	3. Worn or broken axle side gears.	3. Replace side gears.
	4. Excessive axle side gear or pinion gear end play.	4. Install new thrust washers or replace case and/or gears.
	5. Excessive axle end play.	5. Adjust end play.
	6. Improper type of lubricant.	6. Drain. Flush and fill with correct lubricant.
	7. Loose or broken suspension parts (front-wheel drive).	7. Repair or replace parts as needed.
	8. Loose or broken universal joints.	8. Tighten or replace universal joints.

Rear Axle Diagnosis		
Condition	**Possible Causes**	**Correction**
Clunking sound when engaging clutch, accelerating, or decelerating.	1. Excessive ring and pinion backlash. 2. Excessive end play in pinion shaft. 3. Worn axle side gears and pinions. 4. Worn differential bearings. 5. Worn side gear thrust washers. 6. Differential pinion shaft loose in case or pinions. 7. Worn axle shaft splines. 8. Worn wheel hub or axle keyway. 9. Loose wheel or hub. 10. Loose or broken universal joints.	1. Adjust backlash. 2. Preload bearings. 3. Replace worn gears. 4. Replace bearings. 5. Replace thrust washers. 6. Replace pinion shaft, gears, or differential case. 7. Replace axle. 8. Replace hub or axle. 9. Tighten fasteners. 10. Tighten or replace universal joints.
Axle leaking lubricant.	1. Clogged breather. 2. Worn seals. 3. Loose carrier-to-housing or inspection cover. 4. Carrier or inspection cover gasket damaged. 5. Lubricant level too high. 6. Wrong type of lubricant. 7. Porous housing (standard and transaxle). 8. Stripped fill plug threads. 9. Cracked housing (standard and transaxle).	1. Open breather. 2. Install new seals. 3. Tighten fasteners. 4. Install new gasket or sealer. 5. Drain lubricant to proper level. 6. Drain. Flush and install correct lubricant. 7. Repair or replace housing. 8. Repair or replace as needed. 9. Repair or replace housing.
Noises that may be confused with drive axle assembly.	1. Low air pressure in tires. 2. Road surface. 3. Transmission. 4. Bent propeller shaft. 5. Loose U-joints. 6. Engine. 7. Front wheel bearings. 8. Tire tread. 9. Dragging brakes. 10. Excessive front wheel end play.	1. Inflate tires to proper pressure. 2. Test on several different road surfaces. 3. Check transmission. 4. Replace shaft. 5. Tighten or replace U-joints. 6. Check engine. 7. Replace bearings. 8. Inflate temporarily to 50 psi (34.5 kPa) for road test only. 9. Adjust brakes. 10. Adjust wheel bearings.
Rear axle overheating.	1. Wrong type of lubricant. 2. Insufficient lubricant. 3. Overloading (pulling heavy trailer). 4. Worn gears. 5. Excessive bearing preload. 6. Insufficient backlash between ring and pinion.	1. Drain, flush, and fill with correct lubricant. 2. Fill lubricant to proper level. 3. Reduce vehicle load. Advise driver. 4. Replace gears. 5. Adjust preload. 6. Adjust backlash.

Reference books:

1. R. Gscheidle, (1997). Modern automotive technology: fundamentals, service, diagnostics. VERLAG Europa – LehrmittelNorneyVolmer GmbH & Co.KG; Germany.

2. Halderman J.D., (2012). Automotive Technology: Principles, diagnosis and service, 4th ed. Pearson education, 1 Lake Street, Upper Saddle River, New Jersey 07458. USA ISBN-13: 978-0-13-254261-6.

3. Erjavec J., Delmar, (2009). Automotive Technology: A systems approach, 5th ed. 5 Maxwel Drive, Clifton Park, NY12065-2919, USA. ISBN-13:978-1428311497.

4. Gerschler H., (1989). Technology for Automotive Trade, 20th ed. VERLAG Europa – LehrmittelNorneyVolmer GmbH & Co., Wuppertal; Germany .

5. AUTOMOTIVE TECHNOLOGY (5th Edition), by JACK ERJAVEC

6. MODERN AUTOMOTIVE TECHNOLOGY by JAMES E. DUFFY

7.google.com/search?bih=597&biw=1242&hl=fr&sxsrf=ALeKk02l6D6R31dDVfQd7881zZfar4uiuA%3A1606089165292&ei=zfm6X9qEb2g1fAPpsSvgAM&q=Remount++manual+gearbox+mountings+and+starter+motor&oq=Remount++manual+gearbox+mountings+and+starter+motor&gs.

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