CHAPTER

7 Drive Train Service and Inspection

Objectives

Upon completion and review of this chapter, the student should be able to:

- Perform a drive axle lube service.
- Explain the effects of mixing lubricants.
- Perform a check of the fluid level on a drive axle.
- Explain the function of the drive shaft and U-joints.
- Service the drive shaft and U-joints.
- Check the oil level in a manual transmission.
- Perform a service and inspection on a manual transmission.
- Perform adjustments on various styles of clutches.
- Perform service and inspection on various types of clutch linkages.
- Perform service and inspection on an automatic transmission.

Key Terms

American Petroleum Institute
breather
center support bearings
clutch
clutch break
differential carrier
driveshaft
hanger bearings
interaxle differential
lockstrap
pull-type clutch
push-type clutch
release bearing
slip splines
spider
throw-out bearing
TransSynd
trunnions
U-joint
wear compensator
yokes
zerk-type

INTRODUCTION

A technician must know how to perform a proper inspection and service on the complete driveline. Preventive maintenance of this area will mean the difference between a successful trip or the vehicle being stranded and waiting for emergency service by the side of the road.

SYSTEM OVERVIEW

This chapter starts by explaining how to inspect and service a drive axle and driveshafts, including universal joint service and inspection. Servicing of manual transmission and automatic transmission are also discussed.

Clutch maintenance is also explained in this chapter, as well as how to make proper clutch adjustment and linkage adjustment and perform a proper inspection.

DRIVE AXLE LUBE SERVICE

The drive axle is completely dependent upon lubrication to:

- Provide a lubricating film between the moving parts to reduce friction.
- Help cool components subject to friction.
- Keep dirt and wear particles away from mating components.

Proper maintenance of the drive axle depends upon using the correct lubricant, changing it at the proper intervals, and consistently maintaining the correct fill level in the axle. Always follow the OEM service literature for specific maintenance and drain intervals.

Synthetic lubricants have become common in recent years, causing manufacturers to increase their drain intervals. Synthetic oils provide so many advantages that most component manufacturers endorse their use. The upfront cost of purchasing synthetic lubricants is greater when compared to mineral-based lube, but if the drain interval is increased by three times, the synthetic becomes the cheaper option. Generally, synthetic oils can be said to possess:

- Higher lubricity
- Much higher boil points than mineral-based oils (600°F vs. 350°F)
- Better filming properties (boundary lubrication)
- Better cold weather performance

Some OEMs suggest that the initial drain and flush of the factory-fill axle lubricant on a new drive axle is unnecessary when using synthetic lubricants. This extension in drain intervals reduces labor costs and is embraced by most of the major fleets.

Mixing Lubricants

Many trucks are serviced at multiple truck shops, which makes it inevitable that the rear axle lubricant will get mixed. Despite the fact that some manufacturers of synthetic oils state that their product is compatible in a mix with other great lubes, most service experts in the trucking industry suggest that mixing rear axle lubricants accelerates breakdown. All efforts should be made to avoid mixing different gear lubes in the axle housing, because some of the additives will conflict. In some cases, when petroleum-based stock and synthetic lubes are mixed, thickening and foaming can result, producing premature failure of the drive axle.

Approved Lubricants

All lubricants used in a **differential carrier** (rear end) assembly must meet the **American Petroleum Institute** (API) and Society of Automotive Engineers (SAE) GL standards. The best practice is to follow OEM recommendations. Currently all OEMs approve the use of synthetic lubricants meeting the GL-5 performance classification.

API-GL-5 and synthetics are available in several viscosities. The viscosity used in an application depends mostly on the expected operating temperatures. **Table 7-1** shows the appropriate gear lube grades to use for the operating temperatures.

Lube Change Interval

If a mineral-based gear lube is used, the initial lube change should be made at 1,000 to 3,000 miles, with subsequent lube changes at 100,000 mile intervals; for linehaul operation, that is terminal to terminal highway operation. Other types of operations will require more frequent changes. If the truck does not accumulate enough mileage to require a lube change on the basis

TABLE 7-1: AXLE GEAR LUBE VISCOSITY

Ambient Temperature Range	Proper Grade
–40°F to –15°F (–40°C to –26°C)	75W
–15°F to 100°F (–26°C to 38°C)	80W–90
–15°F and above (–26°C and above)	80W–140
10°F and above (–12°C and above)	85W–140

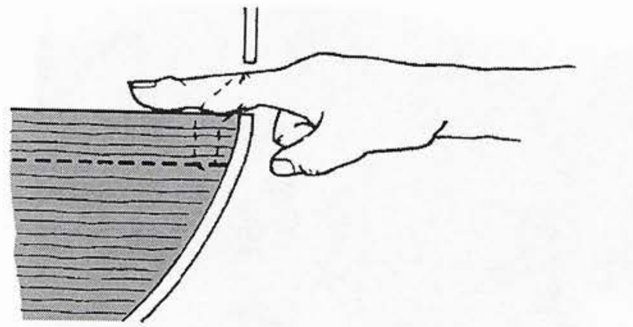


Figure 7-1 Correct and incorrect procedure for checking the drive axle lubricant level. *(Courtesy of Roadranger Marketing. One great drive train, two great companies—Eaton and Dana Corporations.)*

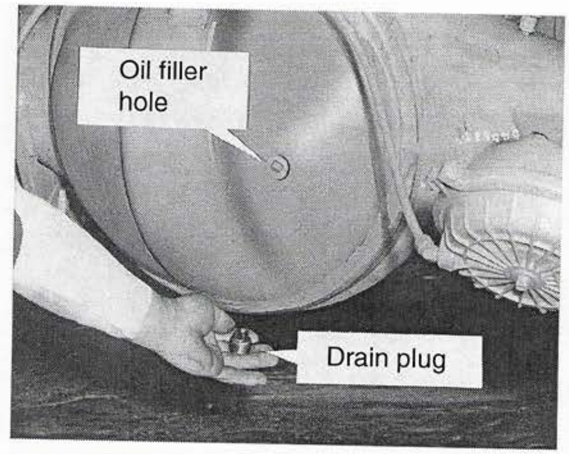


Figure 7-2 Drive axle filler hold and drain plug. *(Courtesy of Roadranger Marketing. One great drive train, two great companies—Eaton and Dana Corporations.)*

of mileage completed, it is good practice to change the lubricant once a year. When using synthetics, use the OEM recommendation or fleet practice.

If the level of the lubricant falls below its proper level between changes, it should be replenished as needed. If loss is excessive, troubleshoot the problem. Use an API-Gl-5 gear lube to maintain proper viscosity levels. However, do not mix lube grades when adding to an existing supply.

Checking Lube Level

Remove the fill hole plug located in either the banjo housing or differential carrier housing. The lube should be level with the bottom of the fill hole, as shown in **Figure 7-1.** To be seen or touched is not sufficient; it must be exactly level with the fill hole. Do not overfill the housing because that can cause problems with aerating the oil. When checking the lube level, also check and clean the housing breather. The breather is usually located on the top of the banjo housing offset from the banjo. If this plugs, the wheel seals can be blown out.

Draining Axle Lube

Draining both the differential carrier housing and the **interaxle differential** should be performed while still warm from the road. Keep in mind that rear axle lubricant runs at high temperatures, so be careful not to burn yourself.

Shop Talk: Draining lubricants when warm ensures that contaminants are still suspended and also reduces drain time.

The location of the drain plug can be seen in **Figure 7-2.** Check the drain plug for metal cuttings. Metal debris on the magnetic tip of the drain plug can be an indication of damage or imminent failure, so let the service manager or an experienced technician know of the problem before proceeding so that they may attempt to identify the problem. A few small particles should not be a problem. Clean the drain plug and replace it after the lube has been completely drained. The oil should be disposed of in accordance to the regulations in your area.

Refill the Rear Axle

Before you proceed to refill the rear axle, make sure you have the correct lubricant on hand. The specific lubricant used for the refill should be recorded in the vehicle file to prevent mixing of fluids during subsequent top-ups. Pump oil into the fill hole. This may be located in either the differential carrier or in the banjo housing. With the truck parked on a level surface, the oil level should be exactly equal to the bottom of the fill plug hole.

If the drive axle is equipped with an interaxle differential, this also should be filled. Some OEMs recommend that this be filled first with a couple of quarts of lube, followed by filling the axle housing to the correct level. The interaxle differential is filled using the filler plug hole as shown in **Figure 7-3.**

The angle of the differential carrier pinion usually determines which oil fill is to be used to fill and set the oil level in a rear axle. Measure the differential carrier pinion angle using a protractor or inclinometer, as shown in **Figure 7-4.** If the angle is less than 7 degrees (above horizontal), use the fill hole located in the side of the

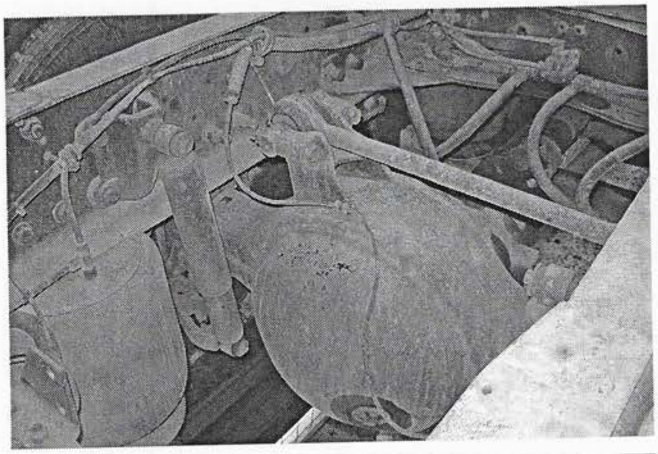


Figure 7-3 The drive axle oil fill plug at the lower portion of the banjo housing. *(Courtesy of John Dixon)*

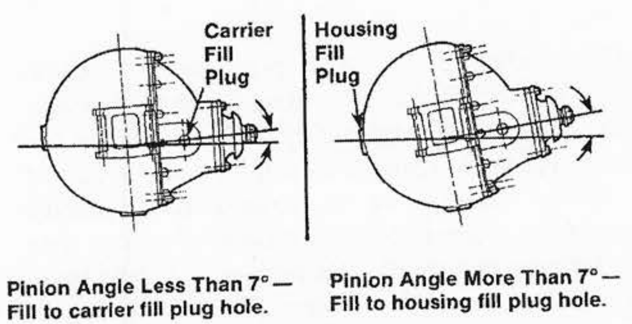


Figure 7-4 Measuring the differential carrier pinion angle. *(Courtesy of Arvin Meritor)*

carrier. If the angle is more than 7 degrees (above the horizontal), use the hole located in the banjo housing.

There are some manufacturers that only use one lube fill hole located in the banjo housing. When this is the case, you have no choice but to use this lube fill hole, regardless of differential carrier pinion. Rear differential carrier axles sometimes have a smaller plug located nearby, usually just below the lubricant level plug. If there is a plug in this hole, it is for a lubricant temperature sensor that is not installed. It should not be used as a fill hole for determining the correct axle oil level.

When you have completely drained and refilled the rear axle housing lubricant, drive the truck for a few miles to circulate the lubricant throughout the axle and differential carrier and allow vehicle to rest for 5 minutes to allow lubricant to settle. It should be exactly level with the bottom of the fill hole, as shown in **Figure 7-1.** If not, adjust level as necessary.

Drive Axles with Lube Pump

When draining an axle that uses a lube pump, remove the magnetic strainer from the power divider cover and inspect for wear material in the same way

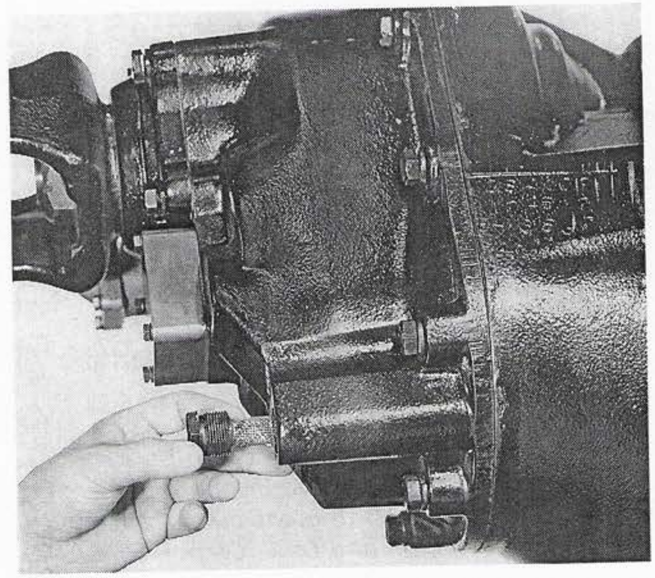


Figure 7-5 Remove the magnetic strainer from the power divider. *(Courtesy of Roadranger Marketing. One great drive train, two great companies—Eaton and Dana Corporations.)*

you would when inspecting a magnetic drain plug. The location of the strainer is shown in **Figure 7-5.** Wash the strainer in solvent and remove any residue by blowing off with compressed air.

WHEEL BEARING LUBRICATION

The wheel bearings are lubricated by the same oil that is in the differential carrier housing. This is one of the reasons why the correct fluid level is so important in the rear end. There is no external visual means of checking the lubricant level of the wheel bearing (unlike a non–drive axle) so the importance of making sure the drive axle lubricant lever is correct cannot be overemphasized. Wheel bearings are entirely lubricated by the gear oil in the banjo housing. There should always be some lube in the cavity of each wheel end (See **Figure 7-6**).

When the drive wheels are installed, the hub cavities should be pre-lubed with the same lubricant used in the differential carrier. Otherwise, they can be severely damaged before gravity and normal action of the differential gearing and axle shafts can distribute lube to the wheel hubs.

Procedure

If the wheel assemblies have not been pulled, you should use this procedure to ensure the wheel bearing cavities have a supply of lubricant:

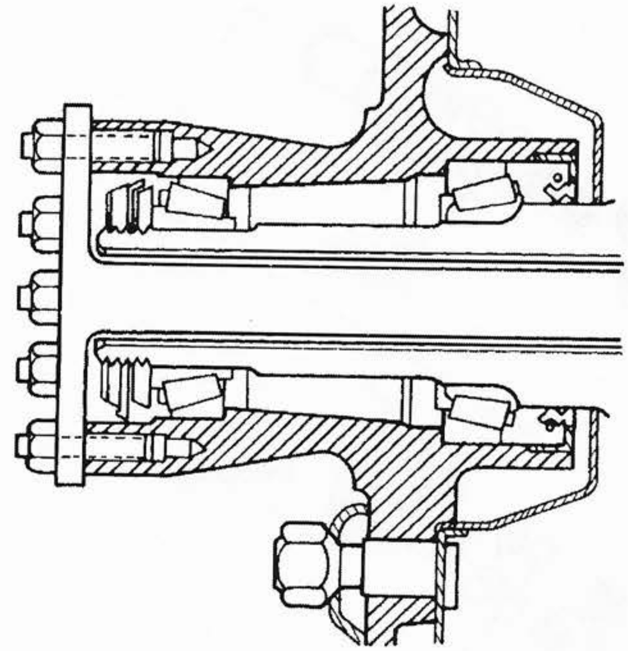


Figure 7-6 Location of wheel hub lube cavity. *(Courtesy of Roadranger Marketing. One great drive train, two great companies—Eaton and Dana Corporations)*

1. Fill the drive axle with lube to the correct level using the fill hole in either the differential carrier or banjo housing.
2. Jack up the left side of the axle, and maintain the position for 1 minute to allow oil from the differential to flow into the right wheel end.
3. Jack up the right side of the axle, and maintain the position for 1 minute to allow oil from the differential to flow into the left wheel end.
4. Lower the axle to the shop floor in a level position, and then check the lube level at the differential carrier fill hole. Add as necessary.

CAUTION *On most drive axles, there is no external visual means of checking lubricant level in the wheel end, so the importance of making sure the drive axle lubricant level is correct cannot be overemphasized. Raising each side of an axle with a jack ensures oil fills the wheel-end hub cavity. Make a final check of the differential carrier oil level after tilting the axle from both sides.*

DRIVESHAFT ASSEMBLIES

The function of the **driveshaft** is to transmit drive torque from one driveline component to another. This should be accomplished in a smooth, vibration-free manner. In a heavy duty truck, that means transmitting engine torque from the output shaft of the transmission to a rear axle or to an auxiliary transmission.

In most cases, a driveshaft is required to transfer torque at an angle to the centerlines of the driveline components it connects to. Because the rear drive axle is part of the suspension and not connected to the ridged frame rails of the truck, the driveshaft must be capable of constantly changing angles as the rear suspension reacts to road profile and load effect. In addition to being able to sustain constant changing angles, a driveshaft must also be able to change in length when transmitting torque. When the rear axle reacts to road surface changes, torque reactions, and braking force, it pivots both forward or backward, requiring a corresponding change in the length of the driveshaft.

Driveshaft Construction

The driveshaft assembly is made of a **U-joint** (universal joint), **yokes, slip splines,** and driveshafts. Driveshafts have a tubular construction designed to sustain high torque loads and be light in weight. **Figure 7-7** shows the components of a typical heavy-duty truck driveshaft. In the next section we will study the role each of these components play.

Driveshafts

To transmit engine torque from the transmission to the rear drive axles, driveshafts have to be durable and strong. If an engine produces 1,000 pound-feet of torque, when this is multiplied by a 12:1 gear ratio in the transmission, it produces 12,000 pound feet of torque at the driveshaft. The shaft has to be tough enough to deliver this twisting force to a fully loaded axle without deforming.

In a simple driveshaft, a yoke at either end connects the shaft to other driveline components. A yoke is usually welded to the shaft tube at one end. At the other end, a slip spline connects to a slip yoke or a second section of driveshaft. The function of a slip spline is to accommodate the variations in driveshaft length required to connect driveshafts between transmissions and drive axle assemblies (the suspension allows the drive axle to move up and down) assemblies. The yokes at either end of a driveshaft are connected by means of U-joints to end yokes on the output and input shafts to the transmission and drive axle(s). A detail of a driveshaft assembly highlighting the slip splines is shown in **Figure 7-8.**

A slip joint is made up of a hardened splined shaft stub welded to the end of the driveshaft tube. The male end of the slip yoke with external splines is inserted

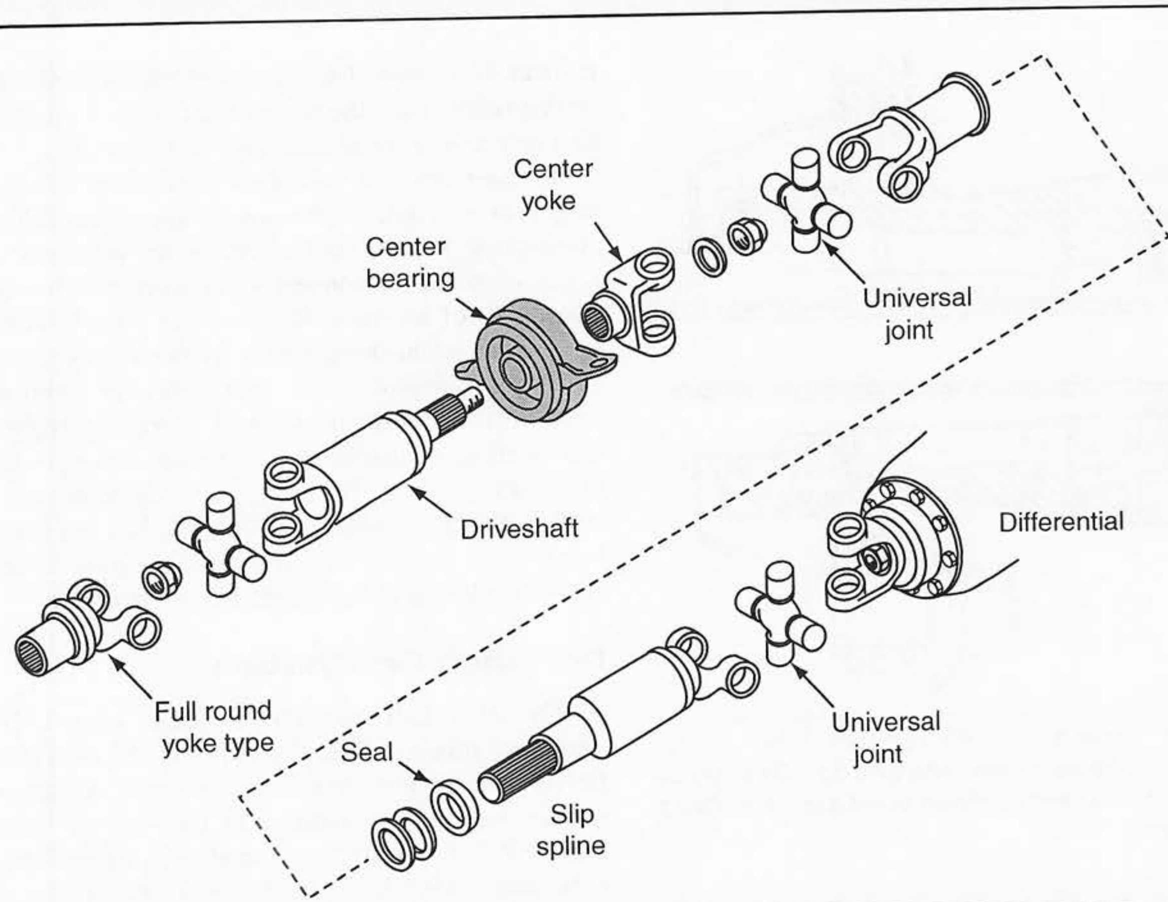


Figure 7-7 Exploded view of a heavy-duty truck driveshaft assembly. *(Courtesy of Volvo Trucks North America, Inc.)*

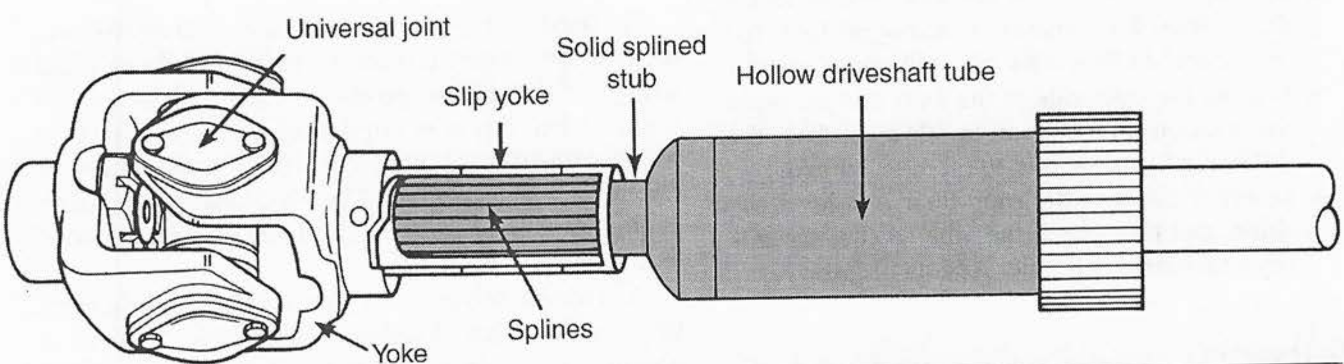


Figure 7-8 Driveshaft slip splines. *(Courtesy of Chicago Rawhide)*

into a female slip yoke with mating internal splines. The splines allow the driveshaft to change in length at the same time as it transmits full torque loads. The slip splines are lubricated with grease and, additionally, are polymer nylon coated to permit slippage while reducing wear. A threaded dust cap contains a washer and seal (usually synthetic rubber or felt) that exclude contaminants and contain the grease.

U-JOINTS

The universal joint, also known in the industry as a U-joint, is used to connect the driveline components while permitting them to operate at different and constantly changing angles. The hub of a U-joint consists of a forged journal cross, also known as a **spider.** The forged cross is machined for grease fitting and four sets of needle bearings. The ends of the U-joints are called **trunnions.** The trunnions are case-hardened ground surfaces on which the needle bearings ride. Bearing caps contain the needle bearings, and these fit tightly to yoke bores to retain the U-joint within a pair of yokes offset from each other. The needle bearings and trunnions are lubricated with chassis grease. A complete U-joint assembly with one

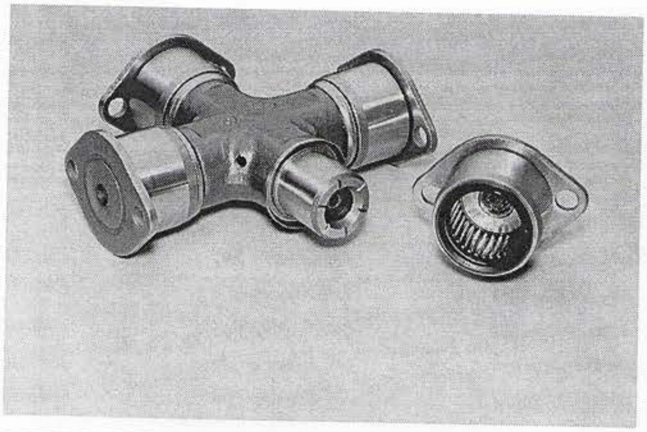


Figure 7-9 Universal joint assembly. *(Courtesy of Chicago Rawhide)*

bearing cap removed from the trunnion is shown in **Figure 7-9.**

U-JOINT GREASE FITTINGS

The U-joints of heavy duty trucks have cross-drilled grease passages and grooves on the ends of the trunnions to permit the needle bearings to be lubricated. Either one or two **zerk-type** grease fitting are used to charge grease into the U-joint.

In the center of each trunnion on some U-joints is a stand pipe (a type of check valve), which prevents reverse flow of the hot liquid lubricant generated during operation. When the U-joint is stationary, one or more of the trunnions has to be upright See **Figure 7-10**). Without the stand pipe, lubricant would flow out of the upper grease passage and trunnion, resulting in a partially dry startup that could cause wear. The stand pipe helps ensure adequate lubrication of the trunnions and needle bearings at each startup. Other U-joints have rubber check valves in each cross that perform the same function. A lubed-for-life U-joint

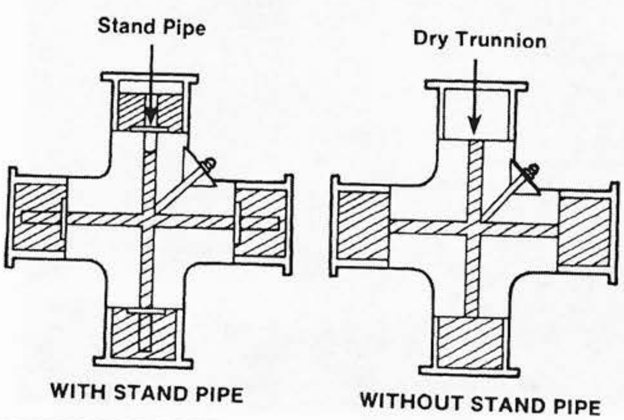


Figure 7-10 A stand pipe at the end of each trunnion ensures constant lubrication and prevents dry start-up. *(Courtesy of Chicago Rawhide)*

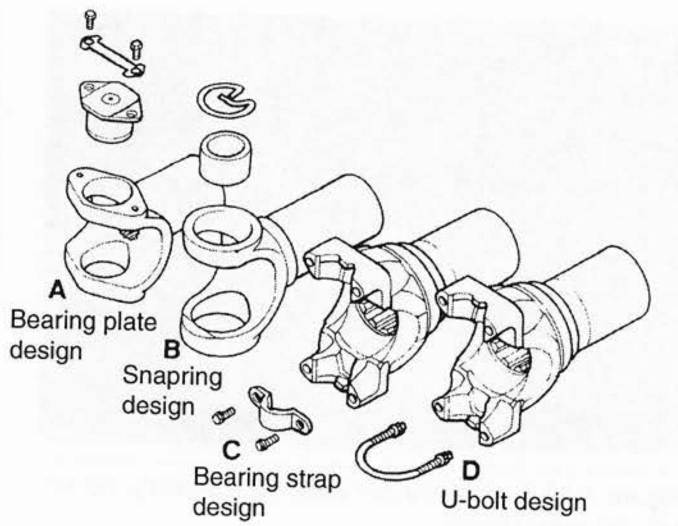


Figure 7-11 Four methods of fastening a universal joint in a yoke: (A) bearing plate; (B) snapring; (C) strap; and (D) U-bolts. *(Courtesy of Spicer Universal Joint Division/Dana Corporation)*

should not require servicing: These have an extensive service life providing the driveshafts are not frequently separated.

BEARING ASSEMBLIES

Each cross consists of four bearing assemblies, one for each trunnion race. These assemblies consist of bearings in a bearing cup and a rubber seal around the open end of the cup. Needle bearings are used because of their strength and durability and are capable of sustaining high loads that result from the oscillation action of rotating driveshafts.

MOUNTING HARDWARE

U-joints can be connected to yokes in different ways. **Figure 7-11** shows four common methods of securing U-joints to yokes. Half-round end yokes are clamped to the U-joint using bearing straps or U-bolts. Full-round end yokes use snaprings or bearing lock plates to secure the joint in the yoke bore.

CENTER SUPPORT BEARINGS

Center support bearings are used when the distance between the transmission (or auxiliary transmission) and the rear axle is too great to span with a single driveshaft. These are commonly known as **hanger bearings** (**Figure 7-12**). The center support bearing is fastenened to the frame and aligns a pair of connecting driveshafts. Hanger bearings also buffer driveline and frame vibrations by surrounding the bearings with a rubber insulator.

A center support bearing is housed in a stamped steel bracket that aligns and fastens the bearings assembly to

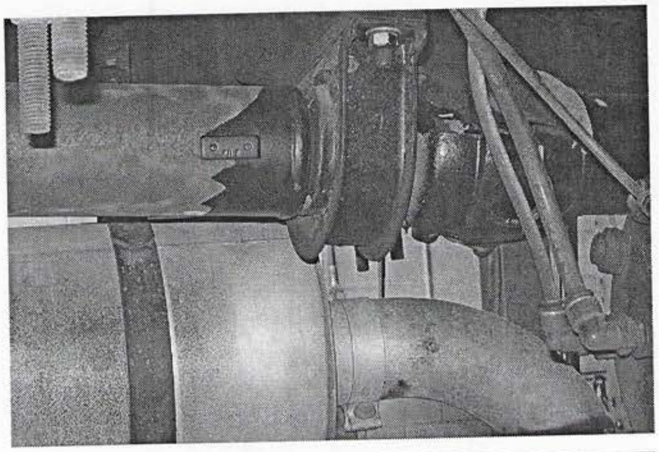


Figure 7-12 Typical hanger bearing assembly. *(Courtesy of John Dixon)*

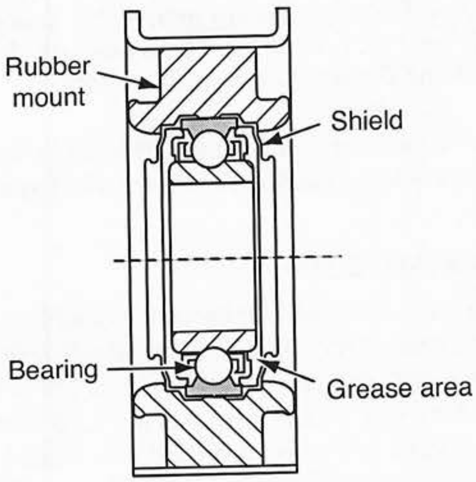


Figure 7-13 Cross-section of a typical center bearing.

the frame cross-member. The rubber insulator supports the bearings with a small margin of forgiveness. Most hanger bearings are sealed. A center support bearing is usually required on driveshafts that exceed 70 inches (178 cm) in length. **Figure 7-13** illustrates a cross-section of a typical center support bearing.

DRIVESHAFT INSPECTION

Whenever a truck is moving, its driveshafts are working. Driveshafts should be routinely inspected and lubricated. Driveline vibration, U-joint failures, and hanger bearing problems are caused by such things as loose end yokes, excessive radial play (side to side), slip spline play, bent driveshaft tubes, and missing lube plugs in slip joint assemblies. A simple inspection during PM lubricating schedules can prevent many of the previously mentioned problems from starting or becoming worse:

Figure 7-14 Check the driveshaft yokes for excessive radial play. *(Courtesy of Chicago Rawhide)*

1. Check the yokes on both the transmission and drive axle(s), for looseness as shown in **Figure 7-14.** If loose, disconnect the driveshaft and retorque the end yoke retaining nut to the OEM specification. If this does not correct the problem, yoke replacement may be necessary. If you do have to replace a yoke, check for the OEM recommendation regarding replacement frequency of the end yoke retaining nut.
2. If the end yokes are tight, check for excessive radial looseness of the transmission output shaft and drive axle input and output shafts in their respective bearings, as shown in **Figure 7-15.** Consult transmission and axle OEM specifications for acceptable radial looseness limits and method of checking. If the radial play exceeds the specifications, the bearings should be replaced.

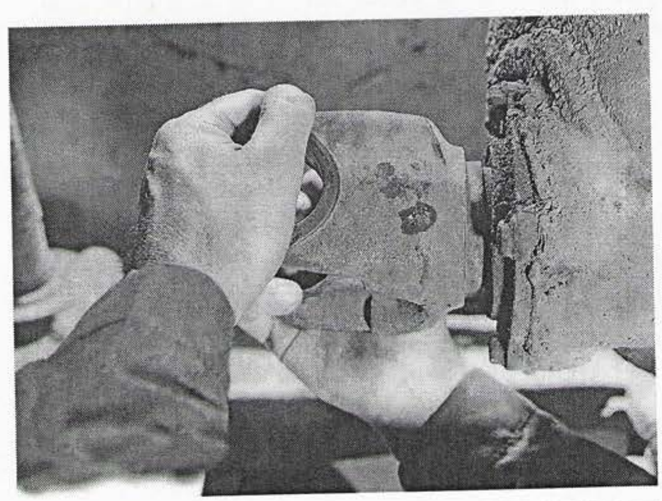


Figure 7-15 Check the transmission output yoke and the rear axle input yoke for excessive radial play. *(Courtesy of Chicago Rawhide)*

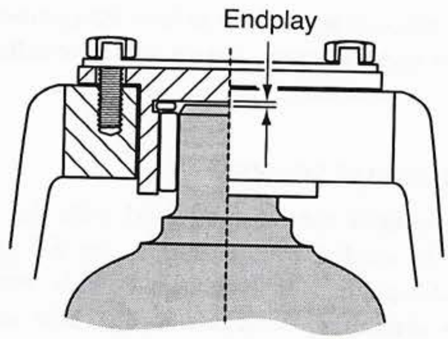


Figure 7-16 Check for excessive play in the U-joint bearings.

3. Check for looseness across the U-joint bearing caps and trunnions (See **Figure 7-16**). This looseness should not exceed the OEM specification, typically as little as 0.006 inch (0.152 mm).
4. Check the slip splines for radial movement. Radial looseness between the slip yokes and the driveshaft stub should not exceed the OEM specification, typically as little as 0.007 inch (0.178 mm).
5. Inspect the driveshaft for damage, bent tubing **(see Figure 7-17)** for missing balance weights. Ensure there is no buildup of foreign material on the driveshaft, such as asphalt or concrete. Anything adhering to the driveshaft has the potential to unbalance it, causing vibration.
6. Check the hanger bearing visually; make sure it is mounted securely. Check for leaking lubricant from the bearing, damaged seals, or rubber insulator failure. Replace the hanger bearing if there is evidence of damage. Do not attempt to repair or lubricate it.

Lubrication

One of the most common causes of U-joint and slip joint problems is the lack of proper lubrication. If U-joints are properly lubricated at the recommended intervals, they will actually last longer than the manufacturer's intended life span. Regular lubricating ensures that the bearings have adequate grease and, additionally, that the trunnion races are flushed, which removes contaminants from the critical surface contact areas.

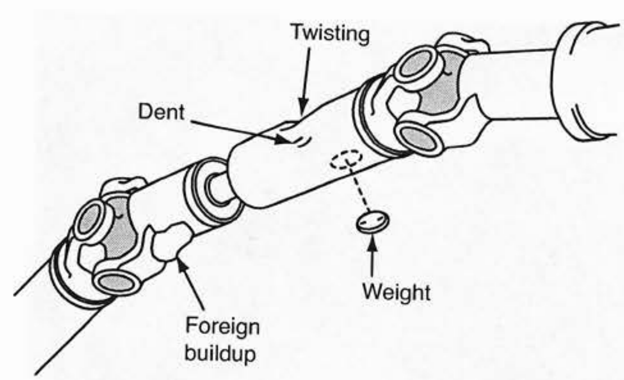


Figure 7-17 Points to inspect when checking a driveshaft for twisting, dents, missing weights, and buildup of foreign material.

It is important to remove the accumulated dirt from the zerk fitting before greasing to prevent abrasive material from being forced through the nipple into the bearing during lubrication.

Heavy-duty driveshafts typically use a lithium soap-based, extreme pressure (EP) grease meeting National Lubricating Grease Institute (NLGI) classification grades 1 or 2 specifications. Grades 3 and 4 are not recommended because of their greater thickness, meaning that they function less effectively when cold. Most lubed-for-life bearings use synthetic greases.

Lubrication cycles vary depending on the service requirements and operating conditions of the vehicle. A typical recommended lube cycle for U-joints is shown in **Table 7-2.**

On-highway operation is generally defined as an application that operates the vehicle running less than 10 percent of total operating time on gravel, dirt, or unimproved roads. Vehicles running more than 10 percent operation time on poor road surfaces are classified as off-highway in terms of preventive maintenance.

TABLE 7-2: RECOMMENDED LUBE CYCLE FOR U JOINTS

Type of Service	Miles/Kms	Or Time
City	5,000–8,000 / 8,000–13,000	3 months
On highway	10,000–15,000 / 16,000–24,000	1 month
On/off highway	5,000–8,000 / 8,000–13,000	3 months
Extended (linehaul)	50,000 / 80,000	3 months
Severe usage off highway (4x4)	2,000–3,000 / 3,000–5000	1 month

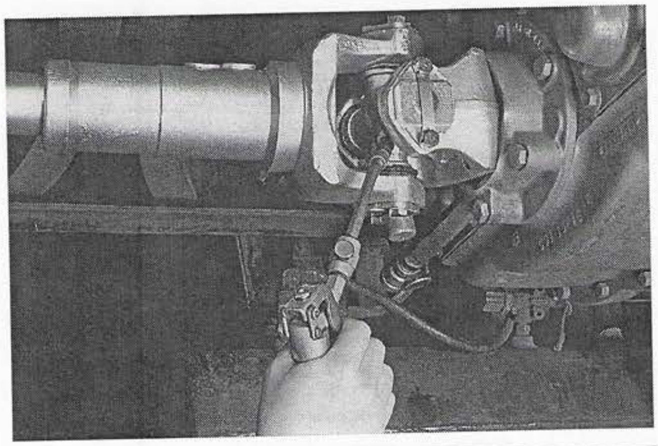


Figure 7-18 Apply grease until grease exits the trunnion seals. *(Courtesy of Dana Corporation)*

LUBRICATING A U-JOINT

Adhere to the following procedure when lubricating U-joints:

1. Apply chassis grease through either one of the two zerk fittings on the U-joint cross. Wipe dirt and contaminants off the grease fitting with a clean shop rag. Fit the grease nozzle over the zerk nipple as shown in **Figure 7-18.** Pump grease slowly into the zerk fitting until each of the four trunnion seals pops. Allow a small quantity of the old grease to be forced out of the bearings. This flushes contaminants out of the bearings and helps ensure that all four have taken grease. The U-joint is properly greased when evidence of purged grease is seen at all four bearing trunnion seals.
2. If grease does not exit from a U-joint trunnion seal, try forcing the driveshaft from side to side when applying gun pressure. This allows greater clearance on the thrust end of the bearing assembly that is not purging. If the U-joint has two grease fittings, try greasing from the opposite fitting. If this does not work, proceed to the next step.
3. Back off the bearing cap bolts on the trunnion that is not taking grease and pop the cap out about 1/8 inch (3 mm). Apply grease. This usually will cure the problem, but if it does not, you should remove the U-joint to investigate the cause.
4. After working on a U-joint that fails to take grease, make sure you torque the bearing cap bolts to OEM specification.

Shop Talk: Half-round end yoke self-locking retaining bolts should not be reused more than five times. If in doubt as to how many times bolts have been removed, replace with new bolts.

LUBRICATING SLIP SPLINES

The slip splines can be lubricated with the same grease that is used on the U-joints. An EP grease meeting NLGI grade 1 or 2 specifications is required. Slip splines should be lubricated in the same service schedule as the U-joints at the intervals outlined in **Table 7-2.**

Use the following procedure:

1. Wipe dirt and contaminants off the grease fitting with a clean shop rag. Apply grease to the zerk fitting until lubricant appears at the relief hole at the slip yoke end of the slip spline assembly.
2. Seal the pressure relief hole with a finger and continue to apply grease until it starts to exit at the slip yoke seal, as shown in **Figure 7-19.** Sometimes it is possible to purge the slip yoke by removing the dust cap and reinstalling it after grease appears.

CAUTION *In cold temperatures, you should drive the vehicle immediately after lubricating drive shafts. This activates the slip spline assembly and removes excessive lubricant. Excess lubricant in slip splines can freeze in cold weather to a wax consistency and force the breather plug out. This would expose the slip joint to contaminants and eventually result in wear and seizure.*

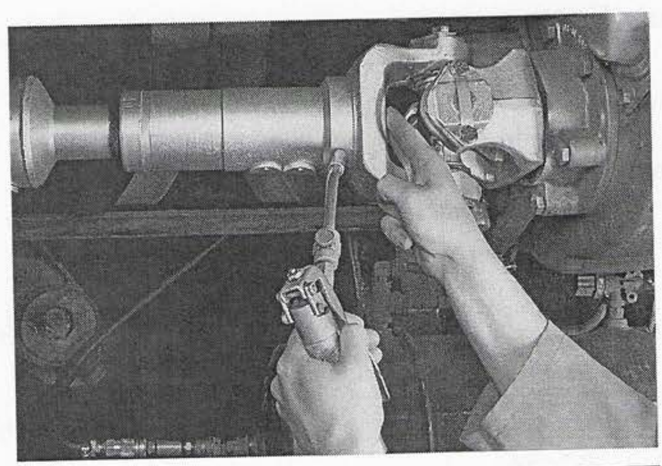


Figure 7-19 Apply grease to the slip joint until grease begins to exit the relief hole. Then cover the hole and continue to apply lubricant until grease begins to ooze out around the seal. *(Courtesy of Dana Corporation)*

LUBRICATING HANGER BEARINGS

Hanger bearings are usually lubricated for life by the manufacturer and are not serviceable. However, when replacing a support bearing assembly, fill the entire cavity around the bearing with chassis grease to shield the bearings from water, salt, and other contaminants.

You should put in enough grease to fill the cavity to the edge of the slinger surrounding the bearing.

When replacing a hanger bearing, make sure you look for and do not lose track of the shim pack that is usually located between the bearing mount and cross-member. The shims set the driveshaft angles, and omitting them will result in a driveline vibration.

STANDARD TRANSMISSION SERVICE

Proper lubrication is one of the keys to a good preventive maintenance program. Maintaining the correct transmission oil level and OEM-recommended type are both critical to ensuring the transmission performs for its expected service life.

Recommended Lubricants

Only the lubricants that the manufacturer recommends should be used in the transmission. Most transmission manufacturers today prefer synthetic lubricants formulated for use in transmissions; they also suggest a specific grade and type of transmission oil. In the past, heavy-duty engine oils and straight mineral oils tended to be more commonly used in truck transmissions. But the demand for extended service intervals has driven the industry to use synthetic oil almost exclusively.

Today Eaton recommends E-500 lubricant for its transmissions. E-500 lube is designed to run 500,000 linehaul miles with no initial drain interval required. E-250 lubricant is rated for 250,000 linehaul miles before a change is required. Most synthetic transmission lubricants exceed the stated viscosity grade ratings, so they can be expected to perform effectively through various geographic and seasonal temperature conditions.

Although most transmission manufacturers recommend the use of synthetic lubes in their transmissions, mineral oil gear lubes are still available and used by some operators. These mineral-based lubricants are slightly cheaper than synthetic lubricants to purchase, but because their projected service life is a fraction of synthetic lubricants, it really doesn't make sense to use them. The service requirements of both mineral-based and synthetic lubricants are covered here.

Mineral-Based Lubes

Most manufacturers will recommend an early initial oil change after the transmission is placed in service. Usually the first oil change will be made between 3,000 and 5,000 miles in linehaul service. In off-highway use, the first transmission oil change should be made after 24 and before 100 hours of service. Although transmission oil is never required to be changed as frequently as engine oil, this first oil change is important because it will flush out any cutting debris created by virgin gears meshing.

There are a number of factors that affect the service interval of mineral-based transmission oil change periods. A key factor is the application: Linehaul operation tends to be gentle to transmission oil, while operating on a construction site can reduce performance life. Manufacturer suggestions for mineral-based transmission oil change intervals vary between 50,000 and 100,000 miles for linehaul applications. Off-highway operation usually requires oil change intervals ranging from 1,000 hours to a maximum of 2,000 hours of service.

Synthetic Lubes

The fact that transmission manufacturers almost exclusively recommend the use of synthetic gear lubes really makes mineral-based lubes obsolete. As previously stated, Eaton recommends E-500 lube for its transmissions, with no initial drain interval. Modern production machining accuracy has all but eliminated the tendency of a gearset to produce break-in cuttings when new. As a result, the initial drain interval, once considered so important to maximize transmission service life, can be eliminated.

It is important that synthetic lubricants not be mixed with mineral-based lubes in transmissions. Although mixing of dissimilar lubricants may not produce an immediate failure, the service of the lube can be greatly reduced. Mixing dissimilar lubricants can sometimes thicken oil and produce foaming.

CAUTION *Do not add transmission lubricant without first checking what lubricant the transmission is using. Mineral-based gear oils, mineral-based engine oils, and synthetic gear lubes are all approved for use in transmissions and none of them is particularly compatible. Mixing transmission oils causes accelerated lube breakdown, resulting in lubrication failures.*

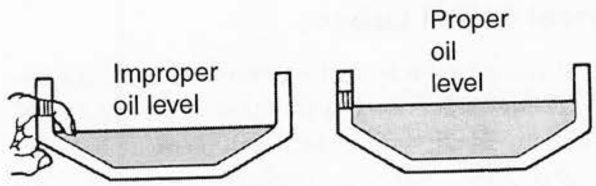


Figure 7-20 The oil level must be level with the bottom of the plug hole. *(Courtesy of Roadranger Marketing. One great drive train, two great companies—Eaton and Dana Corporations.)*

Checking Oil Level

The transmission oil level should be routinely checked at each A-type service, typically at intervals of 5,000 or 10,000 highway miles. When adding oil to transmissions, care should be taken to avoid mixing brands, weights, and types of oil. When you top up or fill the transmission oil level, it should be exactly even with the filler plug opening, as shown in **Figure 7-20.** Overfilling can cause oil aeration, and underfilling results in oil starvation to critical components.

Draining Oil

Drain the transmission oil while it is still warm. Remember that it can be hot enough to severely burn your hand. To drain the oil, remove the drain plug at the bottom of the housing. Allow it to drain for at least 10 minutes after removing the plug. Check the drain plug for cuttings and thoroughly clean it before reinstalling.

Refill

Clean away any dirt or contaminants around the filler plug, then remove the plug from the die of the transmission and refill with the appropriate grade of the new oil. Fill until the oil just begins to spill from the filler plug opening. If the transmission housing has two filler plugs, fill both until oil is level with each filler plug hole.

CAUTION *Do not overfill the transmission. Overfilling usually results in oil breakdown due to aeration caused by the churning action of the gears. Premature breakdown of the oil will result in varnish and sludge deposits that plug up oil ports and build up on splines and bearings.*

PM INSPECTIONS

A good PM program can help avoid failures, minimize vehicle downtime, and reduce the cost of repairs. Often, transmission failure can be traced directly or indirectly to poor maintenance. **Figure 7-21** identifies key areas of a transmission that should be routinely checked.

Daily Maintenance

Some of the practices listed here are part of the driver's pre-trip inspection.

- **Air tanks:** Drain air tanks to remove water or oil. To be sure of removing all liquid contaminants from an air tank, the drain cock must be fully opened and all air discharged. Most of the liquid will drain from the tank after the air has been removed.
- **Oil leaks:** Visually check for oil leaks around bearing covers, PTO covers, and other machined surfaces. Check for oil leakage on the ground before starting the truck each morning.
- **Shifting performance:** Report any shifting performance problems such as hard shift or jumping out of gear.

"A" Inspection

The following should be checked at each A or lube inspection, approximately every 10,000 miles:

- **Fluid level:** Remove filler plug(s) and check lubricant lever. Top off if necessary and tighten plugs securely.
- **Fasteners and gaskets:** Use a wrench to check to torque on bolts and plugs, paying special attention to those on PTO covers/flanges and the rear bearing cover assembly. Look for oil leakage at all gasket-mating surfaces.
- **Output yoke seal:** Check for leaks around the seal, especially if the transmission has recently been serviced or rebuilt.

"B" Inspection

Numbers refer to **Figure 7-21.**

- **Air control system:** (1) Check for leaks, worn hoses and air lines, loose connections, and loose fasteners.
- **Bell/clutch housing mounting flange:** (2) Check fastener torque.
- **Clutch shaft yoke bushings:** (4) If the clutch shaft bushings are equipped with zerk fittings, grease them lightly. Pry upward on the shaft to remove the clutch release mechanism and check for worn bushings.
- **COE (cab over engine) remote shift linkage:** Check the linkage U-joints for wear and

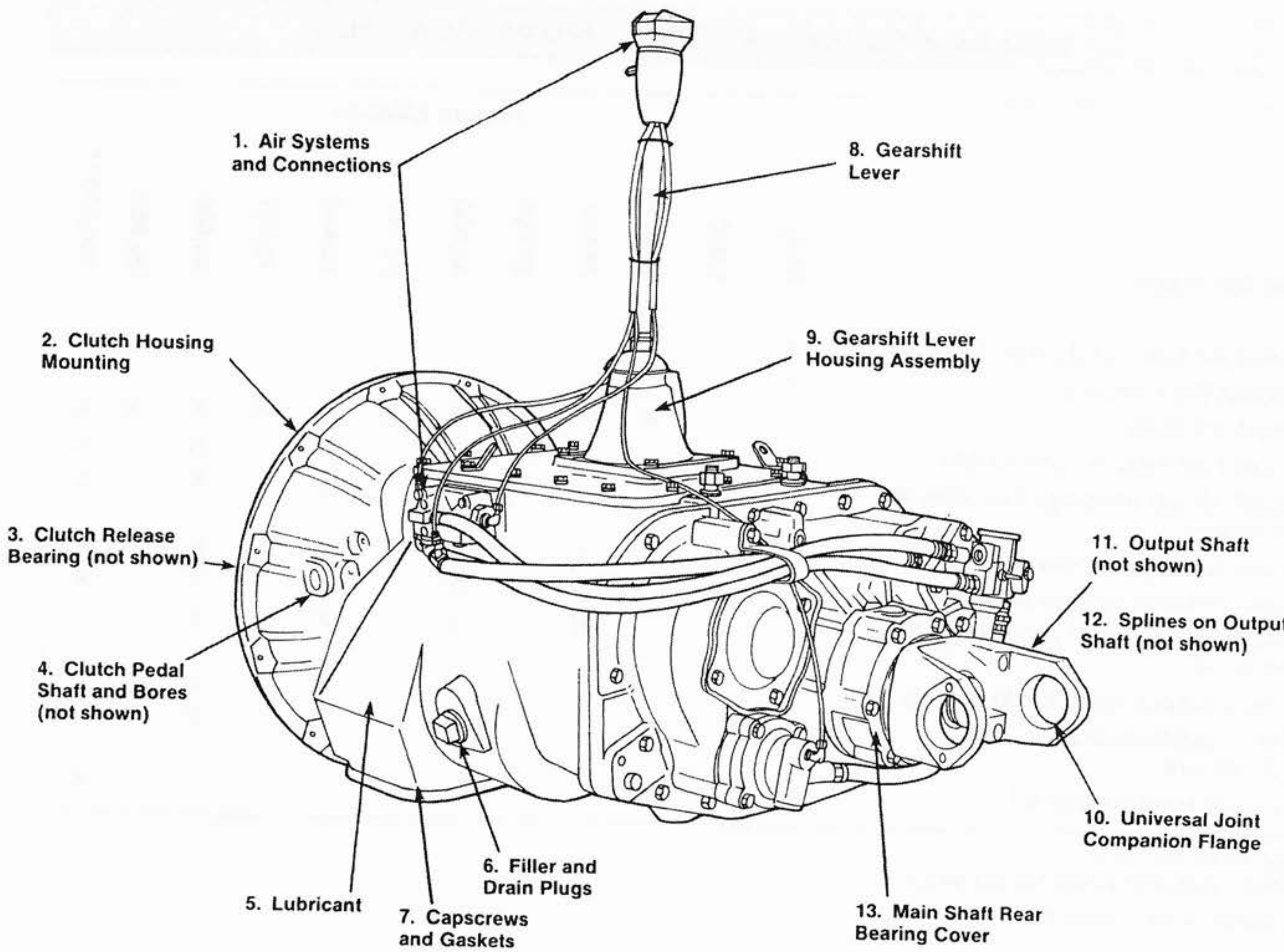


Figure 7-21 Inspection points on a standard transmission. *(Courtesy of Roadranger Marketing. One great drive train, two great companies—Eaton and Dana Corporations.)*

binding. Lubricate the U-joints. Check any bushings in the linkage for wear.

- **Air filter:** Check and clean or replace the air filter element.
- **Transmission output yoke:** (10) Uncouple the U-joint and check the flange nut for proper torque. Tighten if necessary.
- **Output shaft assembly:** (11) Pry upward on the output shaft to check radial play in the mainshaft rear bearing. Check the splines on the output shaft (12) for wear from movement and chucking action of the U-joint yokes.

"C" Inspection

- **Check lubricant change interval:** This means checking the type of lubricant used in the transmission. Remember that many synthetic lubes are performance rated for oil change intervals up to 500,000 linehaul miles, so it is wasteful to change them more frequently. If an oil change is required, drain and refill the transmission with the specified oil. Transmission oil analysis can be used to establish more precise oil change intervals that are better suited to the actual operating condition of the truck.
- **Gearshift lever:** (8) Check for bending and free play in the tower housing. A lever that is excessively loose indicates wear.
- **Shift tower assembly:** (9) Remove the air lines at the slave valves and remove the shift tower from the transmission. Check the tension spring and washer for wear and loss of tension. Check the gearshift lever spade pin/shift finger for wear. Also take a look at the yokes and blocks in the shift bar housing, checking for wear at all critical points.

Preventive maintenance practices vary by manufacturer and by fleets, many of which have tailored PM to exactly suit their needs. **Table 7-3** outlines a preventive maintenance schedule recommended by Eaton Roadranger, but you should note that this assumes the use of mineral-based oil.

TABLE 7-3: PREVENTIVE MAINTENANCE RECOMMENDATIONS**

	Vehicle Mileage											
PM Operation	**Daily**	**5,000**	**10,000**	**20,000**	**30,000**	**40,000**	**50,000**	**60,000**	**70,000**	**80,000**	**90,000**	**100,000****
Bleed air tanks and listen for leaks	X											
Inspect for oil leaks	X											
Check oil level			X	X	X	X	X	X	X	X	X	X
Inspect air system connections				X		X		X		X		X
Check clutch housing capscrews for looseness				X		X		X		X		X
Lube clutch pedal shafts				X		X		X		X		X
Check remote control linkage				X		X		X		X		X
Check and clean or replace air filter element				X		X		X		X		X
Check output shaft for looseness				X		X		X		X		X
Check clutch operation and adjustment						X				X		
Change transmission oil		X*					X					X

*Initial fill on new units.
**REPEAT SCHEDULE AFTER 100,000 MILES.
Courtesy of Eaton Corporation

CLUTCH

The function of a **clutch** is to transfer torque from the engine flywheel to the transmission. At the moment of clutch engagement, the transmission input shaft may either be stationary, as when the truck is stationary, or rotating at a different speed than the flywheel, as in the case of upshifting or downshifting. At the moment the clutch fully engages, however, the flywheel and the transmission input shaft must rotate at the same speed.

Torque transmission through a clutch is accomplished by bringing a rotating drive member connected to the engine flywheel into contact with one or more driven members splined to the transmission input shaft. Contact between the driving and driven members is established and maintained by both spring pressure and friction surfaces. Pressure exerted by springs on the driven members is unloaded by the driver by depressing the clutch pedal: This "releases" the clutch.

A clutch is equipped with one or two discs that have friction surfaces known as facing (See **Figure 7-22**). When the operator pushes down on the clutch pedal, the pressure plate is moved away from the flywheel, compressing the springs and freeing the friction disc(s) from contact with the flywheel friction surface. The

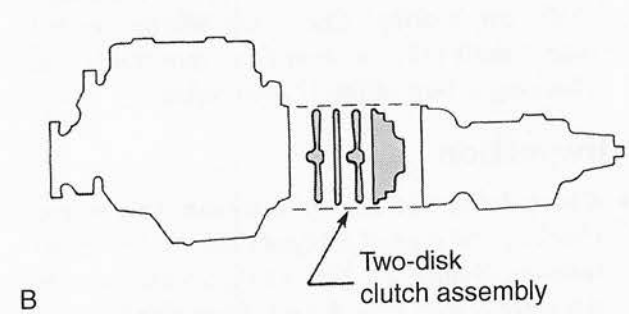


Figure 7-22 Different clutch styles. Example A uses one friction disc while example B uses two friction discs to couple the engine to the transmission. *(Courtesy of Eaton Corp.—Eaton Clutch Div.)*

clutch is now disengaged, and torque transfer from the engine to the transmission is interrupted.

When the clutch pedal is released by the driver, the pressure plate moves toward the flywheel, allowing the springs to clamp the disc(s) between the flywheel and the pressure plate. The discs are designed for moderate slippage as they come into contact with the rotating flywheel. This minimizes the torsional or twisting shock from being transmitted through to driveline components. As clutch clamping pressure increases, the discs accept the full torque from the flywheel. At this point engagement is complete, and engine torque is transferred to the transmission. Once engaged, a properly functioning clutch transmits engine torque to the transmission without slippage.

Clutch Adjustment Mechanisms

As the friction facings wear, there must be a means of compensating for the loss of friction material. There are two styles of clutch adjustment mechanism: manually adjusted and self-adjusting clutches.

MANUALLY ADJUSTED CLUTCHES

These clutches have a manual adjusting ring that permits the clutch to be adjusted to compensate for friction facing wear. The ring is positioned behind the pressure plate and is threaded into the clutch cover. A **lockstrap** or lock plate secures the ring so that it cannot turn during normal operation. When the lockstrap is removed, the adjusting ring can be rotated in the cover to adjust for wear. This forces the pivot points of the levers to advance, pushing the pressure plate forward and compensating for the wear. A manual adjusting ring is shown in **Figure 7-23.**

SELF-ADJUSTING CLUTCHES

Self-adjusting clutches automatically take up the slack between the pressure plate and clutch disc as wear occurs. The adjusting ring has teeth that mesh with a worm gear in a **wear compensator** (See **Figure 7-24**). The wear compensator is mounted in the clutch cover and has an actuator arm that fits into a hole in the release sleeve retainer (See **Figure 7-25**.) As the retainer moves forward each time the clutch is engaged, the actuator

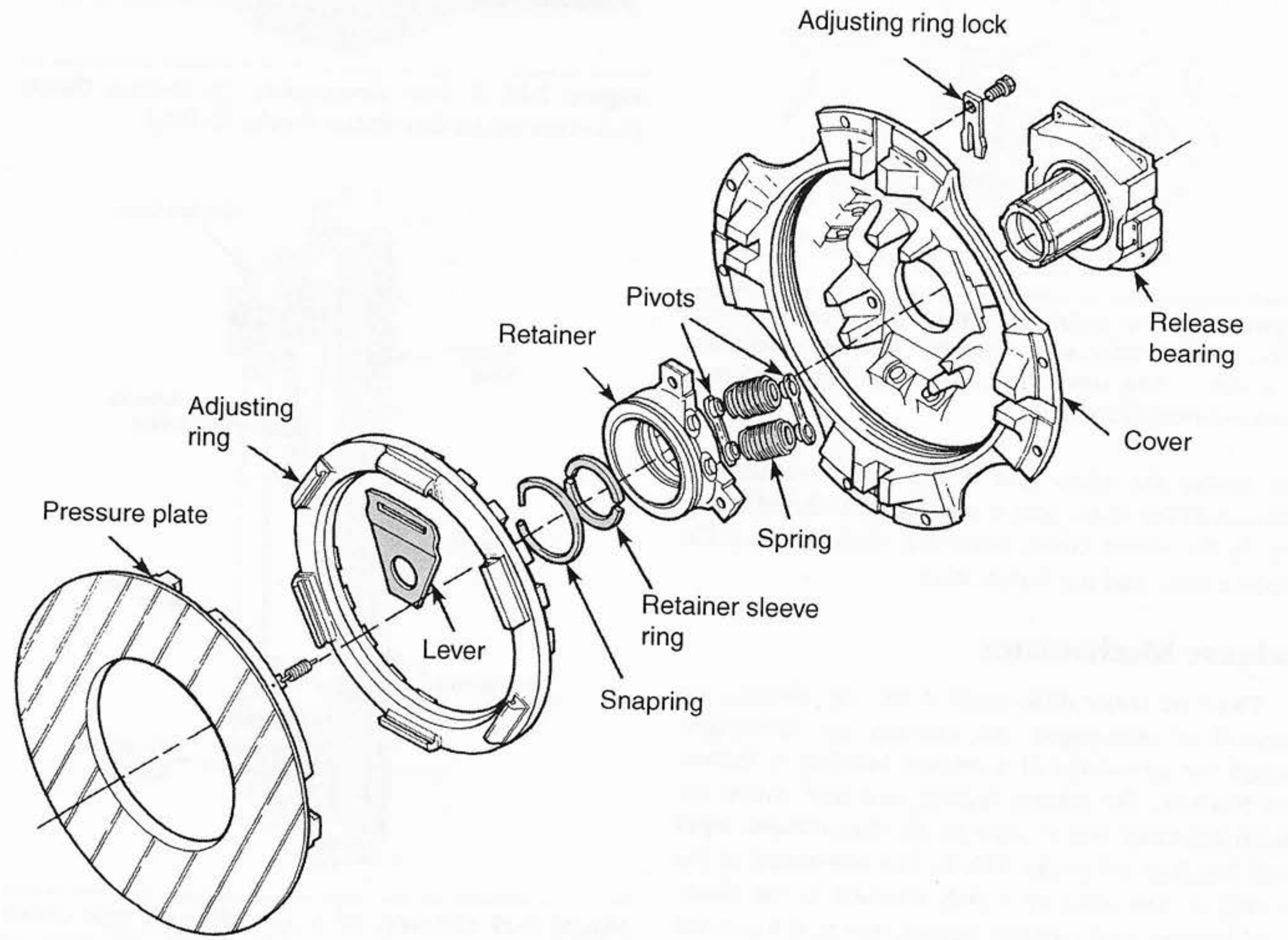


Figure 7-23 Exploded view of an angle-spring clutch assembly. The outside of the adjusting ring is threaded and turns in the clutch cover plate to adjust the clutch. *(Courtesy of Eaton Corp.—Eaton Clutch Div.)*

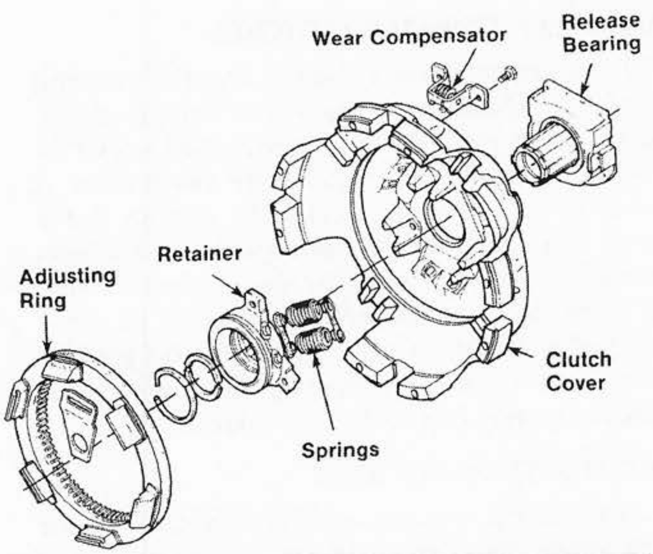


Figure 7-24 Exploded view of the now-obsolete self-adjusting, angle-spring clutch cover assembly. This type of clutch was commonly used into the 1990s. *(Courtesy of Eaton Corp.—Eaton Clutch Div.)*

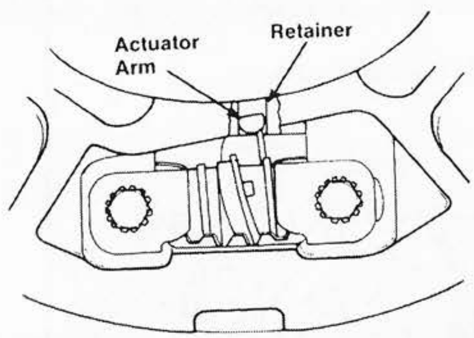


Figure 7-25 The actuator arm of the wear compensator, used in older, self-adjusting clutches, is installed in a slot in the sleeve retainer. *(Courtesy of Eaton Corp.—Eaton Clutch Div.)*

arm rotates the worm gear in the wear compensator. Rotation of the worm gear is transferred to the adjusting ring in the clutch cover, removing slack between the pressure plate and the driven discs.

Release Mechanisms

There are major differences in the way clutches are released or disengaged. All clutches are disengaged though the movement of a **release bearing** or **throw-out bearing.** The release bearing is a unit within the clutch assembly that mounts on the transmission input shaft but does not rotate with it. The movement of the bearing is controlled by a fork attached to the clutch pedal linkage. As the release bearing moves, it forces the pressure plate away from the clutch disc. Depending on the design of the clutch, the release bearing will move in one of two directions when the clutch disengages. It will either be pushed toward the engine and flywheel, or it will be pulled toward the transmission input shaft.

PUSH-TYPE CLUTCHES

In a **push-type clutch** (see **Figure 7-26** and **Figure 7-27**) the release bearing is not attached to the clutch cover. To disengage the clutch, the release bearing is

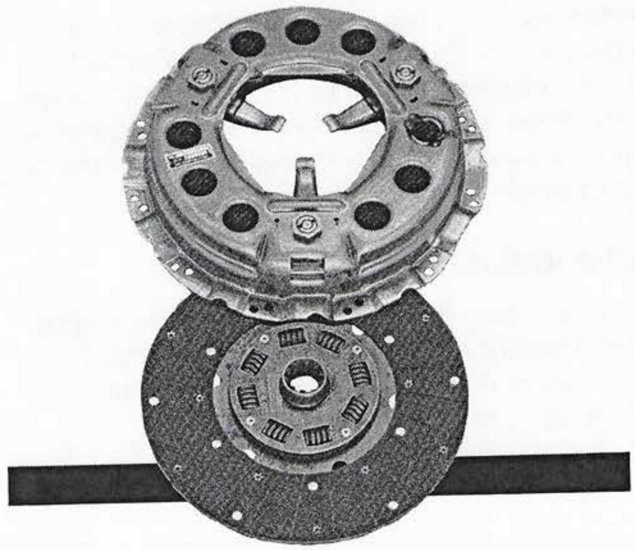


Figure 7-26 A Lipe single-plate, push-type clutch. *(Courtesy of Haldex Brake Products, Inc.)*

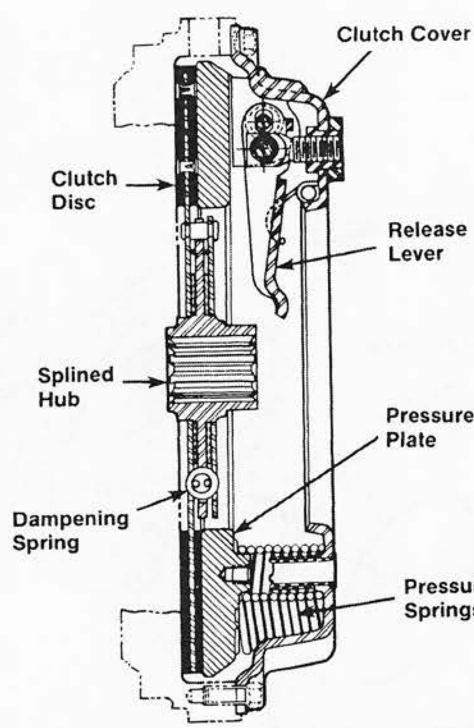


Figure 7-27 Cutaway of a 14-inch push-type clutch assembly on a pot (recessed) flywheel. *(Courtesy of Haldex Brake Products, Inc.)*

pushed toward the engine. When the pedal of a push-type clutch is depressed, there is some free pedal movement between the fork and the release bearing (normally about 1/8 inch). After the initial movement, the clutch release fork contacts the bearing and forces it toward the engine.

As the release bearing moves toward the engine. It acts on release levers bolted to the clutch cover assembly. As the release levers pivot on a pivot point, they force the pressure plate (to which the opposite ends of the levers are attached) to move away from the clutch discs. This compresses the springs and disengages the discs from the flywheel, allowing the disc (or discs) to float freely between the pressure plate and flywheel, breaking the torque between the engine and transmission.

When the clutch pedal is released, spring pressure acting on the pressure plate forces the plate forward once again, clamping the plate, disc, and flywheel together and allowing the release bearing to return to its original position.

Push-type clutches are used predominantly in light- and medium-duty truck applications in which a clutch brake is not required. This type of clutch has no provision for internal adjustment. All adjustments are normally made externally via the linkage system.

PULL-TYPE CLUTCHES

On the **pull-type clutch,** the release bearing is pulled away from the engine toward the transmission. In clutches with angle coil springs or a diaphragm spring, the release bearing is attached to the clutch cover by a sleeve and retainer assembly (see **Figure 7-28** and **Figure 7-29**). When the clutch pedal is depressed, the bearing, sleeve, and retainer are pulled away from the flywheel. This compresses the springs and causes the pivot points on the levers to move away from the pressure plate, relieving pressure acting on the pressure plate. This action allows the driven disc or discs to float freely between the plate(s) and the flywheel. On pull-type clutches with coil springs positioned perpendicular to the pressure plate (see **Figure 7-30**), the release levers are connected on one end to the sleeve and retainer; on the other end they are connected to pivot points (see **Figure 7-31**). The pressure plate is connected to the levers near the pivot points. So, when the levers are pulled away from the flywheel, the pressure plate

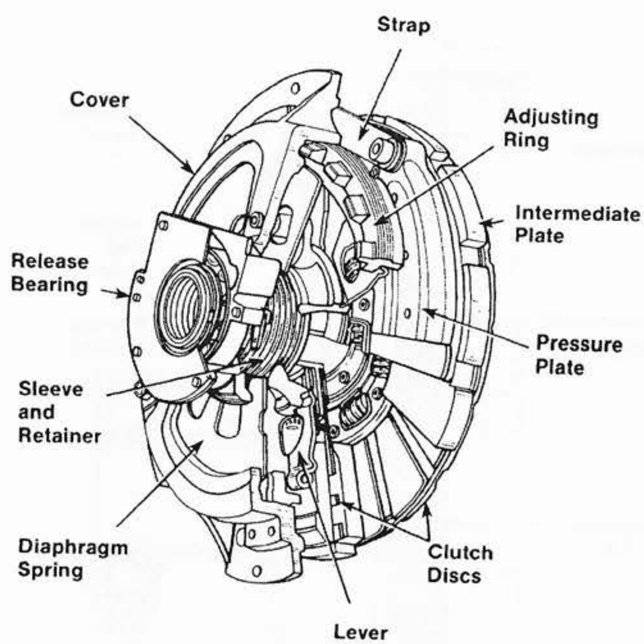
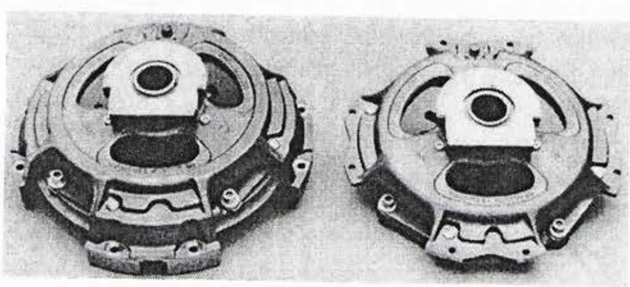


Figure 7-29 Components of a pull-type clutch. *(Courtesy of Arvin Meritor)*



A B

Figure 7-28 Pull-type diaphragm spring clutches; (A) 15 1/2 inch; and (B)14 inch. *(Courtesy of Arvin Meritor)*

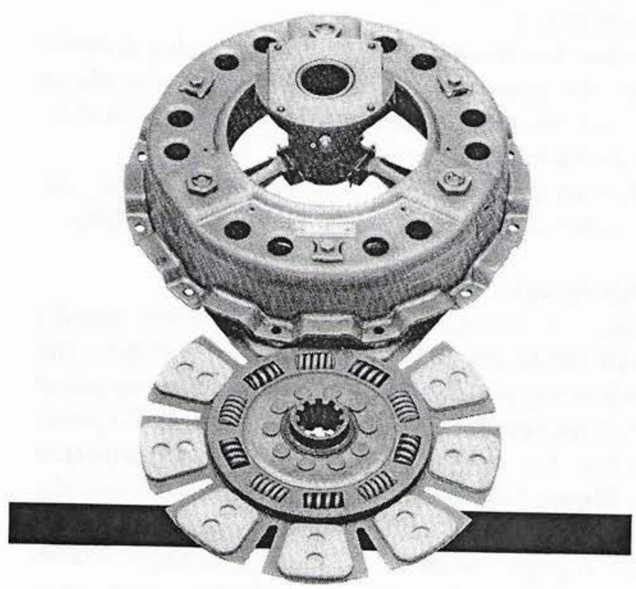


Figure 7-30 A single-plate, pull-type clutch. *(Courtesy of Haldex Brake Products, Inc.)*

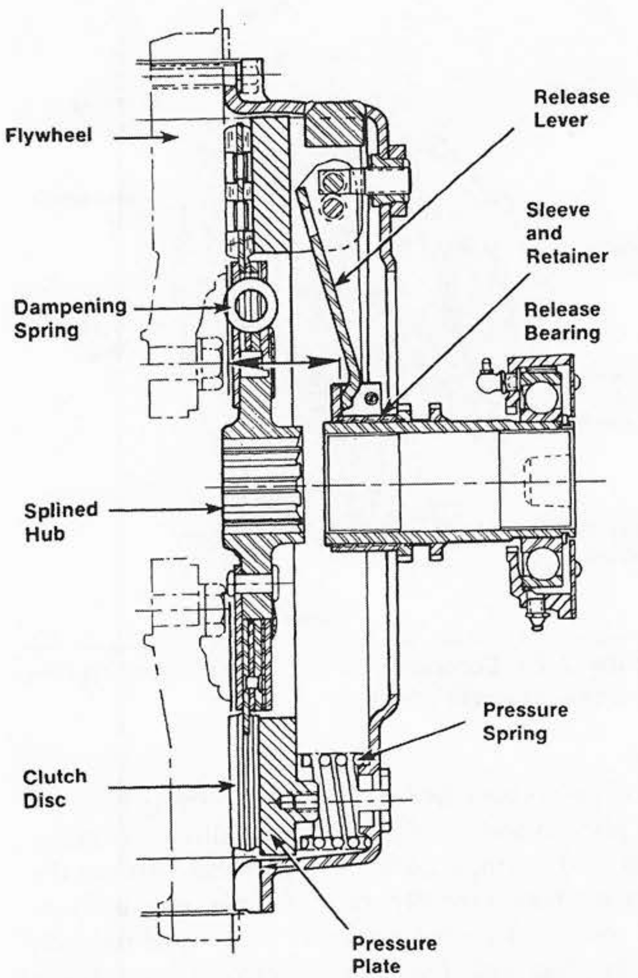


Figure 7-31 Cutaway of a Lipe single-plate, pull-type clutch. *(Courtesy of Haldex Brake Products, Inc.)*

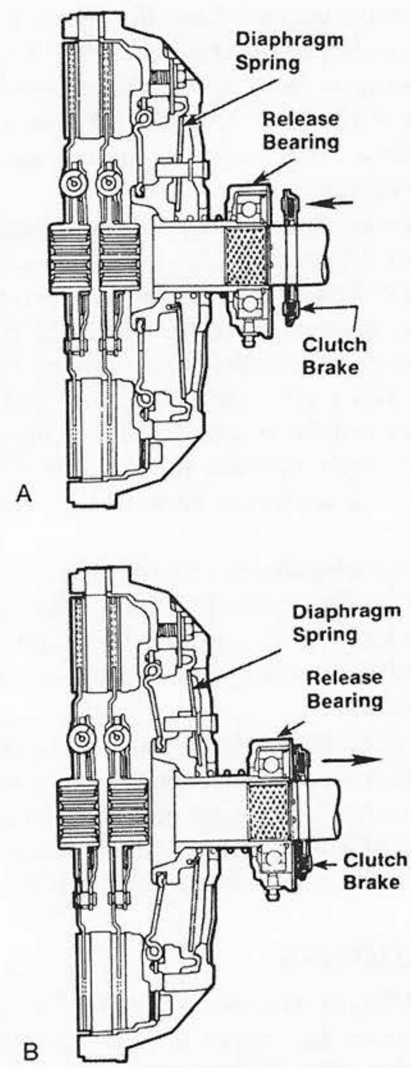


Figure 7-32 Clutch brake: (A) clutch engaged, brake neutral; and (B) clutch disengaged, clutch brake engaged. *(Courtesy of Arvin Meritor)*

is also pulled away from the clutch discs, disengaging the clutch.

When the clutch pedal is released, spring pressure forces the pressure plate forward against the clutch disc, and the release bearing, sleeve, and retainer return to their original position.

Pull-type clutches are used in both medium- and heavy-duty applications and are adjusted internally.

Clutch Brakes

Most pull-type clutches use a component called a **clutch break** not found on push-type clutches. The clutch brake is a disc with friction surfaces on either side. It moves on the transmission input shaft splines between the release bearing and the transmission (see **Figure 7-32A**). Its purpose is to slow or stop the transmission input shaft from rotating to allow gears to be engaged without clashing (grinding). Clutch brakes are used only on vehicles with non-synchronized transmissions.

Only 70 to 80 percent of clutch pedal travel is needed to fully disengage the clutch. The last 1/2 to 1 inch of pedal is used to engage the clutch brake. When the pedal is fully depressed, the fork squeezes the release bearing against the clutch brake, which forces the brake disc against the transmission input shaft bearing retainer (see **Figure 7-32B**). The friction created by the clutch brake facing stops the rotation of the input shaft and countershaft. This allows the transmission gears to mesh without clashing.

Clutch Linkage

Clutches on heavy-duty trucks are usually controlled by a mechanical linkage between the clutch pedal and the release bearing. Some trucks have hydraulic clutch

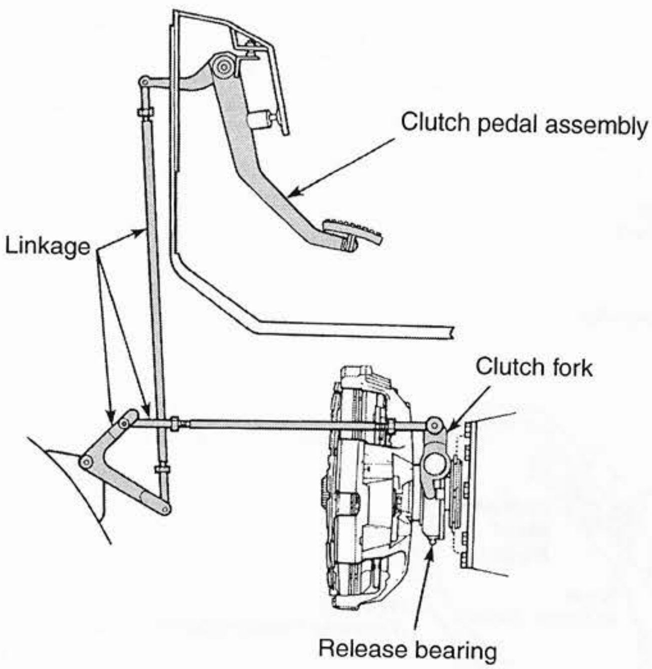


Figure 7-33 The clutch linkage connects the clutch pedal to the clutch release lever and fork. *(Courtesy of Arvin Meritor)*

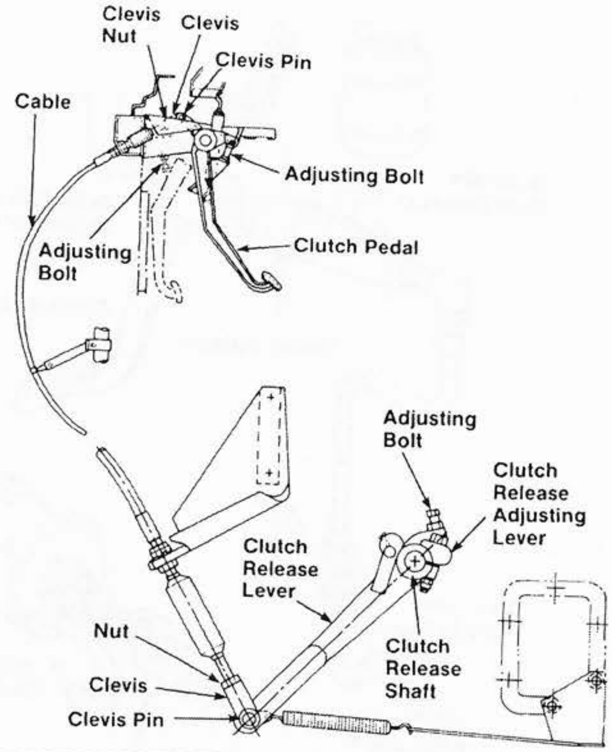


Figure 7-34 Clutch control adjustment arm. *(Courtesy of Eaton Corp.—Eaton Clutch Div.)*

controls. The linkage connects the clutch pedal to the release fork, or yoke (see **Figure 7-33**).

With the clutch pedal fully raised, there should always be 1/8 inch of free play between the fork, or yoke, and the release bearing. This free play should be taken up by the first 1 to 2 inches of clutch pedal travel. Then, as the pedal is depressed farther, the fork acts directly on the release bearing, pulling it back and disengaging the clutch. The last 1/2 to 1 inch of pedal travel will force the release bearing against the clutch brake.

MECHANICAL CLUTCH LINKAGE

Two types of mechanical linkages are used in heavy-duty trucks. The first uses levers to multiply pedal pressure applied by the driver, and the second type links the clutch pedal and release fork by means of a clutch control cable. Examples of both types are shown in **Figure 7-34** and **Figure 7-35.** Components in each type vary, depending on the truck chassis manufacturer.

HYDRAULIC CLUTCH LINKAGE

The typical components of a hydraulic clutch control system can be seen in **Figure 7-36.** The clutch is disengaged by hydraulic fluid pressure, sometimes assisted by an air servo cylinder. The clutch in **Figure 7-36** consists of a master cylinder, hydraulic fluid reservoir, and air-assisted servo cylinder. The components are all connected by rigid and flexible hydraulic lines.

When the driver depresses the clutch pedal, an actuating plunger forces the piston in the master cylinder to move forward. This movement closes off the reservoir and forces hydraulic fluid through the circuit to a reaction plunger and pilot valve in the servo cylinder.

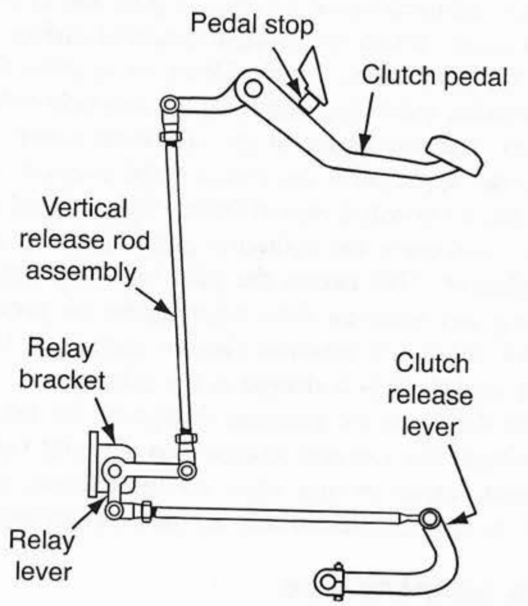


Figure 7-35 Clutch mechanical linkage used on a conventional truck chassis.

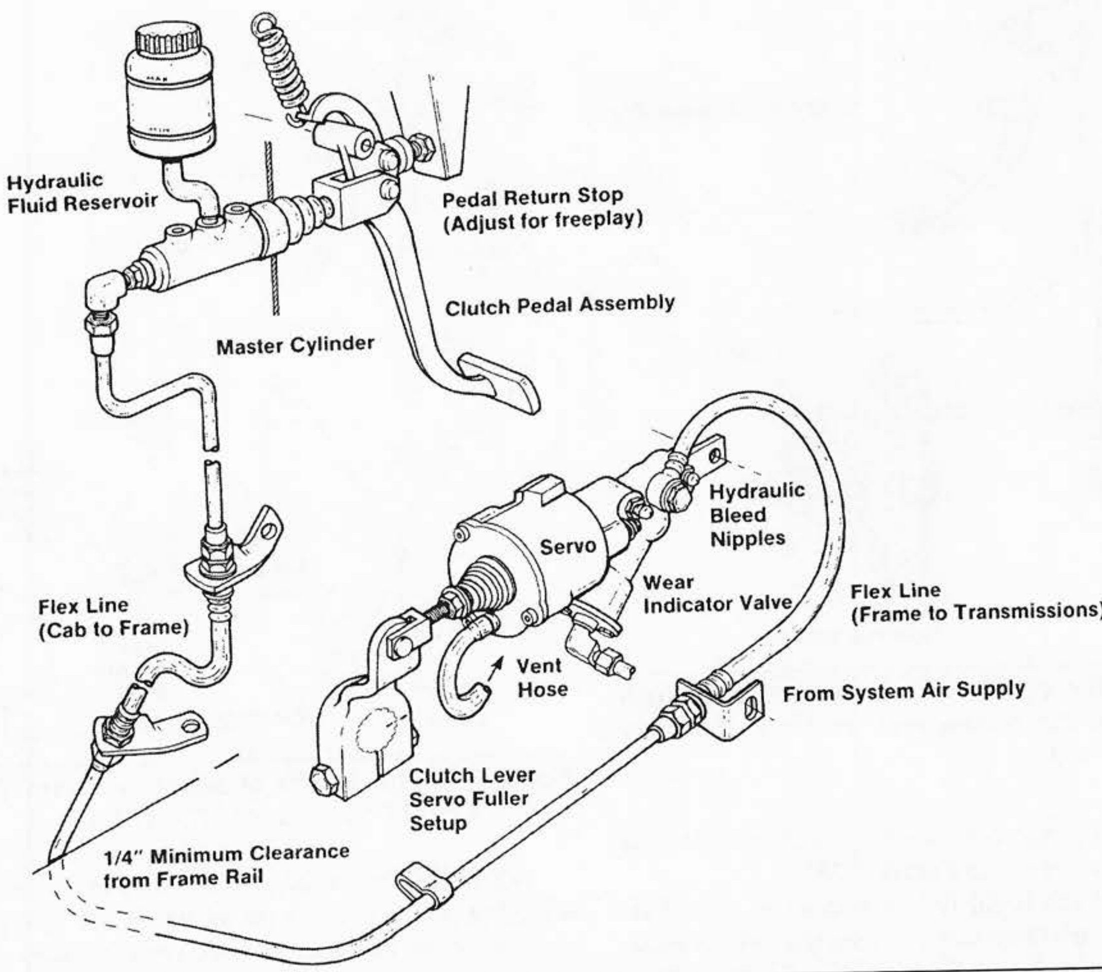


Figure 7-36 The typical components used in a hydraulic clutch circuit.

Hydraulic pressure forces the reaction plunger to move forward to close off an exhaust port and to seat the pilot valve. When the plunger is moved farther, it unseats the pilot valve, which allows air to enter the servo cylinder, exerting pressure on the rear side of the air piston. The movement of the air piston assists in clutch pedal application. As clutch pedal pressure increases, the air piston is moved farther forward, and air pressure overcomes the hydraulic pressure in the reaction plunger. This causes the pilot valve to reseat, preventing any more air from reaching the air piston. The pilot valve and reaction plunger remain in this position until there is a change in the pressure.

When the hydraulic pressure decreases, the return spring returns the reaction plunger and the pilot valve seats itself, which in turn uncovers the exhaust port and allows the air to exhaust from the servo cylinder.

Clutch Maintenance

Clutches should be checked periodically for proper adjustment and lubrication. Actual maintenance varies with the design of the clutch. Some clutches are self-adjusting, and once the clutch has been installed and the initial adjustment made, no further adjustment to bearing free play should be necessary over the life of the clutch. Other clutches are manually adjusted and must be adjusted periodically as the friction material of the disc is worn away. All clutches require regular inspection.

LUBRICATION

Some manufacturers of clutches use sealed release bearings that do not require lubrication over their service life. Other clutches have release bearings fitted with grease fittings (see **Figure 7-37**), and these must be lubed during a PM service. Frequently these bearings are equipped with a lubrication extension tube assembly that will allow the technician to lubricate the release bearing without removing the expansion cover from the transmission bell housing. These grease fitting extensions help to reduce maintenance and downtime.

A clutch release bearing should be lubricated according to schedule. Typically, this means whenever the clutch is inspected, once a month, every 6,000 to

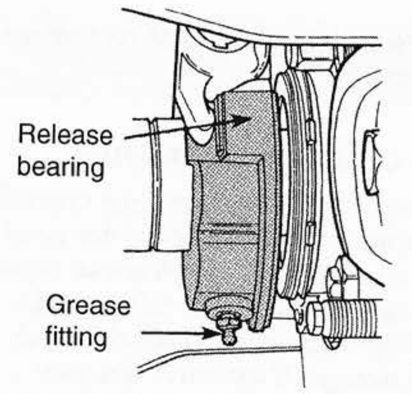


Figure 7-37 Some release bearings have a grease fitting and must be periodically lubricated. *(Courtesy of Arvin Meritor)*

10,000 miles, or whenever the chassis is lubricated, whichever comes first. Off-road or other severe service applications require more frequent service intervals. Good-quality extreme-pressure (EP) grease with a temperature performance range of −10°F to +325°F should be used to lube release bearings

A small amount of grease should be applied between the release bearing pads and the clutch release fork at normal service intervals. Eaton have recently made available an extended-life (EL) release fork equipped with rollers. Because this design significantly reduces friction, it should deliver on the promise of extended service life.

Many clutches have grease fittings in the clutch housing bosses (see **Figure 7-38**) for the clutch cross shaft assembly. These fittings should be greased whenever the release bearing is lubricated.

Whenever the release bearing and other lubrication points on the clutch are serviced, all pivot points on the clutch linkage should also be lubricated (see **Figure 7-39**).

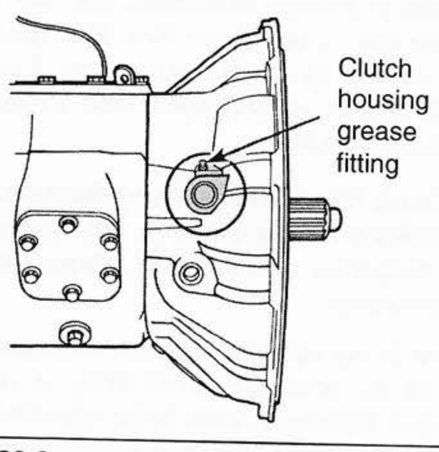


Figure 7-38 Some transmission housings have grease fittings where the clutch release cross shaft passes through the housing bosses. *(Courtesy of Arvin Meritor)*

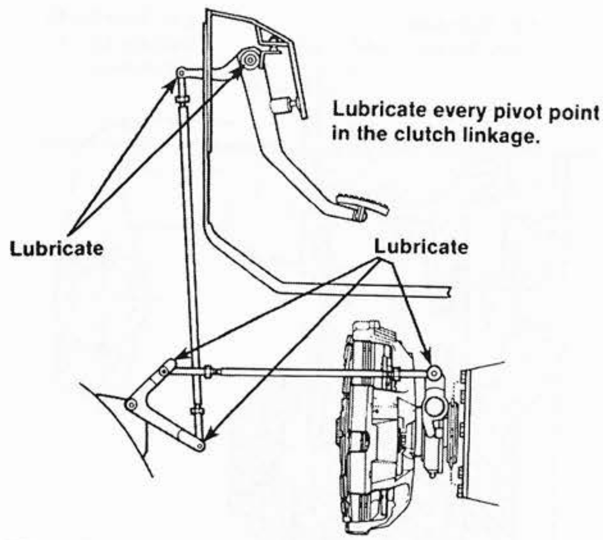


Figure 7-39 Clutch linkage lubrication points. *(Courtesy of Arvin Meritor)*

CAUTION *A replacement release bearing is not pre-packed with grease. They should be lubricated when the clutch is installed in the vehicle, or premature failure of the release bearing will occur.*

CLUTCH ADJUSTMENT

The clutch free pedal, or the initial free travel of the clutch pedal, should be 1-1/2 to 2 inches for either push-type or pull-type clutches. Free pedal is determined by placing your hand or foot on the clutch pedal and gently pushing it down until some resistance to movement is felt. Any movement after this point will cause the release bearing to begin disengaging the clutch.

In a push-type clutch, free pedal is set to 1-1/2 to 2 inches to obtain the desired 1/8-inch free travel clearance between the clutch release bearing and clutch release levers (see **Figure 7-40**), or diaphragm spring, whichever is used.

In a pull-type clutch, the 1/8-inch free travel clearance occurs between the release yoke fingers and the clutch release bearing pads (see **Figure 7-41**). This 1/8-inch free travel at the release bearing should produce 1-1/2 inches of free pedal.

Free pedal dimensions are greater than free travel at the release bearing specifications because, as movement transfers through the linkage, it becomes amplified. Too much free pedal prevents complete disengagement of the clutch. Too little free pedal causes clutch slippage and heat damage and shortens clutch life.

As the friction disc facings wear through normal operation, free pedal will gradually decrease. If

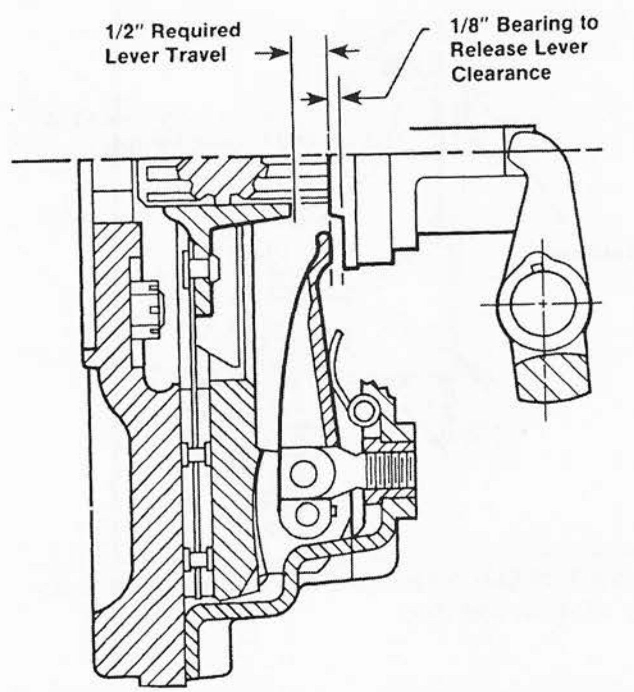


Figure 7-40 In a push-type clutch, the desired free travel clearance is 1/8 inch. Total release bearing travel on a push-type clutch must be approximately 5/8 inch. *(Courtesy of Haldex Brake Products, Inc.)*

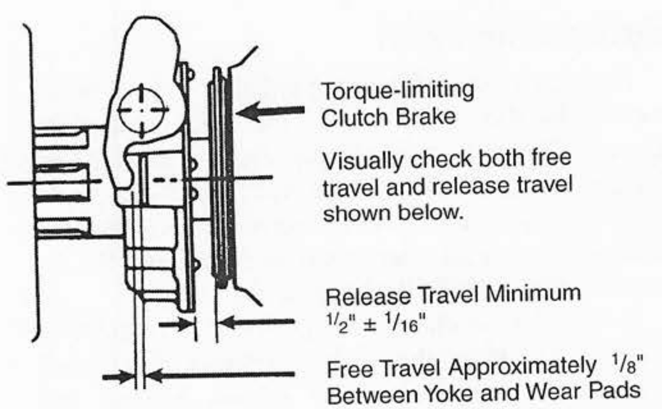


Figure 7-41 On a pull-type clutch, there should be 1/8-inch clearance between the release fork and the boss on the release bearing. *(Courtesy of Eaton Corp.—Eaton Clutch Div.)*

inspection indicates clutch free pedal travel is less than 1/2 inch, adjustment of the clutch is required.

CAUTION *Never wait until no free pedal exists before making this adjustment. Remember that the method of setting free pedal and free travel is different between push-type clutches and pull-types clutches. Use the correct method for adjusting each type of clutch and refer to the service manual.*

PUSH-TYPE CLUTCH ADJUSTMENT

In a push-type clutch, adjusting the external clutch linkage to obtain 1-1/2 to 2 inches of free pedal should result in the specified 1/8-inch clearance between the release bearing and the clutch release forks. Before making a linkage adjustment, check the clutch linkage for wear and damage. If excessive free play is present in the clutch pedal linkage due to worn components, repair as necessary. Excessive wear of the release linkage can give a false impression of release bearing clearance.

Once the free pedal is adjusted between 1-1/2 and 2 inches, it is recommended that the free travel clearance be double-checked. To obtain this adjustment:

1. Set the parking brakes and chock the wheels.
2. Remove the clutch inspection cover from the transmission bell housing.
3. Measure the clearance between the release bearing and the clutch release fork. Clearance must be within specifications for the release bearing to release properly.
4. If this clearance is not present, adjust the linkage until the specified 1/8-inch clearance is obtained. Remember, the linkage must be in good condition to obtain accurate results.

PULL-TYPE CLUTCH ADJUSTMENT

Pull-type clutches may require a two-step adjustment to obtain the specified free travel and free pedal specifications. The first step is a release bearing free travel adjustment that may not be required. The second step is a pedal or linkage adjustment. The free travel adjustment should be performed first. Free travel adjustment is usually an internal adjustment; however, some clutch models are equipped with an external quick adjust mechanism.

Pull-Type Clutch Preadjustment Considerations

Before making adjustments to a pull-type clutch, review the following conditions to ensure optimum clutch performance:

1. Clutch brake squeeze (increase resistance) begins at the point the clutch brake is initially engaged. Optimum clutch brake squeeze begins 1 inch from the end of the pedal stroke or above the floorboard (see **Figure 7-42**). Adjustment is made by shortening or lengthening the external linkage rod.

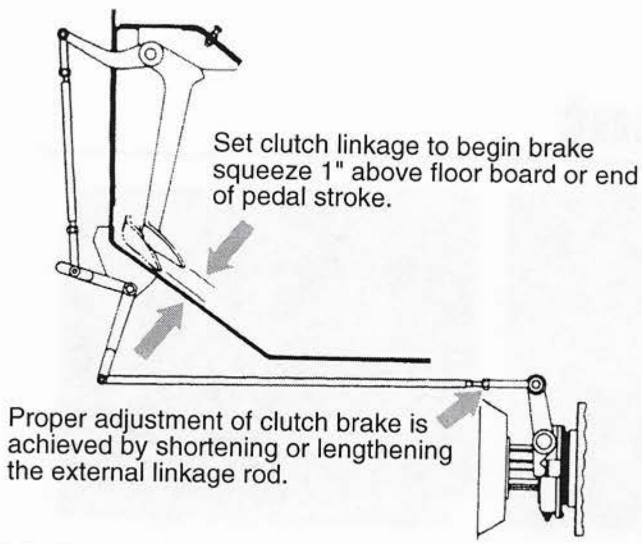


Figure 7-42 The last inch of clutch pedal travel should squeeze the clutch brake. *(Courtesy of Eaton Corp.—Eaton Clutch Div.)*

2. Optimum free pedal is 1-1/2 to 2 inches (see **Figure 7-43**). This adjustment is made internally in the clutch, never with the linkage.
3. Release travel is the total distance the release bearing moves during a full clutch pedal stroke. A typical release travel distance of 1/2 to 9/16 inch is required to ensure that the release bearing releases sufficiently to allow the friction discs to turn freely, with no clutch drag. Optimum free travel is 1/8 inch (See **Figure 14.32**).
4. Internal adjustment of the adjusting ring should be made before attempting linkage adjustments.

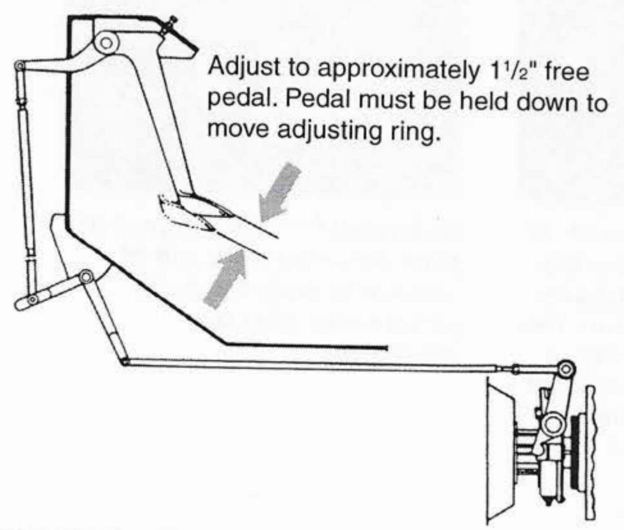


Figure 7-43 The first 1-1/2 inches of pedal travel should take up the clearance between the fork and the release bearing. *(Courtesy of Eaton Corp.—Eaton Clutch Div.)*

5. Internal clutch adjustments should be made with the clutch pedal down (clutch released position).
6. Turning the adjusting ring clockwise moves the release bearing toward the transmission. Turning the adjusting ring counterclockwise moves the release bearing toward the engine.
7. Linkage adjustment on a pull-type clutch should only be made:
   - At initial dealer preparation to set total pedal stroke and yoke throw
   - To compensate for linkage or clutch brake wear
   - When worn or damaged linkage components are replaced

INTERNAL ADJUSTMENT MECHANISMS-ANGLED SPRING CLUTCH

There are three basic types of adjustment mechanisms currently in use on angle coil spring clutches used in heavy-duty truck applications. Two are manually adjusted, and the third category includes several types of self-adjusting mechanisms. **Photo Sequence 5** shows the procedure for adjusting various types of clutches.

LOCKSTRAP MECHANISM

The purpose of the lockstrap mechanism is to lock the clutch adjusting ring. When it is removed, adjustment of free travel can be performed. To adjust a clutch:

1. Remove the inspection plate from the bottom of the clutch housing.
2. Rotate the clutch assembly (bolted to the flywheel) until the lockstrap and its bolt are centered in the opening of the inspection plate as shown in **Figure 7-44.**

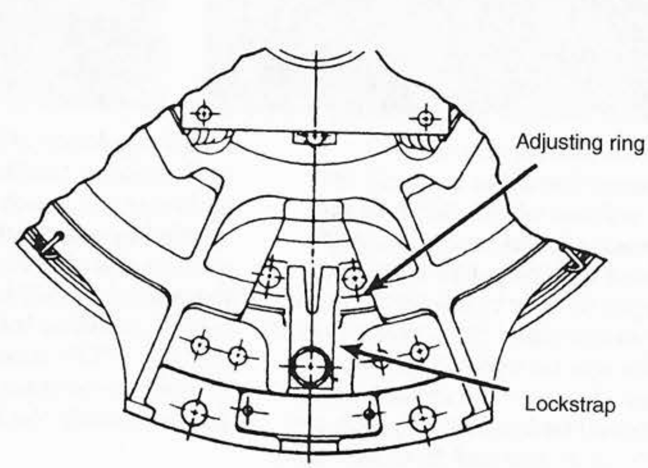
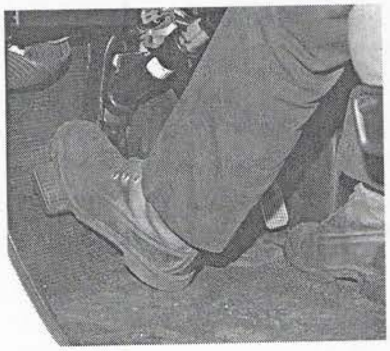


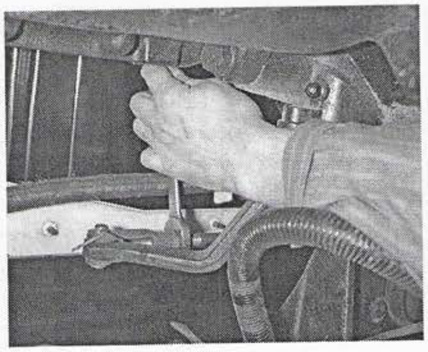
Figure 7-44 For adjustment, the lockstrap and bolt must be centered at the clutch inspection cover opening. *(Courtesy of Eaton Corp.—Eaton Clutch Div.)*

PHOTO SEQUENCE 5

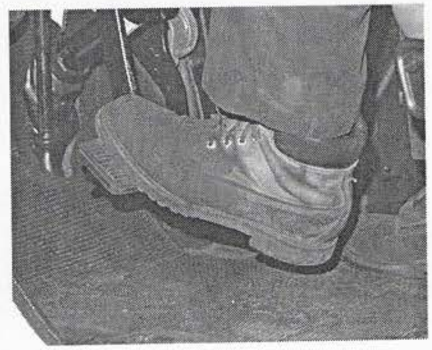
Clutch Adjustment



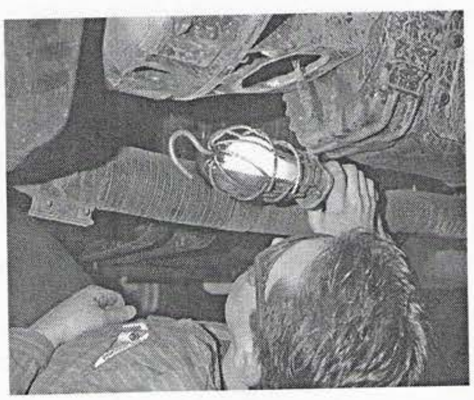
P5-1 Assess the need for a clutch adjustment by first checking clutch brake squeeze. Clutch brake squeeze should begin 1 inch from the floor at the end of the pedal stroke. Clutch brake squeeze should be verified before attempting an internal adjustment of a clutch. In most cases, clutch brake squeeze will not require adjustment, but it should always be checked.



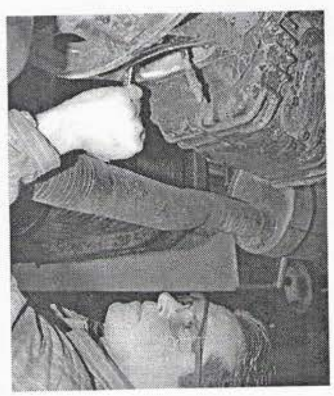
P5-2 To adjust the clutch brake, either lengthen or shorten the external linkage by loosening the locknut and turning the adjusting rod either clockwise or counterclockwise.



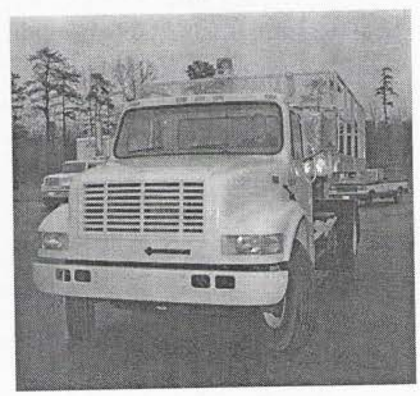
P5-3 Next, check the clutch pedal free play. This is the pedal travel that results before the clutch disengagement occurs. Free travel is always adjusted internally: Attempting to correct this externally will result in incorrect clutch brake squeeze. **Clutch pedal free play should be between $1^1/_2$ and 2 inches.**



P5-4 Remove the clutch inspection plate to check the condition of the clutch brake, release travel, and cross-shaft yoke free play. Use a trouble light to inspect the clutch brake. Release travel (the total travel of the release bearing through a full stroke of the clutch pedal) should be between $^1/_2$ inch and $^9/_{16}$ inch. Internal free play is the distance between the cross shaft yoke and the release bearing when the clutch is fully engaged. It should measure $^1/_8$ inch.



P5-5 To make an adjustment, fit the adjusting tool to the clutch and have the clutch pedal fully applied by a second person. This releases the clutch, permitting the adjusting ring to be rotated by the adjusting tool. Three notches of CW travel will move the release bearing approximately $^1/_{16}$ inch.



P5-6 Install the clutch inspection plate. Drive the truck a short distance to verify the clutch performance after the adjustment.

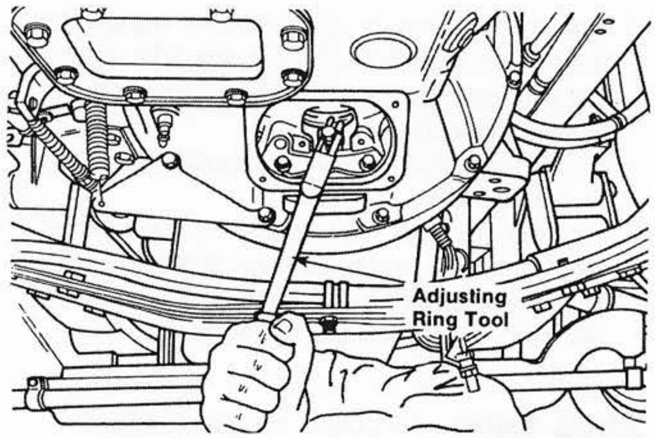


Figure 7-45 Special adjusting ring tools are available for adjusting the clutch. *(Courtesy of Arvin Meritor)*

3. Remove the bolt and lockwasher that fasten the lockstrap to the clutch cover. Remove the lockstrap.
4. Push the clutch pedal to the bottom of pedal travel. Use another person or a block of wood to hold the pedal at full travel. Hold the pedal in this position when the adjusting ring is moved. The pedal should be depressed when turning the adjusting ring, and the pedal must be up when making a measurement.
5. Rotate the adjusting ring to obtain the specified clearance at the release bearing. Use a screwdriver or an adjusting tool as a lever against the notches on the ring to turn the adjusting ring (see **Figure 7-45**). When the adjusting ring is moved one notch, the release bearing will move 0.023 inch. Moving the ring three notches will move the release bearing roughly 1/16 inch. Turning the adjusting ring clockwise moves the release bearing toward the transmission, increasing pedal-free travel. Turning the adjusting ring counterclockwise moves the release bearing toward the engine, decreasing pedal-free travel.
6. Install the lockstrap and torque bolt to specification.
7. Release the clutch pedal.
8. Check the clearance between the yoke and the wear pads. The clearance should be 1/8 inch (see **Figure 7-41**). If out of specification, adjust the clutch linkage according to the vehicle manufacturer's procedures.
9. Reinstall the inspection hole cover and tighten the bolts.

KWIK-ADJUSTMENT MECHANISM.

This manual adjust mechanism (see **Figure 7-46**) allows for the adjustment of free travel without the use of special tools or removing bolts. The adjustment is made using a socket wrench to turn the adjusting bolt:

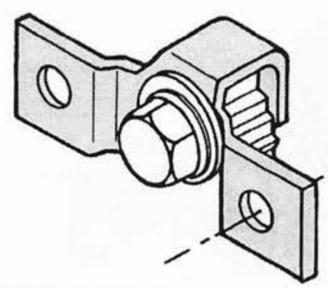


Figure 7-46 Manual adjustment mechanism for quick adjustment of free travel. *(Courtesy of Eaton Corp.—Eaton Clutch Div.)*

1. Using a 3/4-inch socket (12 point) or box-end wrench, depress the adjusting nut and rotate to make the adjustment (see **Figure 7-47**). The Kwik-Adjust will reengage at each quarter turn.
2. Make sure the adjusting nut is locked into position with the flats aligned to the bracket.

WEAR COMPENSATOR

Wear compensators were used on clutches in the 1990s, and although they are not very common today, you still might run across one. A wear compensator automatically adjusts for wear of the clutch friction surface each time the clutch is actuated (see **Figure 7-48**). When friction facing wear exceeds a predetermined amount, the adjusting ring is advanced and free pedal travel returned to original specifications. To make a wear compensator adjustment:

1. Manually turn the engine flywheel until the adjuster assembly is in line with the clutch inspection cover opening.

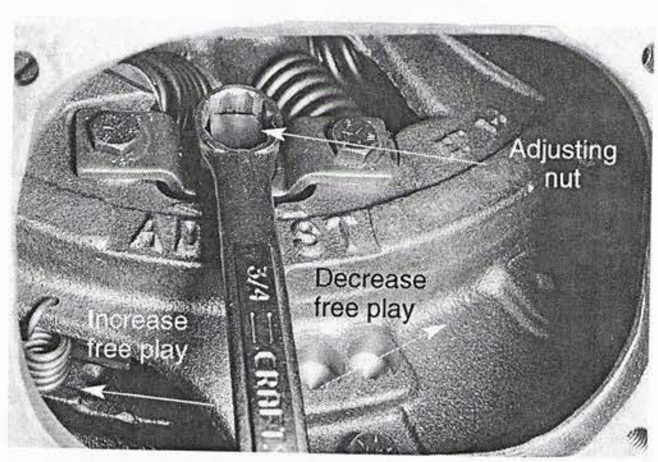


Figure 7-47 Performing the external manual adjustment. *(Courtesy of Eaton Corp.—Eaton Clutch Div.)*

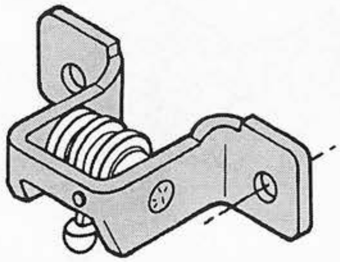


Figure 7-48 Clutch wear compensator used on older, self-adjusting clutches. *(Courtesy of Eaton Corp.—Eaton Clutch Div.)*

2. Remove the right side bolt and loosen the left bolt one turn (see **Figure 7-49A**).
3. Rotate the wear compensator upward to disengage the worm gear from the adjusting ring (see **Figure 7-49B**).
4. Advance the adjusting ring as necessary (see **Figure 7-49C**).

CAUTION *Do not pry on the inside gear teeth of the adjusting ring. Doing this can damage the teeth and prevent the clutch from self-adjusting.*

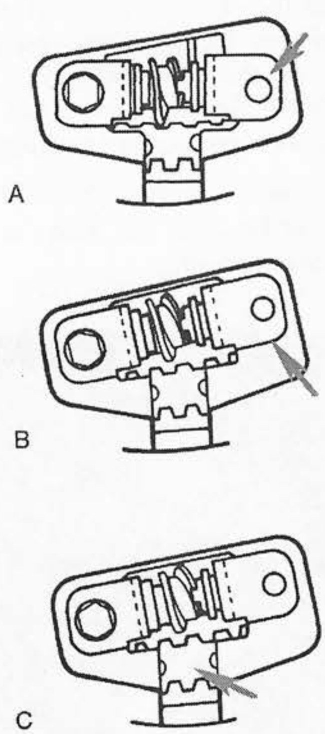


Figure 7-49 Steps in making a clutch adjustment on an older, self-adjusting clutch equipped with a wear compensator. *(Courtesy of Haldex Brake Products, Inc.)*

5. Rotate the assembly downward to engage the worm gear with the adjusting ring. The adjusting ring may have to be rotated slightly to re-engage the worm gear.
6. Install the right-side bolt and torque both bolts to specifications.
7. Visually check that the actuator arm is inserted into the release sleeve retainer. If the assembly is properly installed, the spring will move back and forth as the pedal is full stroked.

Shop Talk: The clutch will not compensate for wear if the actuator arm is not inserted into the release sleeve retainer, or if release bearing travel is less than 1/2 inch.

When a self-adjusting clutch is out of adjustment, check for the following:

- Actuator arm incorrectly inserted into the release bearing sleeve retainer
- Bent adjuster arm
- Seized or damaged clutch components, such as the adjusting ring

After identifying and replacing or repairing the defective component or condition, readjust the bearing setting.

INTERNAL ADJUSTMENT: CLUTCHES WITHOUT CLUTCH BRAKES

The following steps outline the typical internal adjustment procedure for manual and self-adjusting angle-spring clutches not equipped with a clutch brake:

1. Remove the clutch inspection plate below the bell housing.
2. With the clutch engaged (pedal up), measure the clearance between the release bearing and clutch housing.
3. If clearance is not within specifications, typically 1-7/8 inches for a single-plate clutch and 3/4 inch for a two-plate clutch (see **Figure 7-50**), continue with steps 4 and 5 below; otherwise skip to step 6 below.
4. Release the clutch by fully depressing the clutch pedal.
5. Using the internal adjustment procedure outlined previously for lockstrap, Kwik-Adjust, and wear compensator adjustment mechanisms, advance the adjusting ring until the clearance specification is obtained. If the clearance between the release bearing and clutch housing is

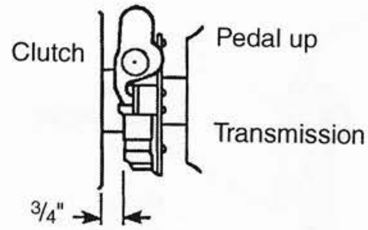


Figure 7-50 Two-plate clutch release bearing clearance on angle-spring clutches without a clutch brake. The ¾-inch specification is used on synchronized transmissions only. On a nonsynchronized transmission, the specification is ½ inch. *Courtesy of Eaton Corp.—Eaton Clutch Div.)*

lower than specification, rotate the adjusting ring counterclockwise to move the release bearing toward the engine. If the clearance is higher than specification, rotate the adjusting ring clockwise to move the release bearing toward the transmission.

6. Apply a small amount of grease between the release bearing pads and the clutch release fork.
7. Check the linkage adjustment.

Internal Adjustment: Clutch Brake Clutches

The following steps outline the typical internal adjustment procedure for manual and self-adjusting angle-spring clutches equipped with a clutch brake:

1. Remove the inspection plate below the clutch housing.
2. With the clutch engaged (pedal up), measure the clearance between the release bearing and the clutch brake. This is the release travel. If clearance (see **Figure 7-51**) is less than 1/2 inch or greater than 9/16 inch (typical), continue with steps 3 and 4 below; otherwise proceed to step 5.

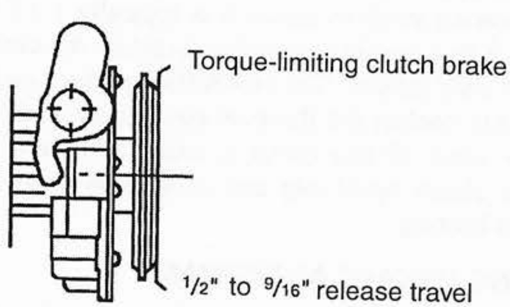


Figure 7-51 Clearance between release bearing and clutch housing on clutches with a clutch brake. *(Courtesy of Eaton Corp.—Eaton Clutch Div.)*

3. Release the clutch by fully depressing the clutch pedal.
4. Using the internal adjustment procedures previously described for lockstrap, Kwik-Adjust, and wear compensator adjustment mechanisms, advance the adjusting ring until a distance of 1/2 to 9/16 inch is attained between the release bearing and the clutch brake with the clutch pedal released.
5. If clearance between the release bearing and the clutch brakes is less than specified, turn the adjusting ring counterclockwise to move the release bearing toward the engine. If the clearance is greater than specification. Rotate the adjusting ring clockwise to move the release bearing toward the transmission.
6. Apply a small amount of grease between the release bearing pads and the clutch release fork.
7. Proceed with linkage adjustment as needed.

CLUTCHES WITH PERPENDICULAR SPRINGS

Pull-type clutches with perpendicular springs use a threaded sleeve and retainer assembly that can be adjusted to compensate for friction disc facing wear. The adjustment procedure is illustrated in **Figure 7-52:**

1. Use a drift punch and hammer or a special spanner wrench to unlock the sleeve lock nut.

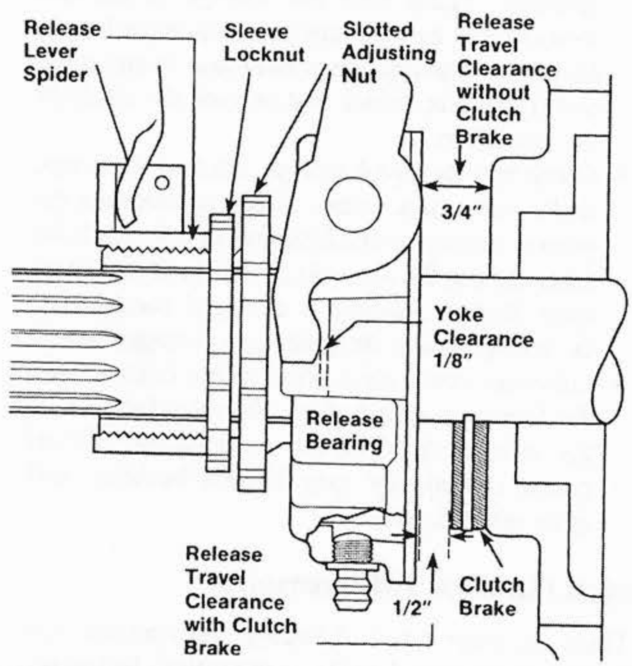


Figure 7-52 Clutch-adjusting mechanism for a clutch with perpendicular springs. *(Courtesy of Haldex Brake Products, Inc.)*

2. Turn the slotted adjusting nut to obtain the release travel clearance of 1/2 inch if the clutch is equipped with a clutch brake and 3/4 inch if it does not have a clutch brake.
3. Securely lock the sleeve lock nut against the release lever retainer, or spider, using the drift punch and hammer or special spanner wrench.
4. Adjust the clutch linkage to obtain a yoke-to-bearing free travel clearance of 1/8 inch if the vehicle is equipped with a nonsynchronized transmission with a clutch brake. On vehicles equipped with synchronized transmissions (without a clutch brake), the yoke clearance should be 1/4 inch and that should result in approximately 3 inches of free pedal.

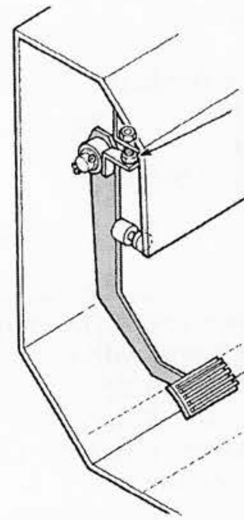


Figure 7-53 Pedal height adjustment point. *(Courtesy of Arvin Meritor)*

Clutch Linkage Inspection

Because the clutch will not operate properly if the linkage is worn or damaged, it should be inspected carefully at all PM services. Inspect the linkage according to the following procedure:

1. Depress the clutch pedal and have another person check the release fork for movement. The smallest movement of the clutch pedal should result in movement at the release fork. If the release fork does not move when the clutch pedal moves, locate and correct the free play condition.
2. The linkage must move when the pedal is actuated. Make sure the linkage is not obstructed and every pivot point operates freely. Make sure the linkage is not loose at any point and if it binds, locate and service the cause of the condition.
3. Check that the pedal springs, brackets, bushings, shafts, clevis pins, levers, cables, and rods are not worn or damaged. In a hydraulic clutch, check for leaks and that the reservoir is filled to the specified level. Replace missing or damaged components. Do not attempt to straighten any damaged parts.
4. Lubricate every pivot point in the linkage. Use the lubricant specified by the manufacturer of the vehicle. A NLGI #2 multipurpose lithium grease is typically specified for bushings and other pivot points.

Clutch Linkage Adjustment

There are three types of linkage mechanisms currently used in truck applications: mechanical, hydraulic, and pneumatic. Adjustment methods vary between truck manufacturers, so always follow the procedure listed in the truck service literature. The following is general information on adjusting the clutch linkage.

PEDAL HEIGHT

On some vehicles, the travel height of the clutch pedal is adjusted. The height is set by stop bolts. If the pedal height is not correct, the amount of free pedal will not be correct (see **Figure 7-53**). Consult the manufacturer's service literature for pedal height specifications.

TOTAL PEDAL TRAVEL

The total pedal travel is the complete distance the clutch pedal must move. It can be adjusted with bumpers and stop bolts in the cab or with stop bolts and pads on the linkage. Total travel makes sure that there is enough movement of the pedal to correctly engage and disengage the clutch (see **Figure 7-54**). Consult the manufacturer's service literature for specifications.

FREE PEDAL TRAVEL

The free pedal is the travel of the pedal before the release bearing starts to move. It is typically 1-1/2 to 2 inches. If free travel is more than 2 inches, the clutch might not fully release. The clutch friction discs could be loaded to contact the flywheel continually, causing excessive wear. If free travel is reduced to zero by wear, the clutch could slip and continually load the throw-out bearing.

CHECKING LINKAGE ADJUSTMENT

The following procedure is used to determine if a linkage adjustment is required on manual and self-adjusting angle-spring clutches (see **Figure 7-55**).

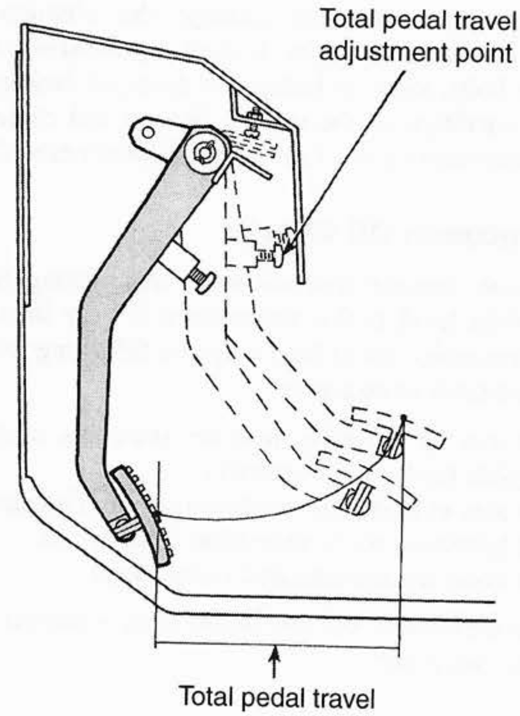


Figure 7-54 Total pedal travel adjustment point. *(Courtesy of Arvin Meritor)*

1. With the clutch disengaged (pedal down), measure the free travel clearance between the release yoke fingers and wear pads on the release bearing. If clearance is either greater or less than 1/8 inch, adjust the external linkage to obtain the 1/8-inch clearance (see **Figure 7-41**).
2. This dimension should correlate to a free pedal of 1-1/2 to 2 inches. If it does not, trim the linkage adjustment to obtain these specifications.
3. Apply a small amount of grease between the release bearing pads and the clutch release fork.
4. Tighten all lock nuts.

ADJUSTMENT

The method for adjusting the release yoke finger to release bearing wear pad clearance can differ, depending on the type of truck and linkage design. A typical procedure is outlined here:

1. Disconnect the lower clutch control rod from the pedal shaft (see **Figure 7-55**) or the bell-crank (see **Figure 7-56**).
2. Place a space block between the pedal stop and the stop bracket or pedal shank. The actual size of the spacer will vary with the linkage design.
3. Force the lower control rod forward until the release bearing contacts the yoke fingers.

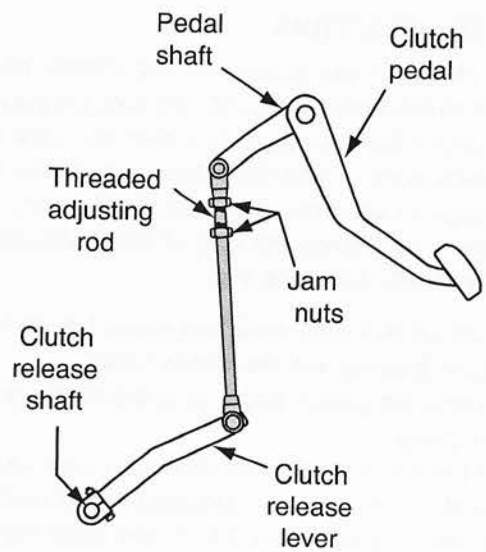


Figure 7-55 This linkage is adjusted by lengthening or shortening the control rod.

4. Loosen the jam nuts on the threaded adjusting rod on the threaded end of the control rod until the holes in the pedal shaft or bellcrank align with the holes in the rod end or clevis.
5. Reconnect the linkage members and remove the spacer block from the pedal stop.
6. Operate the clutch pedal and recheck the yoke-to-bearing clearance. If the clearance is still insufficient it might be necessary to adjust the pedal height or travel. By turning the pedal stop cause the pedal will return farther and the yoke-to-bearing clearance will be increased.

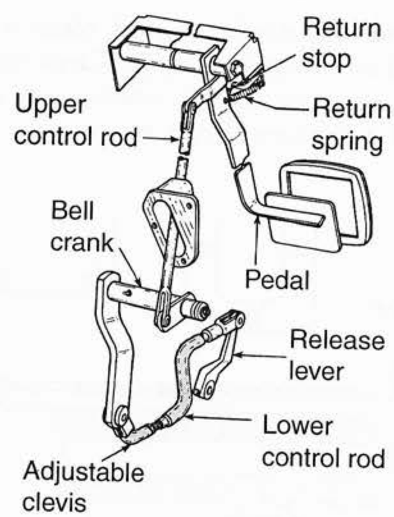


Figure 7-56 Adjustments to this linkage are made by adjusting the clevis on the lower control rod. *(Courtesy of International Truck and Engine Corporation)*

CLUTCH BRAKE SETTING

When checking the setting of the clutch brake, depress the clutch pedal in the cab and note the point at which the clutch brake engages by observation through the inspection cover. With the release travel and free travel settings, clutch brake squeeze should occur approximately 1 inch from the end of the pedal stroke (see **Figure 7-43**). To check this:

1. Insert a 0.010 inch thickness gauge between the release bearing and the clutch brake.
2. Depress the clutch pedal to squeeze the thickness gauge.
3. Let the pedal up slowly until the gauge can be pulled out and note the position of the pedal in the cab. It should be 1/2 to 1 inch from the end of the pedal stroke.
4. To adjust the clutch brake setting, shorten or lengthen the external linkage according to service literature procedure. If the specified adjustment cannot be obtained, check the linkage for excessive wear and pedal height.
5. Reinstall the inspection cover.

AUTOMATIC TRANSMISSION MAINTENANCE

For this section, we will focus on Allison transmissions, as they tend to be the most common ones used in North American trucks and buses. The procedures outlined here are those required for most hydromechanical Allison four- and five-speed transmissions.

Inspection and Maintenance

The transmission should be kept clean to make inspection and servicing work easier. Clean the transmission with a pressure washer, making sure to keep the stream of water away from the breather. Avoid using solvents that could damage the aluminum housing of the transmission. Inspect the transmission for loose bolts, loose or leaking oil lines, oil leakage, and the condition of the control linkage and cables. The transmission oil level should be checked regularly.

Transmission Oil Checks

As with manual transmissions, maintaining the correct fluid level in the transmission is very important. Transmission oil or fluid plays the following roles in an automatic transmission:

- It acts as the drive medium (transfers torque inside the torque converter).
- It acts as hydraulic medium to apply clutches.
- It lubricates the transmission components.
- It cools the transmission components.

If the oil level is tool low or too high, a number of problems can occur.

Low Oil Level

When the transmission oil level is low, oil will not completely cover the oil filter. This pulls air into the pump inlet along with oil, which is then routed to the clutches and converter. The resulting air in the hydraulic system is known as aeration. Air is compressible, so it compromises the operation of hydraulic circuits. The result is converter aeration, irregular shifting, overheating, and poor lubrication. Aeration of transmission oil alters its viscosity and changes its appearance to that of a thin frothy liquid.

High Oil Level

At normal oil levels (FULL mark on the dipstick with oil at operating temperature), the sump oil level should be slightly below the planetary gearsets (see **Figure 7-57**).

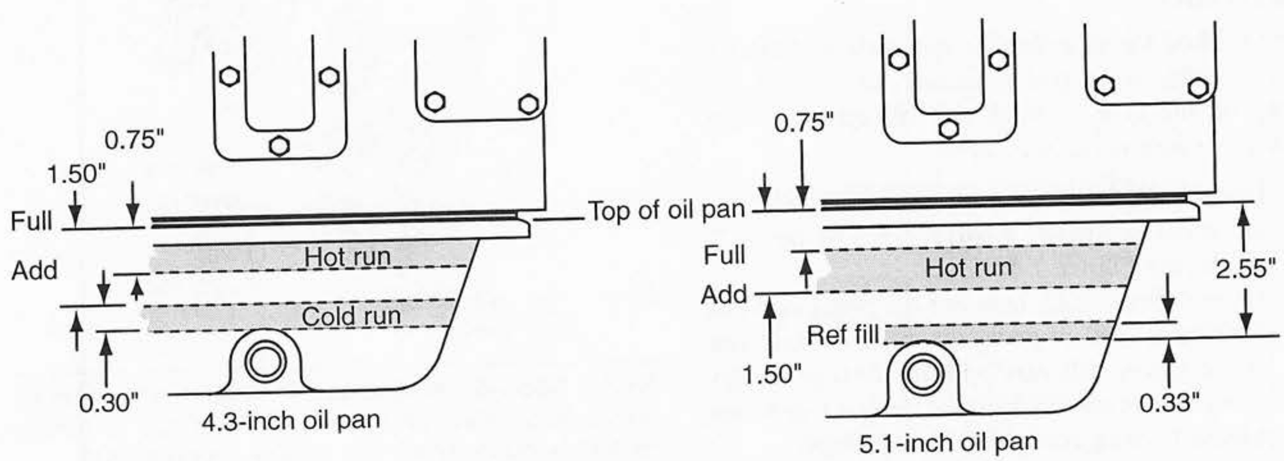


Figure 7-57 Oil levels on a 4.3-inch transmission oil pan and a 5.1-inch oil pan.

When the oil level is maintained above the FULL mark on the dipstick, the oil level in the sump rises so that the planetary gears run in oil, a condition that can cause foaming and aeration. Once again, aerated transmission fluid results in converter aeration, irregular shifting, overheating, and poor lubrication. If accidental overfilling occurs during servicing, the excess oil should be drained.

CAUTION *It should be noted that a defective oil filler tube seal ring will allow the oil pump to draw air into the oil from the sump, which will result in aeration of the oil.*

Interpreting Oil Level Readings

Transmission input speed and oil temperature significantly affect the oil level. An increase in input speed will lower the oil level, whereas an increase in oil temperature will raise it. For these reasons, always check the oil level with the engine at its specified idle speed with the transmission in neutral. Both cold and hot level check should be taken.

A cold level check is required to ensure there is sufficient oil in the transmission until normal operating temperature is reached. The hot check is made when the transmission oil reaches normal operating temperature (160°F to 200°F) and is the more reliable of the two checks.

Foreign material should never be allowed to enter the filler tube when you are checking or adding oil to the transmission. Clean around the filler tube opening before removing it. When testing transmission oil level, park the vehicle on a level surface and apply the parking brakes.

Shop Talk: You should check the transmission oil level at least twice to ensure that an accurate reading is made. If the dipstick readings are inconsistent (some high, some low), check for proper venting of the transmission breather or oil filler tube. A clogged breather can force oil up into the filler tube and cause inaccurate readings. If the filler tube is non-vented, the vacuum produced will cause the dipstick to draw oil up into the tube as it is pulled from the tube. Again, the result will be an inaccurate reading.

Cold Fluid Level Check

Run the engine for around 1 minute to purge air from the system. Shift the transmission into drive, then reverse, and then back into neutral. This charges the clutch cavities and hydraulic circuits with oil. The oil temperature should be between 60°F and 120°F for an accurate cold check. Wipe the dipstick clean and take the reading. If the oil level registers in the REF FILL (COLD RUN) band of the dipstick, the oil level is sufficient to run the transmission until a hot check can be made. Familiarize yourself with the appearance of the Allison dipstick as illustrated in **Figure 7-58.**

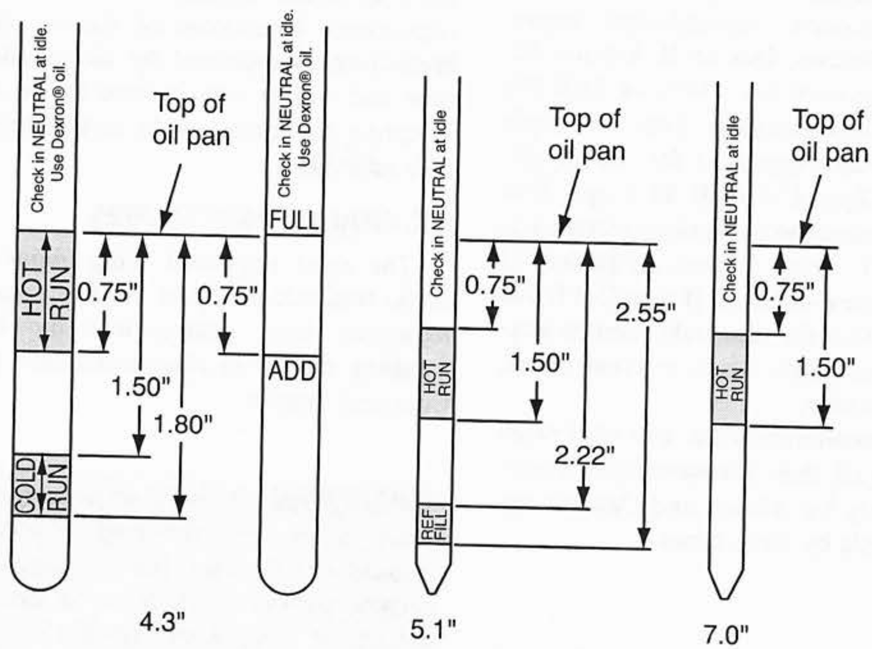


Figure 7-58 (A) Typical current and early 4.3-inch oil pan dipstick markings; (B) typical current 5.1-inch and 7.0-inch oil pan dipstick markings.

Shop Talk: The REF FILL (COLD RUN) level is an approximate level and can vary with specific transmissions. To ensure proper operating levels, a hot oil level check must be performed.

If the oil level registers at or below the lower line of the REF FILL (COLD RUN) band, add oil to bring the level within the REF FILL (COLD RUN) band. Do not fill above the upper line of this band. If the oil level is above the upper line of the REF FILL (COLD RUN) band, drain some oil to correct the level. Next, you can operate the vehicle until the hot check temperate is reached. Then continue with the hot fluid level check.

Hot Fluid Level Check

The oil temperature should be between 160°F and 200°F to make this test. With the engine at idle and the transmission in neutral, wipe the dipstick clean and check the oil level. If the oil level registers in the HOT RUN band (between ADD and FULL), the oil level is correct. If the oil level registers on or below the bottom line of the HOT RUN band or the ADD line, add oil to bring the level to the middle of the band. Note that one quart of oil will raise the level from the bottom of the band to the top of the band in most transmissions (from ADD Line to the FULL line).

Hydraulic Fluid Recommendations

Check the OEM hydraulic fluid specifications. For example, several automatic transmission manufacturers recommend Dexron, Dexron ll, Dexron III, and type C-4 (ATD approved SAE 10W or SAE 30) oils for their automatic transmissions. Type C-4 fluids are the only fluids usually approved for use in off-highway applications. Type C-4 SAE 30 is specified for all applications in which the ambient temperature is consistently above 86°F. Some but not all Dexron II fluids also qualify as type C-4 fluids. If type C-4 fluids are to be used, check that the materials used in auxiliary equipment such as tubes, hoses, external filters, and seal are C-4 compatible.

Allison currently recommends the use of **TransSynd** synthetic oil in all their transmissions. TransSynd, formulated jointly by Allison and Castrol, can extend oil drain intervals by three times.

Cold Startup

The transmission should not be operated in forward or reverse gears if the transmission oil falls below a certain temperature. Minimum operating temperatures for recommended fluids are as follows:

TransSynd	−10°F
Dexron (I, II, III)	−10°F
Type C-4 SAE 10W	10°F
Type C-4 SAE 30	32°F

When the ambient temperature is below the minimum fluid temperatures listed and the transmission is cold, preheat is required either by using auxiliary heating equipment or by running the engine in neutral at idle a minimum of 20 minutes to reach the minimum operating temperature. Failure to observe the minimum temperature limit can result in transmission malfunction or reduced transmission life.

Oil and Filter Changes

The change interval specified by Allison must also take into account the chassis application. Typical filter and oil change intervals are 25,000 miles or 12 months for on-highway trucks and 1,000 hours or 12 months for off-highway applications. When the Allison-recommended TransSynd synthetic oil is used, oil change intervals can be extended by around 300 percent, depending on application.

Some operating conditions may require shorter oil and filter change intervals. Oil should be changed when there is visible evidence of contamination or high-temperature breakdown of the oil. High-temperature breakdown is indicated by discoloration and burned odor and can be corroborated by oil analysis. Severe operating conditions might require more frequent service intervals.

OIL CHANGE PROCEDURES

The most important thing about changing automatic transmission fluid is cleanliness. Prevent contaminants from getting into the transmission by handling the oil in clean containers and using clean filler and funnels.

CAUTION *Containers or transfer devices that have been used for engine coolant solutions should not be used for transmission fluid. Antifreeze contains ethylene or propylene glycol, which, if transferred to the transmission, can cause clutch plate failure.*

Place the dipstick on a clean surface when filling the transmission and keep replacement filters and seals in their packaging until ready for installation. Before you drain the transmission fluid, it should be at an operating temperature of between 160°F and 200°F. Shift the gear selector to neutral before draining the oil from the sump pan.

Allison transmissions are equipped with either a standard or heavy-duty oil pan (see **Figure 7-59**). When changing oil and filters on a standard pan, the entire oil pan is removed from the base flange of the transmission to access the filter. The heavy-duty oil pan does not have to be removed, because the filter is accessed through an opening in the side of the oil pan.

Standard Oil Pan

The oil and filter change on an Allison transmission with a standard oil pan should be performed as follows:

1. Remove the oil drain plug and gasket from the right side of the oil pan. Allow the oil to drain.
2. Remove the oil pan, gasket, and oil filler tube from the transmission. Discard the gasket. Thoroughly clean the oil pan.

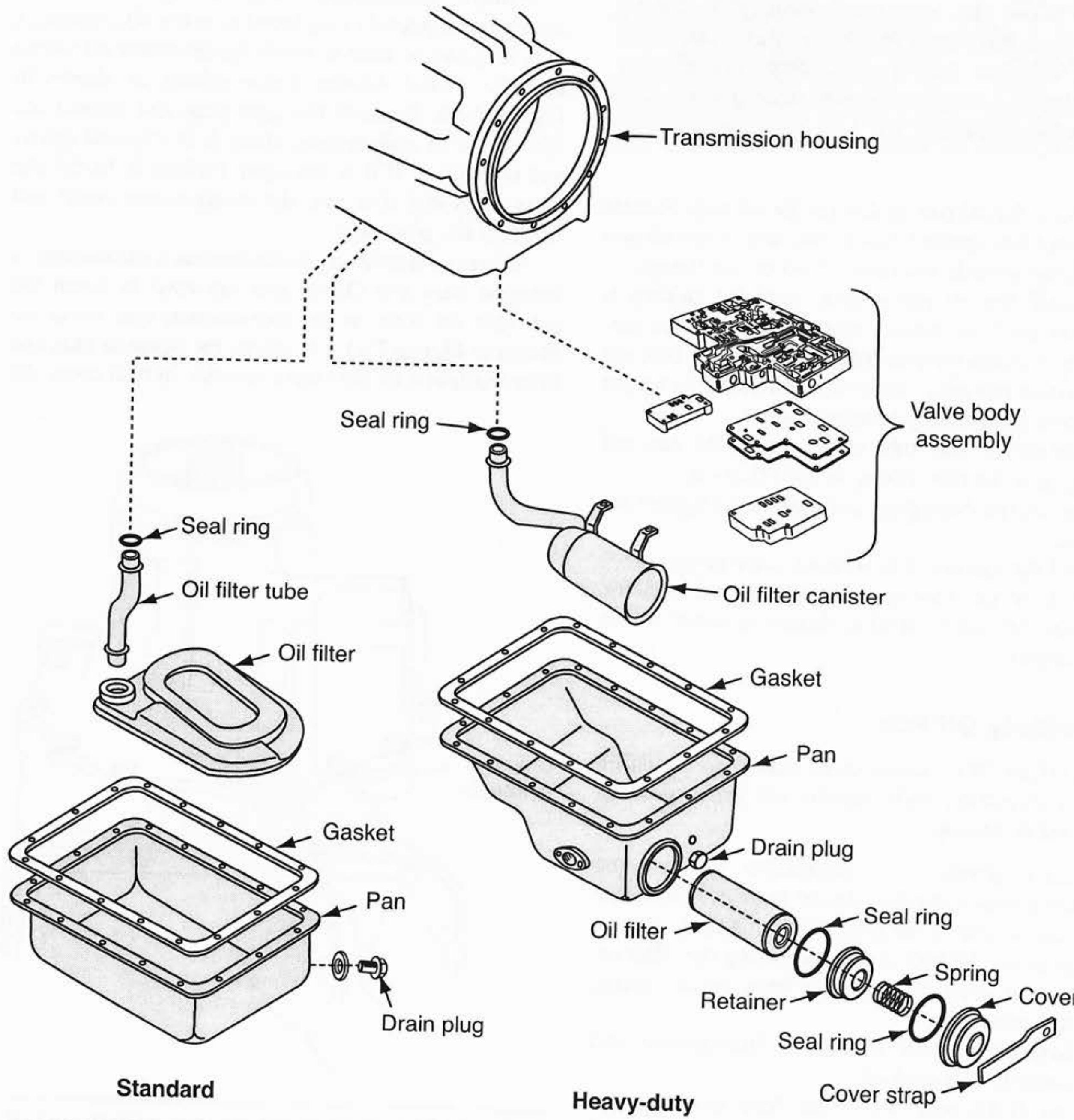


Figure 7-59 Typical transmission housing with a standard and a heavy-duty oil filter and oil pan configuration.

3. Remove the oil filter retaining screw. Remove the oil filter and discard it. The oil filter intake pipe is not part of the filter and should be kept for reinstallation.
4. Install the filter tube into the new filter assembly. Install a new seal ring onto the filter tube. Lubricate the seal ring with transmission oil. Install the new oil filter, inserting the filter tube into the hole in the bottom of the transmission. Secure the filter with the screw torqued to 10–15 feet pound.

CAUTION *Do not use gasket-type sealing compounds anywhere inside the transmission. If grease is used for internal assembly of the transmission components, use only greases approved by Allison.*

5. Place the oil pan gasket on the oil pan. Sealant should be applied only to the area of the oil pan flange outside the raised bead of the flange.
6. Install the oil pan gasket, carefully guiding it into position. Ensure that no dirt or other material enters the pan during installation. Turn the oil pan retaining screws by hand and then torque them sequentially to specification.
7. Install the filler tube at the side of the pan and tighten the tube fitting to specification.
8. Install the drain plug and gasket and tighten the plug.
9. Fill the transmission with oil to the proper level. Follow the OEM specifications for oil capacity. Recheck the oil level as described earlier in this chapter.

Heavy-Duty Oil Pan

The oil and filter change on an Allison transmission with a heavy-duty, high-capacity oil pan should be performed as follows:

1. After getting the transmission to operating temperature, remove the oil drain plug from the rear or side of the pan. Allow the oil to drain.
2. Remove the bolt and nut securing the filter retaining strap. Remove the filter cover, spring, and retainer.
3. Remove the filter. Discard the filter retainer and cover O-ring gaskets.
4. Install the seal ring on the filter retainer, then install the filter and retainer into the external access canister.
5. Install the cover seal ring onto the lip of the oil pan.
6. Install the spring onto the cover and place it over the filter retainer.
7. Install the strap, bolt, and nut to the pan and torque to specification.
8. Install the drain plug and tighten.
9. Fill the transmission with oil to the proper level. Follow the OEM specification for oil capacity. Recheck the oil level.

Governor Filter Change

Allison recommends that the governor filter screen be inspected or replaced at every oil change. A pipe plug can be used to retain the governor oil screen in older model Allison transmissions, as shown in **Figure 7-60.** Remove the pipe plug and inspect the filter. If it is undamaged, clean it in mineral spirits and reinstall it. If it is damaged, replace it. Install the filter open end first into the transmission cover and reinstall the pipe plug.

In later generation hydromechanical transmissions, a hexagon plug and O-ring seal are used to retain the governor oil filter in the transmission rear cover, as shown in **Figure 7-61.** On others, the hexagon plug and filter location is on the output retarder. In both cases, the

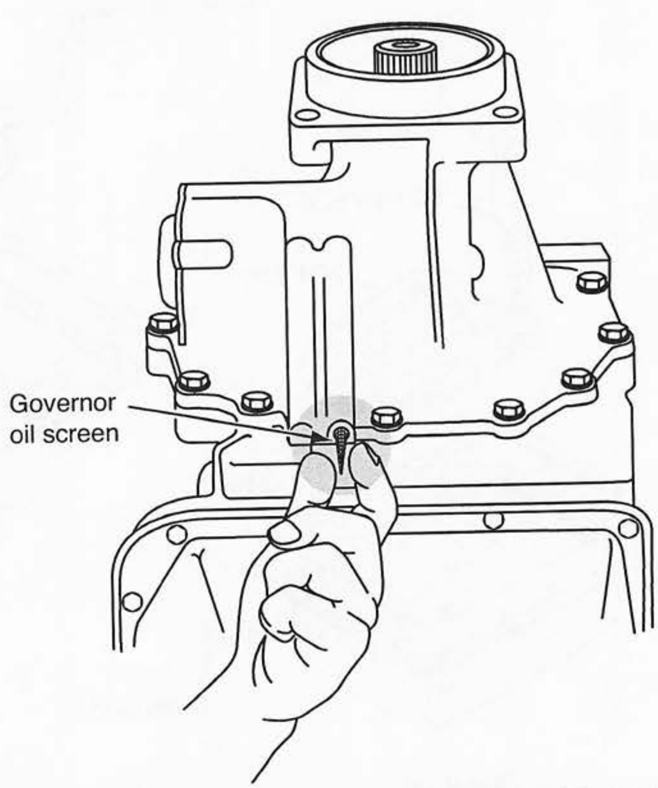


Figure 7-60 Location of the governor filter on early model transmissions.

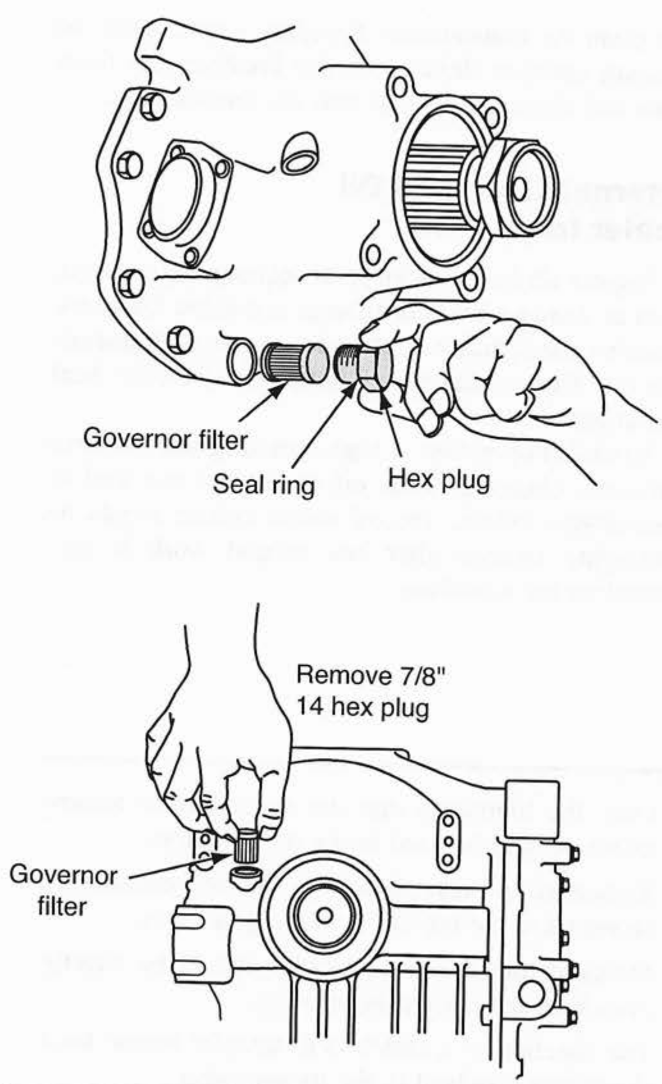


Figure 7-61 Location of the governor filter on later model transmissions.

O-ring and filter should be changed at every oil change. Remember to torque the plug to specifications.

Oil Contamination

At each oil change, examine the oil drained from the transmission for evidence of dirt or water. Trace condensation is normal; this will emulsify in the oil during operation. However, if there is visible evidence of water in the oil, check the transmission cooler for internal leakage between the coolant and oil circuits. Oil in the coolant circuit of the transmission cooler is another indication of leakage.

Metal Particles

When draining the oil from the transmission, inspect for any metallic flakes in the oil and on the magnetic drain plug (except for those minute particles normally trapped in the oil filter); these may indicate transmission damage. When larger metallic particles are found in the sump, the transmission should be disassembled and inspected to locate the source of the breakdown. Beyond locating the cause, metal contamination requires a complete disassembly of the transmission and cleaning of all internal and external circuits, cooler, and all other areas where the particles could lodge.

CAUTION *Metal contamination normally requires the replacement of all the transmission bearings.*

Coolant Leakage

If engine coolant leaks into the transmission oil circuit, action should be taken to prevent malfunction

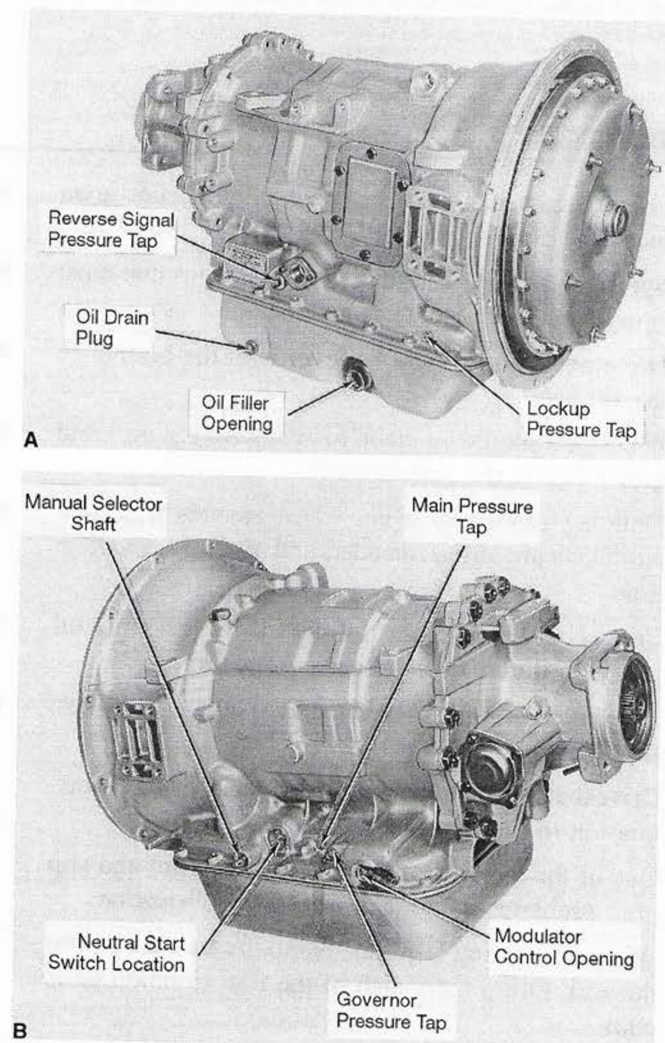


Figure 7-62 Breather location on top of a transmission housing; also note the position of the manual selector shaft, neutral start switch, modulator control opening, pressure taps, plugs, and other key components.

and complete failure. The transmission should be disassembled, inspected, and cleaned. All traces of the coolant and varnish deposits that result from coolant contamination should be removed.

Test kits can be used to detect traces of glycol in the transmission oil. You should note, however that certain additives in some transmission oil can produce a positive reading. If this is the case, a lab oil analysis should be performed.

Breathers

The **breather** is located at the top of the transmission housing (see **Figure 7-62**). It prevents pressure buildup within the transmission and should be kept clean and unplugged. Exposure to dust and dirt will determine the frequency with which the breather requires cleaning. Use care when cleaning it whenever you clean the transmission. Spraying steam, water, or cleaning solution directly on the breather can force water and cleaning solution into the transmission.

External Lines and Oil Cooler Inspection

Inspect all lines for loose or leaking connections, worn or damage hoses or tubing, and loose fasteners. Examine the radiator coolant for traces of transmission oil. The condition may indicate a defective heat exchanger.

Extended operation at high operating temperatures can cause clogging of the oil cooler and can lead to transmission failure. The oil cooler system should be thoroughly cleaned after any rebuild work is performed on the transition.

Summary

- Proper maintenance of the drive axle depends upon using the correct lubricant.
- Synthetic oils provide so many advantages that most component manufacturers endorse their use.
- Drive axle fluid should be level with the bottom of the fill hole.
- All efforts should be made to avoid mixing different gear lubes in the axle housing.
- Draining lubricants when warm ensures that contaminants are still suspended and also reduces drain time.
- The wheel bearings are lubricated by the same oil that is in the differential carrier housing.
- The driveshaft assembly is made of a U-joint, yokes, slip splines, and driveshafts.
- Driveshafts transmit engine torque from the transmission to the rear drive axles.
- One of the most common causes of U-joint and slip joint problems is the lack of proper lubrication.
- When lubricating U-joints, pump grease slowly into the zerk fitting until each of the four trunnion seals pops.
- Slip splines can be lubricated with the same grease that is used on the U-joints.
- Hanger bearings are usually lubricated for life by the manufacturer and are not serviceable.
- Only the lubricants that the manufacturer recommends should be used in the transmission.
- Transmission manufacturers almost exclusively recommend the use of synthetic gear lubes.
- Standard transmission lubricant should be exactly even with the filler plug opening.
- The function of a clutch is to transfer torque from the engine flywheel to the transmission.
- There are two styles of clutch adjustment mechanism: manually adjusted and self-adjusting clutches.
- All clutches are disengaged through the movement of a release bearing or throw-out bearing.
- The purpose of a clutch brake is to slow or stop the transmission input shaft from rotating, to allow gears to be engaged without clashing.
- Maintaining proper fluid levels in an automatic transmission is critical to the life and performance of the transmission.
- When draining the oil from the transmission, inspect for any metallic flakes in the oil and on the magnetic drain plug.
- The breather is located at the top of the transmission housing. It prevents pressure buildup within the transmission.

Review Questions

1. Technician A says that most OEMs recommend extended rear axle oil drain intervals when synthetic lubricants are used. Technician B says that the differential carrier should be flushed with kerosene at every oil change. Who is correct?

   A. Technician A
   B. Technician B
   C. Both technician A and B are correct.
   D. Neither technician A nor B is correct.

2. Which of the following would indicate that the level is correct when checking lube oil level in a differential carrier housing with the fill plug removed?

   A. Oil spilled from fill hole
   B. Oil level exactly even with bottom of fill hole
   C. Oil level within one finger joint of fill hole
   D. Oil level within 1 inch of fill hole

3. Which gear lube viscosity rating is usually recommended for use in a differential carrier for a truck operating in a temperature of −30°F?

   A. 75W
   B. 80W
   C. 80W-90
   D. 80W-140

4. Which type of lubricant is recommended when hypoid gearing is used in a differential carrier?

   A. API GL-4
   B. Synthetic lube only
   C. Any EP-rated lubricant
   D. Any API-rated lubricant

5. After a differential carrier overhaul, which of the following methods would best ensure that the wheel bearings receive proper initial lubrication?

   A. Fill the differential carrier to the interaxle differential fill hole.
   B. Fill the differential carrier through the axle breather.
   C. Jack the axle up at each side for one minute, then level and check fill hole level.
   D. Remove each axle shaft rubber fill plug and fill to the indicated oil level.

6. When planning to drain and replace the lubricant in a differential carrier, which of the following is preferred?

   A. Drain when the lubricant is at operating temperature.
   B. Flush with kerosene.
   C. Drain after allowing to cool overnight.
   D. Flush with solvent.

7. When a U-joint is lubricated, fresh grease appears at all four trunnion seals. Which of the following is probably true?

   A. The bearings are worn and should be replaced.
   B. The seals are worn and should be replaced.
   C. The trunnions are worn and the U-joint should be replaced.
   D. The U-joint has been properly lubricated.

8. The OEM recommendation for U-joint lubrication interval scheduling on a truck used for an on-highway operation should be:

A. every 10,000 to 15,000 miles.
B. once per year.
C. 3,000 to 5,000 miles.
D. every 50,000 miles.

9. Technician A says that when lubricating a U-joint and grease does not exit from one of the four trunnion seals, the U-joint must be immediately replaced. Technician B says that backing off the bearing cap on a U-joint sometimes helps a trunnion to take grease. Who is correct?

A. Technician A
B. Technician B
C. Both technician A and B are correct.
D. Neither technician A nor B is correct.

10. What is the function of a driveshaft slip spline joint?

A. It accommodates variations in driving angles.
B. It multiplies drive torque.
C. It allows the driveshaft to change length while transmitting torque.
D. All of the above

11. Which of the following OEM-approved lubricants would produce the longest service life in a standard transmission?

A. Synthetic E-500 gear lube
B. SAE 50 grade heavy-duty engine oil
C. Multipurpose or EP gear lube
D. SAE 50 grade transmission fluid

12. After breaking in a new transmission filled with E-500 lube on a truck used in a linehaul application, when should the first oil change take place?

A. Between 3,000 and 5,000 miles of service
B. After 25,000 miles of vocational service
C. After 100,000 miles of linehaul service
D. After 500,000 miles of linehaul service

13. Which of the following would indicate that transmission oil in a truck's standard transmission is at the correct level?

A. Oil is visible through the filler hole.
B. Oil is reachable with the first finger joint through the filler hole.
C. Oil is level with the bottom of the filler hole.
D. Oil is at the high level on the dipstick.

14. Which of the following conditions can cause aerated oil in automatic transmissions?

A. Low oil level
B. High oil level
C. A clogged breather
D. Both a and b

15. On most Allison transmissions, when the oil level reads at the FULL mark on the dipstick with the transmission at operating temperature, which of the following indicates the actual level of oil in the transmission?

A. If it is slightly below the planetary gearsets
B. If it is slightly above the top of the oil pan
C. If it is slightly above the ring gears
D. If it is at the axis of the sun gears

16. Which of the following could result in an inaccurate dipstick reading?
    A. Failure to wipe the dipstick clean before taking the reading
    B. A clogged breather
    C. An unvented oil filler tube
    D. All of the above

17. When performing an automatic transmission cold check level, at what temperature should the oil be?
    A. Between 0°F and 60°F
    B. Between 60°F and 120°F
    C. Between 120°F and 160°F
    D. Between 160°F and 200°F

18. What effect will an increase in oil temperature have on the transmission oil level?
    A. Lower the oil level
    B. Raise the oil level
    C. No effect
    D. Aerate the oil

19. The __________ is located at the top of the transmission housing, and its function is to prevent pressure buildup within the transmission housing.
    A. auxiliary filter
    B. governor
    C. breather
    D. release valve

20. How often should a clutch be inspected and lubricated?
    A. Every month
    B. Every 6,000 to 10,000 miles
    C. Any time the chassis is lubricated
    D. All of the above

21. When adjusting the clutch linkage, technician A says that pedal free travel should be about 1-1/2 to 2 inches. Technician B says that free travel should be less than 1/2 inch. Who is correct?
    A. Technician A
    B. Technician B
    C. Both technician A and B are correct.
    D. Neither technician A nor B is correct.

CHAPTER 8

Tire Hub Wheel and Rim Inspection

Objectives

Upon completion and review of this chapter, the student should be able to:

- Identify the different wheel configurations used in the trucking industry.
- Perform wheel inspections on the different wheel configurations used in heavy-duty trucks.
- Explain the difference between standard and wide-base wheel systems and stud- and hub-piloted mountings.
- Explain the importance of proper matching and assembly of tire and rim hardware.
- Describe brake drum mounting configurations.
- Explain the proper mounting procedures for the wheel configurations used on heavy-duty trucks.
- Perform wheel runout checks and adjustments.
- Explain the proper techniques for front and rear wheel bearing adjustment.
- Outline the procedures for installing preset bearing wheels.
- List the different types of tires used in the trucking industry based upon construction.
- Properly match tires in dual and tandem mounting.
- Explain inspection procedures for tires.
- Identify tire wear conditions and causes.

Key Terms

axial runout

bias ply

ConMet PreSet hub

footprint

hub-piloted

radial tires

scrubbing

scuff

stud-piloted

Technical and Maintenance Council (TMC)

tire square

Unitized Hub System

unsprung weight

zipper

INTRODUCTION

Wheel assemblies can be broken down into wheels, rims, tires, and hubs. Each of these components must be properly maintained, serviced, and inspected by the servicing technician. Because of the critical nature of wheel assemblies, there is no room for error, making it imperative that technicians be properly trained in all aspects of wheel inspection and service assembly. A new technician should never be afraid to ask questions of more experienced and qualified technicians. Any misdiagnosis or improperly repaired wheel component can mean potential disaster for the vehicle and all those who share the road with it.

SYSTEM OVERVIEW

This chapter begins by explaining the difference between the different styles of wheel assemblies that are available in the trucking industry and also explains mounting and proper torquing. This chapter also explains the reasons for retorquing wheel assemblies.

This chapter then explains the TMC recommendations for adjusting wheel bearings on trucks and trailers.

Tires are an expensive consumable item that must be serviced properly to achieve maximum service life. This chapter will explain how technicians identify the tire's construction type and size so as not to mismatch tires on the vehicle. It then discusses how to inspect the tire's serviceability and how to diagnose tire wear conditions and ends with the out-of-service criteria for tires.

WHEELS AND RIMS

The term *wheel* with regard to trucks can be used to describe the hub assembly to which the rims and brake drum (or rotor) are attached.

Today's trucks use one of two types of wheel configurations that are used along with several methods of attaching tire assemblies to the wheels. The two general types of wheels used are:

- Cast spoke wheels
- Disc wheels

With spoke wheels, the rim and wheel are separate components. On a disc wheel, the rim is a distinct section, a wheel assembly. Disc wheels can also be divided into the two ways in which they are fastened to the hub assembly:

- Stud-piloted
- Hub-piloted

CAST SPOKE WHEELS/ DEMOUNTABLE RIM SYSTEMS

The cast spoke wheel has been around for many years and was used almost universally, but this has changed as operators have come to understand the advantages of disc wheels. This being said, the cast spoke wheel has not outlived its usefulness and is by no means obsolete. These wheels have the disadvantage of being heavy, but they are tough and can withstand more punishment than disc wheels, making them a common choice for dump, construction, and refuse use, and for many leased trucks and trailers.

A spoke wheel consists of a one-piece casting that includes an integral hub and spokes (see **Figure 8-1**). Generally they are manufactured from cast steel, and the hub and wheel mounting surfaces are machined after casting. The tires of this assembly are mounted on a separate rim or rims. In dual applications (two tire/rim assemblies mounted on a wheel) a spacer band is positioned between the inner and outer rims in the manner shown in **Figure 8-2A.** This space band is clamped between the two tires and rims to provide exact spacing between them (see **Figure 8-2B**).

The spoke wheel may be found in three-, five-, and six-spoke configurations. The six-spoke designs are often used on heavily loaded front axle applications. Five

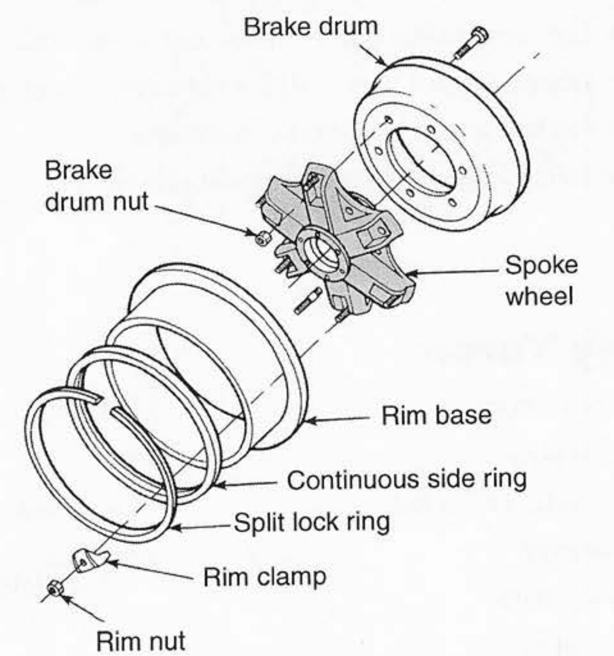


Figure 8-1 Components of a cast spoke wheel and multi-piece rim. *(Courtesy of Daimler Trucks North America)*

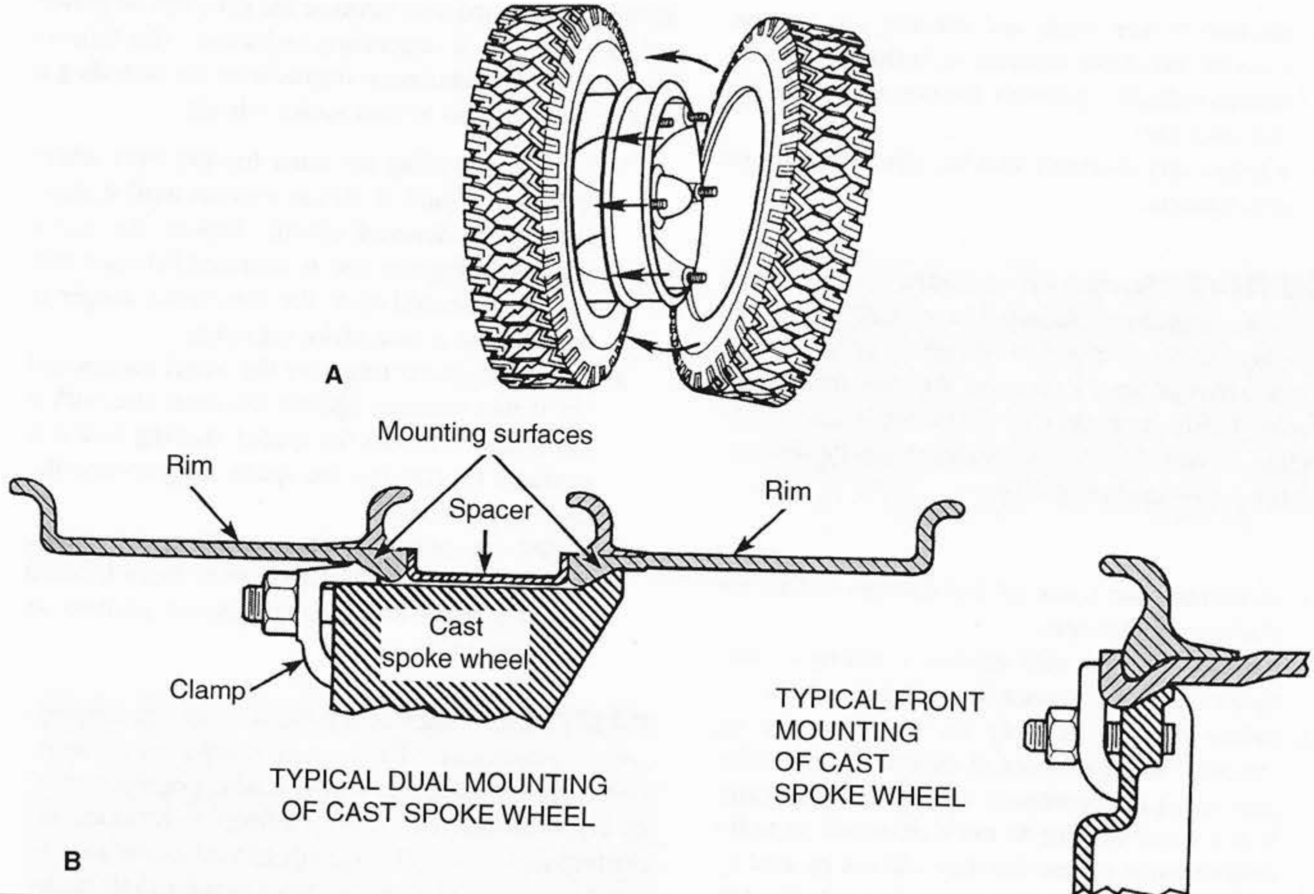


Figure 8-2 (A) Position of the spoke wheel dual mounting spacer band, and (B) cross-section view of mounted dual wheels. *(Courtesy of Navistar International Corp.)*

or six spokes are used on drive axle duals, but six-spoke designs are often preferred because of the added wheel clamping force on the rim, which reduces the chance of rim slippage. Three-spoke wheels have wide spokes, using two wheel clamps per spoke. Trailers are their most popular application.

From the diagram in **Figure 8-2**, you can see that there are many components that make up the spoke wheel assembly. They can use a multi-piece rim or single-piece rim that clamps to the spokes with wheel clamps.

Maintenance on these wheels is very critical, because if the clamps are not installed correctly, the tire/rim will produce a wobble condition known as **axial runout.** Axial wheel runout is more of a problem in cast spoke wheels than with disc wheels, but it can be minimized by following proper installation procedures and torquing sequences, and by checking runout after assembly. Although cast spoke wheels experience greater alignment and balance challenges because of their extra weight and rim mounting, they usually encounter fewer outright failure problems and, notably, fewer "wheel-off" incidents than disc wheel assemblies.

Wheel Inspections: Spoke Wheel/ Demountable Rim Systems

When servicing a vehicle, inspect the wheel system for the following:

1. Check that valve caps are installed. Replace if missing.
2. Check all metal surfaces thoroughly, including space bands and tire side or rims. Watch for:
   - Excessive rust or corrosion buildup
   - Cracks in metal
   - Bent flanges or components
   - Loose, missing, or damaged nuts, clamps
   - Bent, broken, or stripped studs
   - Incorrectly matched rim parts
   - Check valve locators for slip damage and improper location
3. Correct any problem that is discovered.

4. Replace broken studs and missing rim clamps. Uneven rim clamp advance or bottomed-out rim clamps indicate a problem. Loosen all rim clamps and retorque.
5. Replace any assembly that has damaged rims or components.

CAUTION *Excessively corroded or cracked rims are dangerous during the removal of the assembly. Deflate the tire (both tires if dual) before attempting to remove the rim from the vehicle. Verify deflation by installing a piece of mechanic's wire into the tire valve to assure debris has not prevented deflation.*

6. Determine the cause of the damage before installing another rim.
7. Replace any rim with excessive pitting or corrosion that has reduced the metal thickness.
8. Inflate the tires to only the recommended air pressure, being sure not to exceed the rim inflation rating in accordance with OSHA standards. It is a good practice to mark defective parts for destruction to ensure that they will not be used by mistake. Remember that a leak in a tubeless tire assembly can be caused by a cracked rim. Do not put a tube in a tubeless assembly to correct this problem. Cracked rims should be destroyed (use a torch) to avoid accidental reuse. Never attempt to weld or otherwise repair cracked, bent, or out-of-shape components: it is illegal as well as dangerous.

Shop Talk: Determine the cause of any damage before replacing a component to avoid the damage reoccurring.

Spoke Wheel/Demountable Rim Installation

When mounting the tire rim assembly onto the wheel, ensure that you have the correct studs, nuts, and clamps. Spoke wheels use rim studs. Rims studs are threaded on both ends with an anaerobic locking compound that essentially glues them into the spoke of the wheel. If a stud had been damaged, it must be removed with a stud remover and replaced.

Rim lug nuts should be kept tight and checked on a regular basis. Checking alignment of the rim/wheel installation is important because the rims can be pulled out of alignment if improperly tightened. The following are general installation instructions for installing a dual set of tire/rims to cast spoke wheels:

1. Start by installing the inner tire/rim over wheel spokes and push it all the way on until it stops against the tapered mount. Ensure the valve stem is facing out and is centered between two spokes. It should clear the disc brake caliper if installed on a disc brake assembly.
2. Install the spacer ring over the wheel spokes and tap it into position against the inner tire with a tire hammer. Check the spacer, making sure it is centered by rotating the spacer ring around the cast spoke wheel.
3. Install the outer tire/rim over the spoke wheel, making sure that the valve stem faces inboard and is located in the same relative position as the inner valve stem.

CAUTION *Take precautions when mounting wheel assemblies. Watch your fingers to prevent getting them pinched, and it is also good practice to wear gloves. Use proper lifting techniques to protect your back. Many professional wheel installers lift the wheel assembly from behind their body to prevent back injuries.*

4. Install all the wheel clamps and nuts. Turn the nuts on their studs until each nut is flush with the end of each stud. Tap the outside tire/rim with a tire hammer to keep it centered while you are doing this.
5. Using the diagrams in **Figure 8-3** as a guide, turn the top nut 1 until it is snug.
6. Rotate the wheel and rum until nut 2 is at the top position and snug the nut.
7. Rotate the wheel and rim until nut 3 is at the top position and snug the nut.
8. Rotate the wheel and rim until nuts 4, 5, and 6, respectively, are at the top and snug these nuts. Because the entire weight of the tire and rim assembly is on the top spoke, this crisscross sequence will help ensure an even application of force at all points in the rim, keeping the rim in alignment.
9. Repeat the sequence of tightening the nuts incrementally to the OEM torque.
10. After operating the vehicle for approximately 50 miles (80 km), check the lug nuts for tightness in the same tightening sequence. Check the wheel nut torque frequently and at all service intervals.

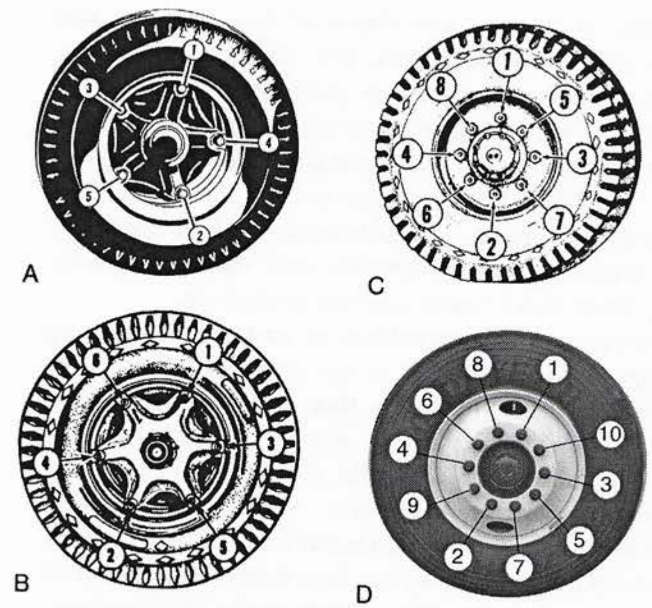


Figure 8-3 Wheel nut tightening sequence: (A) six lug, (B) five lug, (C) twelve lug, and (D) ten lug. *(Courtesy of Mack Trucks, Inc.)*

CAUTION *Correct components must be used. Spoke/demountable wheels use rim clamps to secure rims (which have no center bolting disc) to a hub or cast spoke wheel, which may have either three, five, or six spokes. The rim clamps, fastened by hex nuts, wedge the rim onto the cast spoke hub (see* ***Figure 8-4*** *). There are wheel designs with different numbers of rim clamps and of various shapes. Each spoke wheel requires rim clamps designed for the specific spoke wheel and designated rim. Dual rims are mounted using a space band, which holds the two rims apart and provides proper dual spacing for the tires, so it is imperative that the correct space band, rim, and clamp combinations be used for the application.*

RECOMMENDED MOUNTING TORQUE FOR DEMOUNTABLE RIMS

Stud Size	Torque Level ft.-lb. Dry
5/8"–11"	160–200
3/4"–10"	200–260

Spoke Wheel/Demountable Rim Runout

Whenever a spoke wheel is reinstalled, it must be checked for runout after it is torqued to specifications. To check runout, position a wooden block on the floor or tire hammer stood on end and position about 1/2 inch (13 mm) from the tire as shown in **Figure 8-5.**

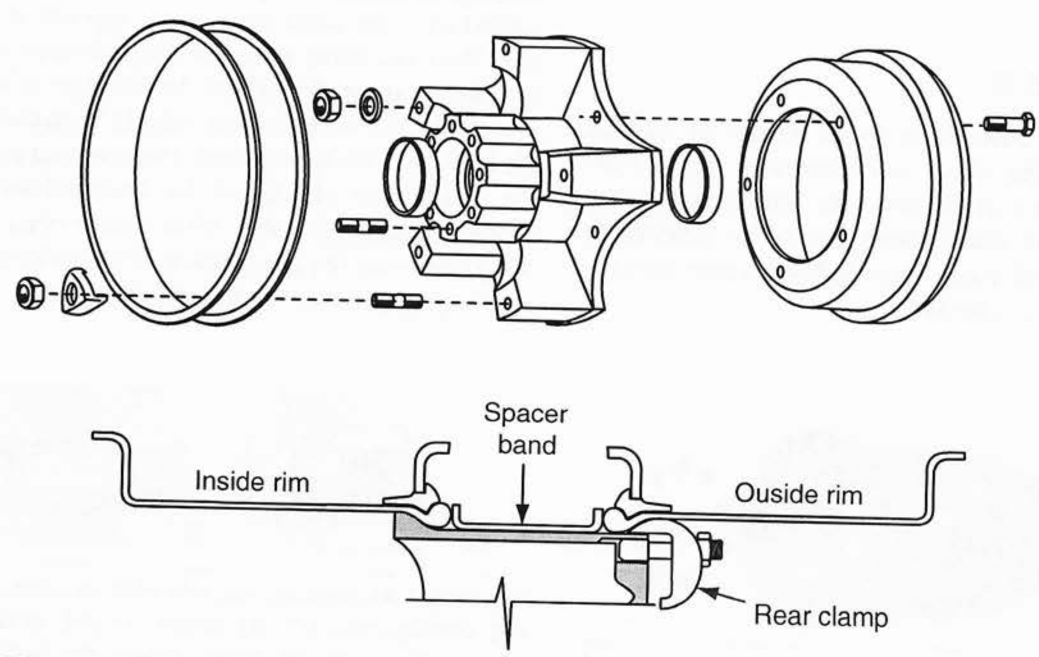


Figure 8-4 Spoke wheel end.

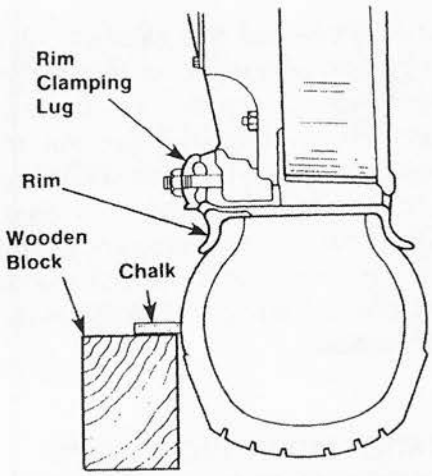


Figure 8-5 Checking tire runout using a wood block and chalk. *(Courtesy of Mack Trucks, Inc.)*

If the wheel runout exceeds 1/8 inch (3 mm), it should be corrected.

Position a piece of chalk on the wood block as shown and rotate the wheel through one revolution so that the chalk marks the tire high spots. The high and low (unmarked) areas indicate which lug nuts have to be loosened and which have to be tightened to correct the condition. Slightly loosen the lug nuts 180 degrees opposite to the chalk marks and tighten those on the chalk-marked side of the tire. Do not overtorque the nuts. Recheck runout and repeat until runout is within 1/8 inch (3 mm). If runout cannot be corrected in this way, inspect for part damage or dirt between the mating parts.

DISC WHEELS

Disc wheels differ from spoke wheels in that the tire rim forms the wheel and mounts to the hub assembly as shown in **Figure 8-6.** Stud holes in the center of the disc wheel allow them to be mounted to the hub studs with nuts. These hub studs pass through both rim and disc wheels.

One of the real advantages of disc wheels is that they run true and produce few alignment problems. Disc wheels use one-piece steel or aluminum construction, which makes them lighter, reducing vibration (and tire running temperatures) and extending tire life. Because of their ability to extend tire life, disc wheels are popular with cost-conscious fleet managers. By improving driver comfort and vehicle handling, they have also become a driver preference.

Because wheel assemblies are part of the **unsprung weight** (the weight that is not supported by the vehicle's suspension system), there is always a handling advantage to reducing their weight. The other advantage to reducing this weight is that payload can be increased, so aluminum disc wheels have steadily gained in popularity. Aluminum is not only lighter than steel but also dissipates heat faster, with the result that tires run cooler. Disc wheels can be used in single and dual configurations. There are also two different mounting systems for disc wheels: **stud-piloted** and **hub-piloted.**

Stud-Piloted Wheels

A stud-piloted mounting system is illustrated in **Figure 8-7A,** a single configuration. The wheel simply mounts onto studs on the hub and is secured using single cap nuts. **Figure 8-7B** shows a dual stud-piloted configuration for disc wheels.

In a dual mounting system, an inner cap nut, often called a cone, secures the inner wheel. The tapered shape of the nut secures the inner rim in addition to helping to center the wheel. The outer wheel is installed over the inner cone and a cap nut is installed onto the inner cone; again the tapered shape of the nut centers the outer disc wheel. In this type of mounting system, all the weight of the vehicle is placed between the studs and the wheel rims. The torquing procedures for stud-piloted wheels will be discussed later in this chapter. Stud-piloted disc wheels have been used less often following the introduction of hub-piloted wheels, which use a simpler mounting procedure.

Figure 8-6 Components of a typical disc wheel. *(Courtesy of the Budd Company)*

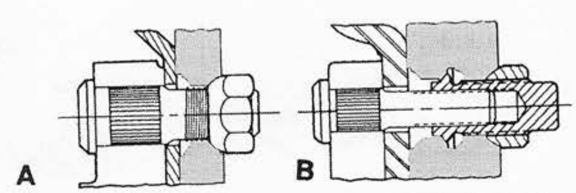


Figure 8-7 Aluminum disc wheel stud-piloted mounting configurations: (A) single wheel, and (B) dual wheel. *(Courtesy of Alcoa Wheel Products International)*

Hub-Piloted Wheels

The hub-piloted system is a much simpler mounting system for disc wheels compared to stud-piloted wheels. Both the inner and outer wheels are secured to the hub with only one nut per stud. The wheel hub has pilot pads around the circumference of the hub. The weight of the vehicle is transferred through these pilot pads to the wheels and not through the studs. The one-piece flange nut applies a clamping force to secure the wheel to the hub.

In stud-piloted systems, a loose inner nut can easily go undetected, eventually pounding out the nut ball seat. With hub-piloted systems, both the inner nut and its ball seats are eliminated.

CAUTION *Correct components must be used. It is important to note that some hub-piloted and stud-piloted wheels may have the same bolt circle pattern. Therefore, they could mistakenly be interchanged.*

Each mounting system requires its correct mating parts. It is imperative that the proper components be used for each type of mounting and that the wheels are fitted to the proper hubs.

If hub-piloted wheel components (hubs, wheels, fasteners) are mixed with stud-piloted wheel components, loss of torque, broken studs, cracked wheels, and possible wheel loss can occur, since these parts are not designed to work together.

Mixing hub-piloted and stud-piloted wheels will not allow the inner cap nut to fit into the inner wheel and will result in the inner cap nut interfering with the outer wheel (see **Figure 8-8**).

Ball seat, stud-piloted wheels should not be used with flange nuts because they have larger bolt holes and do not have sufficient area near the bolt hole to support the flange nut. Slippage may occur. Also, the center hole is too large to center the wheel (see **Figure 8-9**).

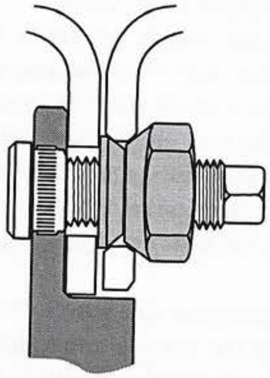


Figure 8-8 Using incorrect hardware to mount a wheel.

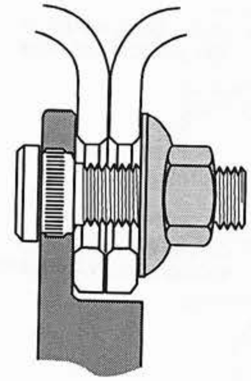


Figure 8-9 Using incorrect hardware to mount a wheel.

It is also important to note that hardware for stud and aluminum wheels cannot be randomly mixed. If stud and aluminum wheel hardware are mixed, loss of clamp load, broken studs, cracked wheels, or possible wheel loss can occur, since these parts are not designed to work together (see **Figure 8-10**).

If combinations of stud and aluminum wheels are used in a dual application, consult your wheel manufacturer for hardware recommendations.

Wide-Base Wheels

Wide-base wheels can also be referred to as high flotation, super singles, wide body, duplex, or jumbo

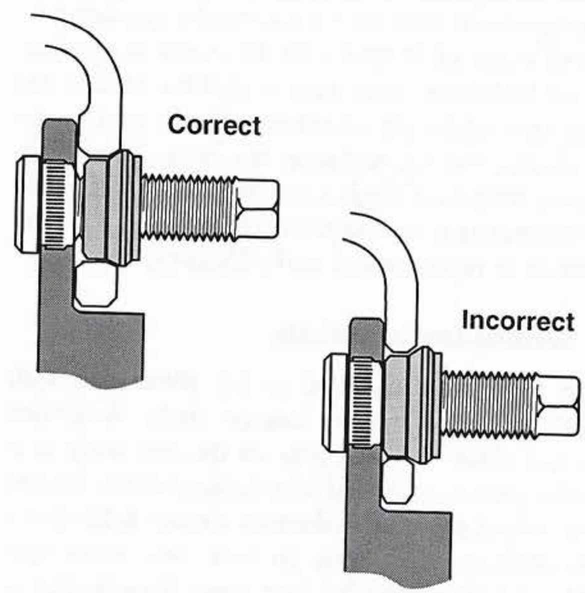


Figure 8-10 Using both correct and incorrect mounting hardware.

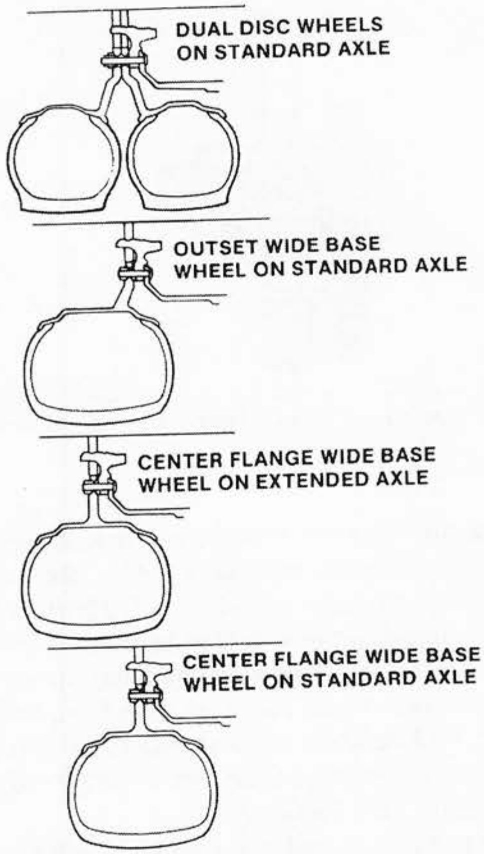


Figure 8-11 Wide-base wheel mounting compared to dual configurations. *(Courtesy of Navistar International Corp.)*

wheels. One wide-base wheel and tire replaces traditional dual wheels and tires. You can see some of the available configurations in **Figure 8-11.** If wide-base wheels were to be used for a tractor trailer combination, instead of a total of 18 tires, only 10 would be required: a pair of traditional steer tires would be used at the steering axle, and eight wide-base wheels used everywhere else on the rig, replacing the duals. The advantage of the wide-base single is that they are significantly lighter compared to steel dual wheels and tires, allowing an increase in payloads and fuel efficiency.

Disc Wheel Installation

Disc wheels are mounted to the wheel hub with threaded studs and nuts or headed studs. A headed wheel stud either has serrations on the stud body or a single flat groove machined into the head of the stud to prevent it from spinning in the hub. **Figure 8-12** shows the two different stud styles. In some disc wheel systems, the end of the stud that faces away from the hub is stamped with an "L" or "R" indication that the stud uses left- or right- hand threads. "R" studs are mounted

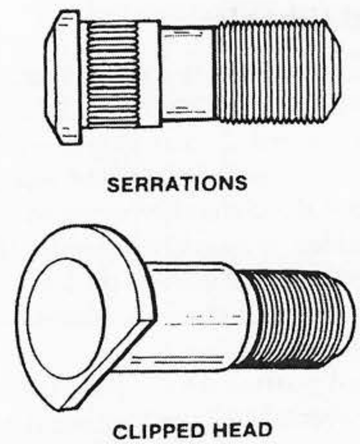


Figure 8-12 Headed wheel stud shanks for disc wheels. *(Courtesy of Daimler Trucks North America)*

on the passenger (curb or right) side of the vehicle. "L" studs are mounted on the road (driver's or left) side of the vehicle. This helps ensure that wheel rotation does not loosen the fasteners. Other systems use right-handed threads only. Whatever type of fastener is used, ensure that all hardware is in good condition.

Note: The right and left sides of the vehicle are always identified as if you were sitting in the driver's seat facing forward.

STUD-PILOTED DISC WHEEL INSTALLATION

The following are some general installation instructions for installing stud-piloted dual disc wheels that use conical (cones) nuts:

1. Slide the inner wheel (dual configuration) into position over the studs and push back as far as possible, taking care not to damage the threads of the studs and ensuring valve stem has clearance at the caliper (disc brakes).
2. Install the outer wheel nut for a single or the conical nut in a dual. Run the nuts on studs until they come into contact with the wheel. Rotate the wheel a half turn to allow parts to seat naturally.
3. Draw up the stud nuts alternately following the sequence (crisscross pattern), as illustrated in **Figure 8-13.** Do not fully tighten the nuts at this time.
4. Continue tightening the nuts to torque specifications using the same alternating method.
5. Install the outer wheel and repeat the preceding method. Be sure that both inner and outer tire valve stems are accessible.

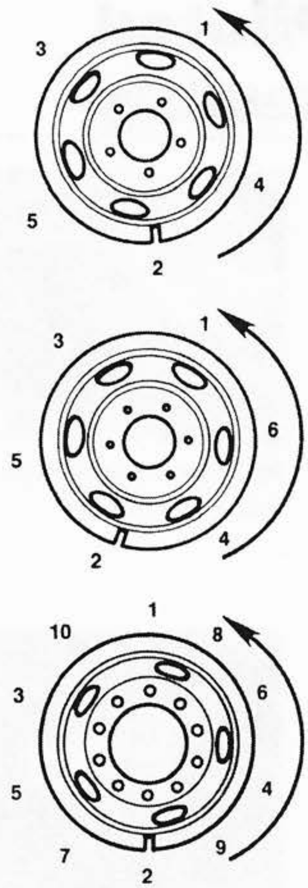


Figure 8-13 Torquing sequence for disc wheels. *(Courtesy of Navistar International Corp.)*

6. After the vehicle is operated for approximately 50 miles (80 km), the wheel should be retorqued. This is because the wheel will settle once the vehicle is operated; some nuts may become loose, so all nuts should be retorqued.

RETORQUING STUD-PILOTED DUALS

To retorque a dual configuration, both the inner and outer nuts must be checked. The problem is that you do not want to allow the wheels to relax during the process, or you will have accomplished nothing. To do this:

- Loosen the outer nut on every other stud.
- Check the torque on the inner cones.
- Retorque the outer nuts.
- Loosen the remaining outer nuts.
- Check the torque on those inner nuts.
- Retorque the outer nuts.

HUB-PILOTED DISC WHEEL INSTALLATION

Figure 8-14 illustrates a cross-section of a hub-piloted installation (see **Photo Sequence 6**). Follow these procedures when installing hub-piloted disc wheels:

1. Check the wheel nuts. Ensure that multi-piece nuts turn smoothly on their flanges. Discard all nuts with damaged threads.
2. Apply two drops of oil to a point between the nuts and flange and two drops to the last two or three threads at the end of each stud. Also, lightly lubricate the pilots on the hub to ease wheel installation and removal. Do not get lubricant on the mounting face of the drum or wheel.
3. Install the inner wheel of a dual configuration or the single steer wheel over the studs and push back as far as possible. Be sure not to damage the threads of the studs during installation.
4. Position the outer rear tire and wheel in place over the studs and push back as far as possible, again using care not to damage the studs.
5. Run the nuts onto the studs until the nuts contact the wheel(s). Rotate the wheel assembly a half turn to permit parts to seat.
6. Draw up the nuts alternately following the crisscross sequence illustrated in **Figure 8-14.** Do not fully tighten the nuts at this time. This allows uniform seating of the nuts and ensures even face-to-face contact of wheel and hub (see **Figure 8-15**).
7. Continue tightening the nuts to torque specifications using the same alternating sequence.

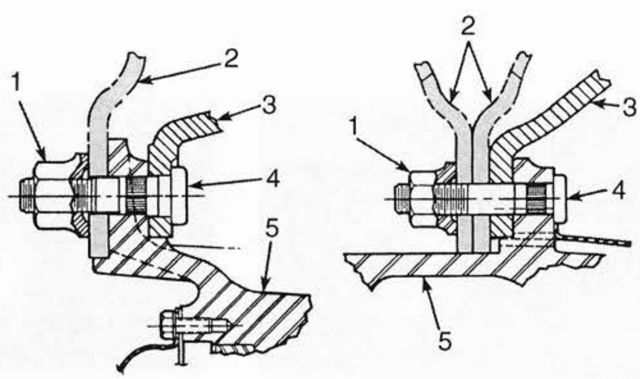
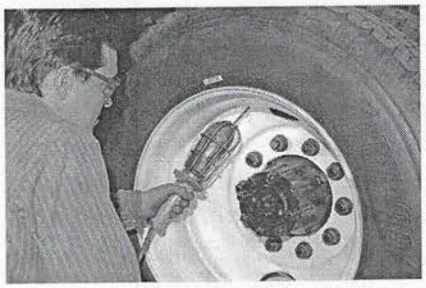


Figure 8-14 Cross-section of a hub-piloted disc wheel. *(Courtesy of Navistar International Corp.)*

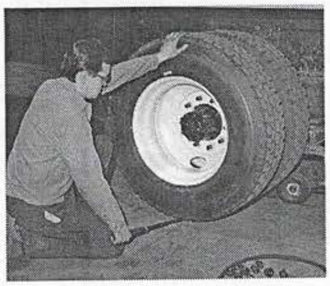
PHOTO SEQUENCE 6 Install a Set of Hub-Piloted Duals to a Wheel Assembly



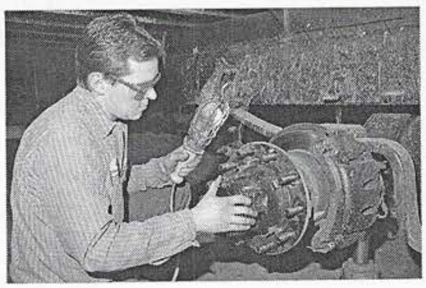
P6-1 Before beginning the disassembly of the wheel, perform a visual inspection. Check that the wheel nuts are properly engaged and look for damaged studs.

P6-2 Remove rust and road dirt from the wheel studs with a wire brush.

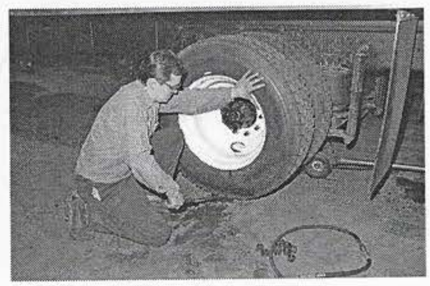
P6-3 Use an air gun to remove the wheel nuts.



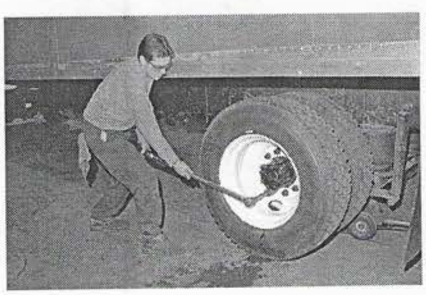
P6-4 Carefully remove the wheels, ensuring that they are not dragged over the studs damaging the threads.



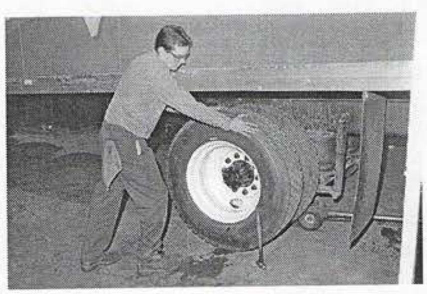
P6-5 Before reassembling the wheel, clean the hub, wheel, and hub/brake drum mounting faces of rust, dirt, and loose paint. Visually inspect all the studs. Do not paint or apply any other substance on the mounting faces.



P6-6 If an outboard mounted drum is used, make sure that the brakes are released and lift the drum into position, ensuring that it is not sitting on the pilot ledge. Lubricate the fasteners. (Hubpiloted studs must be lightly lubricated to ensure that the correct amount of clamping force is achieved.) Mount the wheels to the hub.



P6-7 Tighten the wheel nuts in sequence in three stages using a torque wrench. First-stage torque value should be 50 ft.-lb. Second-stage torque should be between 50 and 80 percent of the final torque value. Final torque values are listed at right.



P6-8 As a final step, check the wheel runout by rotating the wheel through a full revolution. Do not attempt to correct a runout problem by loosening and retorquing the nuts: disassemble the wheel assembly and locate the problem.

Typical Torque Values for Steel Disc Wheels

Socket Size	Thread Size	Torque Specification
$1\frac{1}{2}$" or 38 mm	M22 × 1.5	450–500 lb.-ft.
30 mm	M20 × 1.5	280–330 lb.-ft.

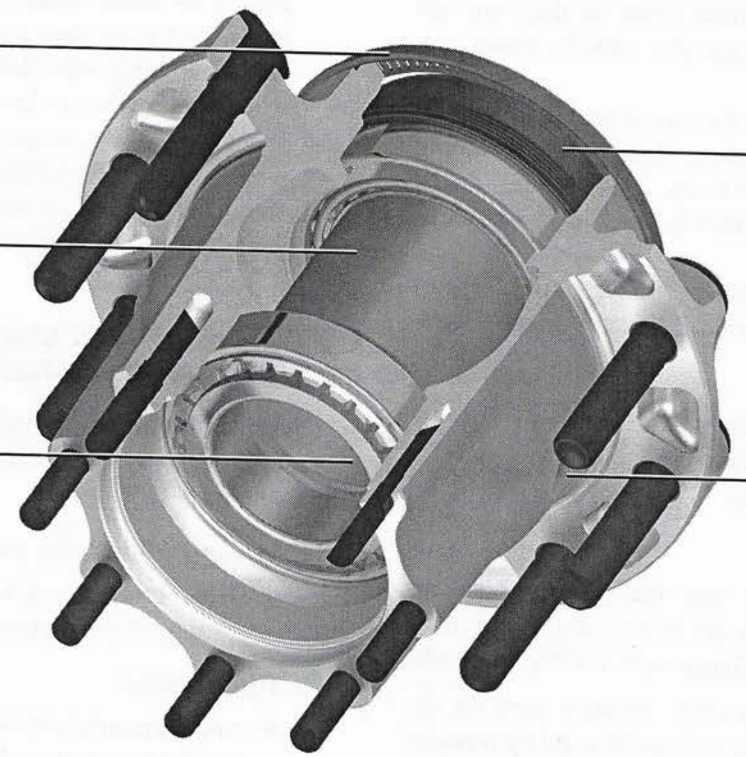


Figure 8-15 ConMet PreSet hub. *(Courtesy of ® Consolidated Metco, Inc.)*

RETORQUING HUB-PILOTED WHEELS

After the vehicle is operated for approximately 50 miles (80 km), the wheel should be retorqued. The retorquing process for hub-piloted disc wheels is a simpler task in dual configurations as opposed to stud-piloted disc wheels.. Simply take a torque wrench and, using the same crisscross pattern as previously mentioned, torque all the wheel studs.

Shop Talk: Whenever the vehicle is in to the shop for service, the torque of the wheel studs should be rechecked.

Wheel Inspections: Disc Wheels

When servicing a vehicle, inspect the wheel system for the following:

1. Check that valve caps are installed. Replace if missing.
2. Missing or worn nuts: If missing or worn, replace. Retighten all other nuts to the proper torque. The inner nuts on both sides of a broken inner cap nut should also be replaced.
3. Broken studs: If a stud is broken, replace it and the stud on each side of the broken one. If two or more studs are broken, replace them all. Use a press to install studs and be sure the hub flange is supported. Aluminum hubs require different stud installation procedures. Consult the OEM for procedures. Stud heads can be bent from hammer blows, which will prevent the stud from seating properly and can result in stud failure.
4. Rust streaks extending from the bolt holes: This indicates either worn, poor-quality, or loose wheel nuts. Make sure the correct nuts for the wheel system are being used, inspect wheel bolt holes for wear or damage, and then tighten fasteners to the correct torque. Then remove rust streaks.
5. Cracks in washers of hub-piloted wheel nuts: Replace damaged nuts and tighten to the proper torque.
6. Variations in the number of stud threads that protrude beyond the nuts indicate loose, backed-off wheel nuts. Check all components for damage.

7. Wheels not seated on pilots of hub-piloted mounting: Remove the wheels and inspect the wheels, hub, and brake drum. If they are not damaged, reinstall on the vehicle using the correct procedures.
8. Cracks or damage on any wheel component: Check all metal surfaces thoroughly, including both sides of the wheels and between duals. Replace any wheel that is cracked or has damaged components.
9. Replace any rim with excessive pitting or corrosion that has reduced the metal thickness.

Shop Talk: Determine the cause of any damage before replacing a component to avoid the damage reoccurring.

10. Inflate the tires to only the recommended air pressure, being sure not to exceed the rim inflation rating in accordance with OSHA standards.

It is a good practice to mark defective parts for destruction to ensure that they will not be used by mistake. Remember that a leak in a tubeless tire assembly can be caused by a cracked rim. Do not put a tube in a tubeless assembly to correct this problem. Cracked rims should be destroyed (use a torch) to avoid accidental reuse. Never attempt to weld or otherwise repair cracked, bent, or out-of-shape components; it is illegal as well as dangerous.

RECOMMENDED MOUNTING TORQUE FOR DISC WHEELS

Mounting Type	Nut Thread	Torque Level ft.-lb. Oiled*
Hub-piloted with flange nut	11/16"–16"	300–400
	M20 X 1.5	280–330
	M22 X 1.5	450–500
		ft.-lb. Dry
Stud-piloted, double cap nut standard type (7/8" radius)	3/4"–16"	450–500
	1-1/8"–16"	450–500
Stud-piloted, double cap nut heavy duty type (1-3/16" radius)	15/16"–12"	750–900
	1-1/8"–16"	750–900
	1-5/16"–12"	750–900

*See Hub-Piloted Disc Wheel Installation step 2

Note: If using specialty fasteners, consult the manufacturer for recommended torque levels.

- Tightening wheel nuts to their specified torque is extremely important. Undertightening, which results in loose wheels, can damage wheels, studs, and hubs and can result in wheel loss. Overtightening can damage studs, nuts, and wheels and result in loose wheels as well.
- Regardless of the torque method used, all torque wrenches, air wrenches, and any other tools should be calibrated periodically to ensure the proper torque is applied.

OUT-OF-SERVICE CRITERIA FOR WHEELS, RIMS, AND HUBS

(Taken from the North American Standard Out-of-Service Criteria by the Commercial Vehicle Safety Alliance, April 1, 2006)

1. **Lock or Slide Ring (multi-piece wheel)**
   - Bent, broken, cracked, improperly seated, sprung, or mismatched ring(s)
2. **Rim Cracks**
   - Any circumferential crack except on intentional manufactured crack at a valve stem hole
3. **Disc Wheel Cracks**
   - Any single crack 3" (76 mm) or more in length
   - A crack extending between any holes, including hand holes, stud holes, and center hole
   - Two or more cracks any place on the wheel
4. **Stud Holes (Disc Wheels)**
   - Fifty percent or more elongated stud holes (fasteners tight)
5. **Spoke Wheel Cracks**
   - Two or more cracks more than 1" (25 mm) long across a spoke or hub section
   - Two or more web areas with cracks
6. **Tubeless Demountable Adapter Cracks**
   - Cracks at three or more spokes
7. **Fasteners**
   - Loose, missing, broken, cracked, or striped (both spoke and disc wheels) ineffective as follows: for ten fastener positions—three anywhere or two adjacent; for eight fastener positions or fewer (including spoke wheels and hub bolts)—two anywhere.

8. **Welds**
   - Any cracks in welds attaching disc wheel to rim
   - Any crack in welds attaching tubeless demountable rim to adapter
   - Any welded repair on aluminum wheel(s) on a steering axle
   - Any weld repair other than disc to rim attachment on steel disc wheels(s) mounted on the steering axle
9. **Hubs**
   - When any axle bearing (hub) cap is missing or broken, allowing an open view into hub assembly
   - Smoking from wheel hub assembly due to bearing failure

Note: Not to be associated with smoke from dragging brake.

WHEEL BEARING ADJUSTMENT

There has been an unacceptable number of heavy truck wheel-off incidents in the United States and Canada, some of which have been the result of improperly adjusted wheel bearings. For this reason, all the manufacturers of wheel-end hardware have approved a single method of wheel bearing adjustment. This method was agreed to through a meeting of the **Technical and Maintenance Council (TMC)** committee of the American Trucking Associations, and the trucking industry has embraced this single standard throughout the continent. Wheel bearing adjustment is a simple but highly critical procedure. It is recommended that technicians learn the procedure, follow it precisely, and use no other method of adjusting wheel bearings. The TMC-recommended procedure is reprinted here, word for word.

CAUTION *The TMC adjustment procedure explained here does not apply to hubs with preset bearings and seal assemblies.*

TMC Wheel Bearing Adjustment

This procedure was developed by the TMC's Wheel End Task Force, and it is important to remember that it represents the combined input of manufacturers of wheel and components. **Photo Sequence 7** runs through the procedure outlined below:

- Step 1. Bearing Lubrication. Lubricate the wheel bearing with clean lubricant of the same type used in the axle sump or hub assembly.
- Step 2. Initial Adjusting Nut Torque. Tighten the adjusting nut to a torque of 200 ft.-lb; while rotating the wheel.
- Step 3. Initial Back-Off. Back the adjusting nut off one full turn.
- Step 4. Final Adjusting Nut Torque. Tighten the adjusting nut to a final torque of 50 ft.-lb, while rotating the wheel.
- Step 5. Final Back-Off, use **Table 8-1.**
- Step 6. Jam Nut Torque, use **Table 8-2.**
- Step 7. Acceptable End Play. The dial indicator should be attached to the hub or brake drum with its magnetic base. Adjust the dial indicator so that its plunger is against the end of the spindle with its line of action approximately parallel to the axle of the spindle. Grasp the wheel or hub assembly at the three o'clock and nine o'clock positions. Push and pull the wheel-end assembly in and out while oscillating the wheel approximately 45 degrees. Stop oscillating the hub so that the dial indicator tip is in the same position as it was before oscillation began. Read the bearing end play as the total indicator movement. Acceptable end play is 0.001–0.005 inch.

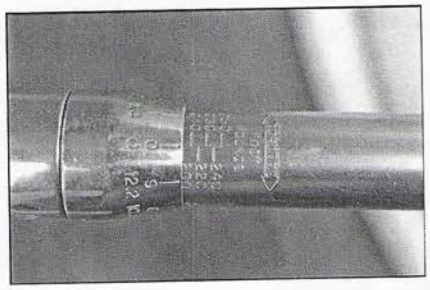
This is a simple hands-on procedure that you must become familiar with before working on the shop floor. Observing the TMC wheel-end procedure takes only a little longer than the numerous shortcut methods that result in hit-or-miss adjustments that make our roads unsafe.

TABLE 8-1: FINAL BACK-OFF

Axle Type	Threads Per Inch	Final Back Off
Steer (single nut)	12	1/6 turn*
	18	1/4 turn*
Steer (double nut)	14	1/2 turn
	18	1/2 turn
Drive	12	1/4 turn
	16	1/4 turn
Trailer	12	1/4 turn
	16	1/4 turn

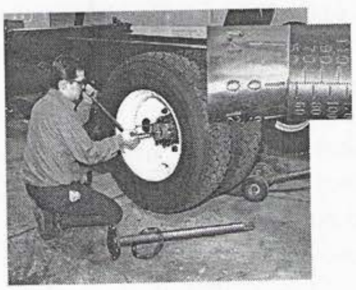
PHOTO SEQUENCE 7 Wheel-End Procedure: TMC Method of Bearing Adjustment

P7-1 Torque the adjusting nut to 200 ft.-lb. to seat the bearing. Ensure that the wheel is rotated during torquing.

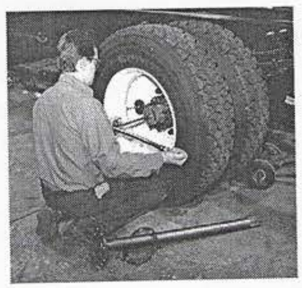


P7-2 Torque wrench specification should read 200 ft.-lb.

P7-3 Now back off the adjusting nut one full turn; this will leave the wheel assembly loose.

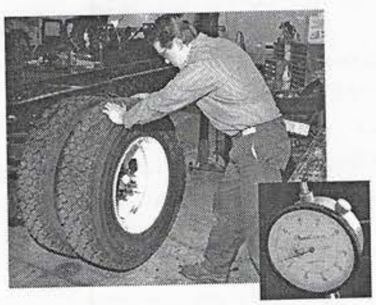


P7-4 Now torque the wheel adjusting nut to 50 ft.-lb. while rotating the wheel.



P7-5 To establish endplay, back off the wheel adjusting nut: The amount of rotation required to back off the nut will depend on the tpi (threads per inch). For a typical 12-tpi axle spindle, the adjusting nut should be backed off ${}^{1}/_{4}$ of a turn.

P7-6 Use a jam nut and locking plate on double nut systems. Torque the locking nut to specification. Generally, jam nuts $2\ {}^{5}/_{8}$ inch(hex diameter) or less are torqued to 200–300 ft.-lb. and those larger than $2\ {}^{5}/_{8}$ inch (hex diameter) are torqued to 250–400 ft.-lb. Check OEM specifications.



P7-7 Now verify that endplay exists. Install a dial indicator on the axle spindle and apply a rocking force to the wheel assembly. The endplay reading on the dial indicator must be between 0.001 inch and 0.005 inch. If not within specification, the complete procedure must be repeated.

Remember, the consequences of not observing correct wheel-end procedures are wheel-off incidents that can kill.

TABLE 8-2: JAM NUT TORQUE		
Axle Type	**Nut Size**	**Torque Specification**
Steer (double nut)	Less than 2 5/8" 2 5/8" and over	200–300 ft.-lb. 300–400 ft.-lb.
Drive	Dowel type washer Tang type washer	300–400 ft.-lb. 200–275 ft.-lb.
Trailer	Less than 2 5/8" 2 5/8" and over	200–300 ft.-lb. 30–400 ft.-lb.

CAUTION *A truck wheel-off incident can have fatal consequences. When such an incident occurs at highway speeds, any other vehicle on the road is not the match for the weight of a bouncing wheel assembly. Wheels have been falling off trucks since trucks first traveled our highways. However, our roads are more congested today, and the consequences tend to be more severe. The media have rightly placed some focus on such incidents and forced the trucking industry to take action. The first thing that can be said about wheel-off incidents is that they are almost always related to a service practice error. In few cases is the cause sourced to equipment failure. For this reason, anybody working in the trucking industry must become aware of what is required to safely work on wheel ends.*

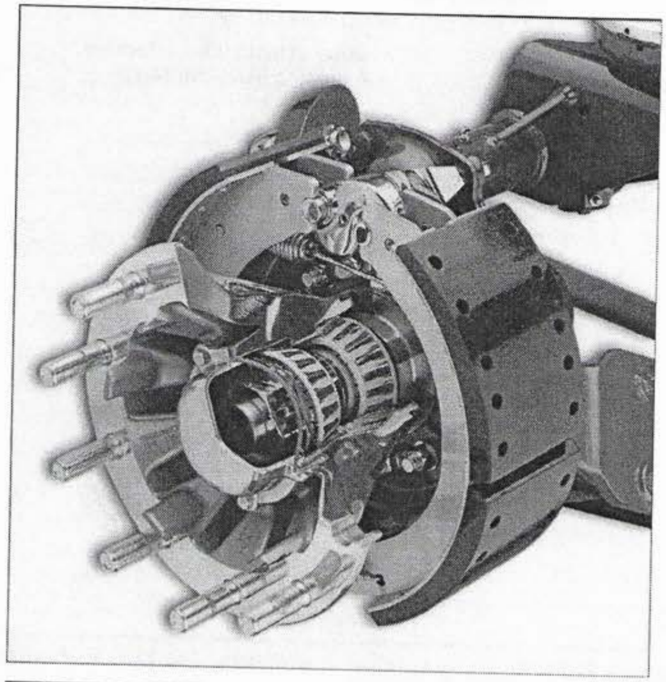


Figure 8-16 Dana Spicer UHS. *(Courtesy of Dana Spicer® UHS Unitized Hub)*

Preset Hub Assemblies

In response to wheel-off incidents, most OEMs have made preset (bearing) and unitized hub systems available. A preset hub is a preadjusted but serviceable assembly, where a unitized hub is preadjusted and nonserviceable. A couple of examples are the **ConMet PreSet hub** assembly and the Dana Spicer **Unitized Hub System** (UHS). These types of hub systems are projected to become adopted almost universally over the coming years, if for no other reason than they limit the liability fleets and service facilities have assumed over wheel-off incidents.

The ConMet PreSet hub uses a precision-dimensioned spacer between the tapered roller bearings in the axle hub that allows the assembly to be torqued to 300 ft.-lb. on installation, eliminating bearing adjustment by the technician. The ConMet PreSet hub is shown in **Figure 8-15.** They are available for truck steer axle, drive axle, and trailer axle hubs.

The Dana Spicer Unitized Hub System more recently introduced represents an improvement on the low maintenance system (LMS) for hubs that was similar to the ConMet PreSet hub. It unitizes the key hub components and lubricates them with synthetic grease for life. This eliminates the need for bearing adjustment, seal replacements, and even periodic lubrication top-ups. The USH hub is shown in **Figure 8-16.**

WHEEL END SUMMARY

Make sure you know exactly what you are working with when servicing wheel ends. If you are not sure, ask questions. Learn how to identify wheel ends that require bearing adjustments and the newer preset hubs. After having made a wheel bearing adjustment, make sure that you lock and set the adjusting nut with the appropriate locking/jam mechanism. **Figure 8-17** shows some examples of wheel-end bearing setting mechanisms.

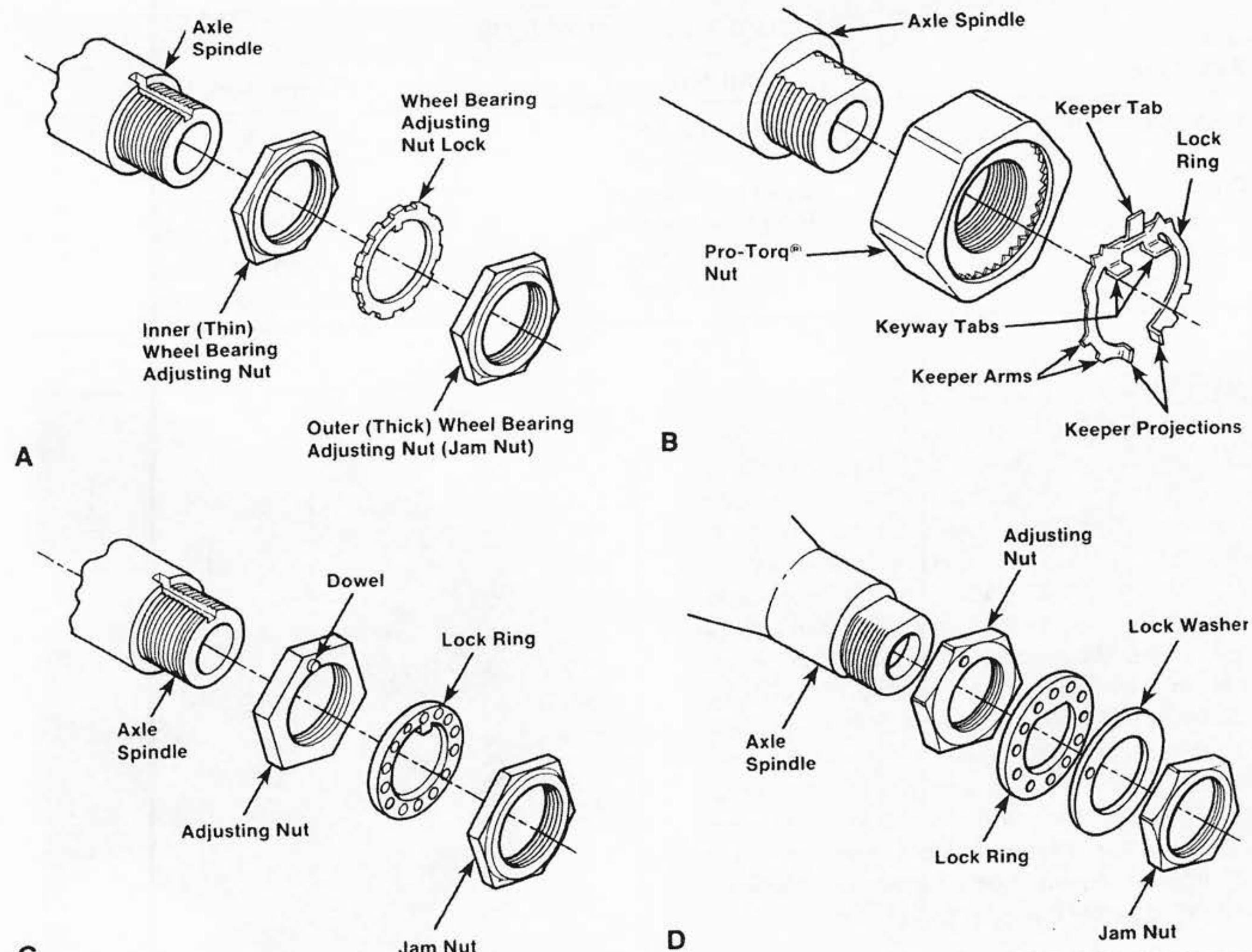


Figure 8-17 Bearing setting hardware: (A) jam nut and D-shaped lock ring, (B) Pro-Torq nut, (C) Eaton axle with adjusting nut and jam nut, and (D) Rockwell axle with adjusting nut and jam nut. *(Courtesy of Daimler Trucks North America)*

TIRES

The trucking industry generally uses one of two basic types of tire construction: **bias ply** and **radial tires.** It is important that the technician be able to distinguish the difference between the two because radial and bias ply tires should never be mixed on the same axle. Radial and bias ply tires differ in their tread profile, surface contact, and handling characteristics. Tire manufacturers recommend using one type of tire construction on all axles on a vehicle.

Dual wheels should never have mismatched tires. The tires on an axle should be of the same construction, tread pattern, and nominal size. Mismatched tires on opposite sides of the same axle can cause drive axle failure by continually working the differential. This can happen even if the bias ply and radial tires are the same size; the tire side walls don't flex at the same rate, causing the radial diameter to become smaller under load and producing a different dynamic **footprint.** Footprint is the tread-to-road contact area of a tire at a given moment of operation. Radial tires tend to have a constantly changing footprint in operation, and they tend to bounce down the road. The action can cause cyclic overloading of bias ply tires if mixed with radial tires. If the vehicle has two or more drive axles, the tires on the drive axles should be either all bias ply or all radial.

Figure 8-18 shows a comparison of the static contact footprint of bias ply and radial tires.

Tire Size

The size of any type of tire can be obtained by the information printed on the sidewall of the tire. It is

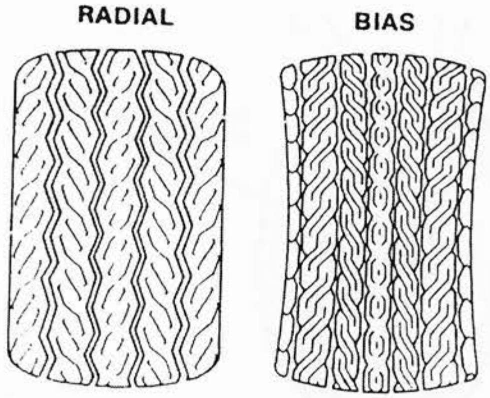


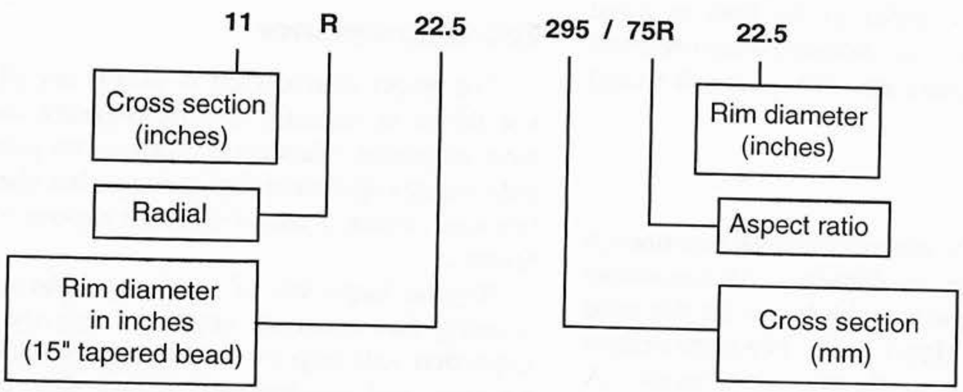
Figure 8-18 Comparison of footprint between a radial and bias ply-type truck tire. *(Courtesy of Bridgestone Firestone Tire Sales Co.)*

important that the technician be able to compare the sidewall information to ensure that all the tires are the same size. See **Figure 8-19** for a breakdown on sidewall information.

Matching of Dual Wheels

Mismatched tire sizes for dual wheel assemblies has the same effects on tire wear as does running with one wheel overloaded or underinflated. An underinflated tire on a dual assembly shifts its share of the load to its mate, which then becomes overloaded and may fail prematurely. A difference of 15 psi inflation may result in the lesser inflated tire supporting 500 pounds less than the tire with the proper inflation. A similar action occurs when one tire's diameter is smaller that its mate's. A difference of 1/4 inch in diameter may result in the larger tire carrying 600 pounds more than the smaller. The shift in load becomes greater as the difference in diameter increases.

Improperly matched duals are subject to rapid tread wear because the larger tire carries more load and will wear fast and unevenly. Even though mismated duals have differing diameters, they must rotate at the same speed. This will cause the smaller tire to wear because the outside diameter of the tire travels a shorter distance,



More recently the trend has been towards low profile tires. These are usually tubeless tires designed for either 22.5" or 24.5" diameter wheels. The most common low profile tires are listed below showing conventional sizes which they normally replace.

Low profile sizes	Conventional sizes
295/75R22.5 (275/80R22.5)	10.00R20, 11R22.5
285/75R24.5 (275/80R24.5)	10.00R22, 11R24.5

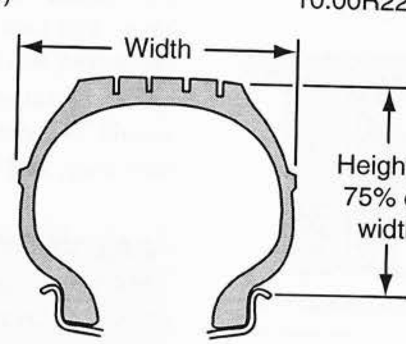


Figure 8-19 Breakdown of tire sidewall information.

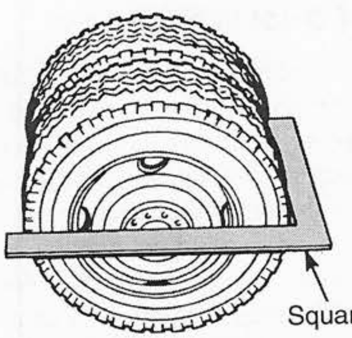


Figure 8-20 Using a square to check dual tire matching. *(Courtesy of Daimler Trucks North America)*

which will cause it to **scuff** (skid) over the road. The overall result is abnormal and unequal tread wear for both tires.

Checking Dual Mating

Check dual tire assemblies for proper mating with a **tire square.** This is the standard method of checking dual diameter matching on the vehicle (see **Figure 8-20**). The square must be placed parallel to the floor to avoid the tire "bulge." Measure the distance (if any) between the tire tread and the square arm with a ruler. It should not exceed 1/4 inch.

Straightedge

A straightedge can be placed across the four tires on a dual axle to compare tire diameters. Measurements should be taken from the straightedge to the tire tread where gaps show (see **Figure 8-21**). The measurement should be doubled to obtain the diameter difference. A taut string can be used in place of the straightedge.

Tape Measure

A flexible tape measure can be used to check the circumference of an unmounted tire (see **Figure 8-22**). Make sure the tape runs around the tread centerline of

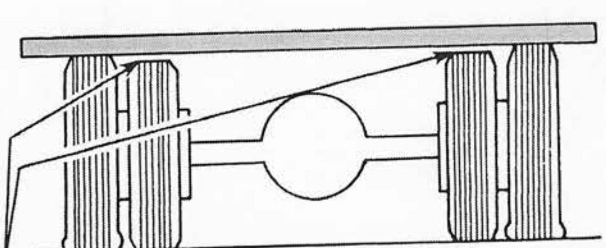


Figure 8-21 A straightedge positioned across the tires will detect difference in tire size. *(Courtesy of Daimler Trucks North America)*

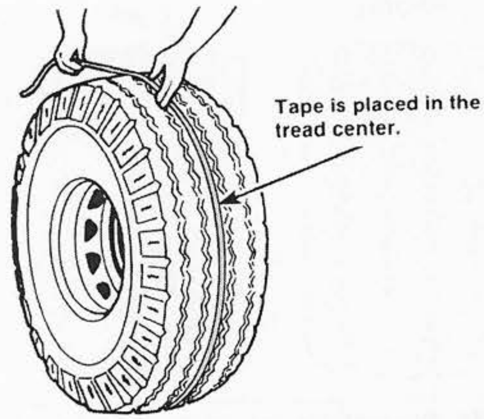


Figure 8-22 Measuring tire circumference with a flexible tape measure. *(Courtesy of Daimler Trucks North America)*

the tire. A difference of 3/4 inch in circumference is normally acceptable in mated tires.

The smaller of the two tires should always be mounted on the inside wheel position of the dual tire assembly.

Tire Maintenance

The proper maintenance of tires is one of the easiest things to maintain but unfortunately one of the most neglected. Maintaining correct tire pressure not only ensures optimized fuel economy but also reduces tire wear, which is one of the most expensive areas to maintain.

Regular inspection of tires is the first step in increasing fuel economy and tire longevity. Regular inspection will help to identify underinflation, overinflation, and misalignment before they can cause damage. Minor damage that can be detected and repaired during an inspection can sometimes save a tire that would otherwise blow out.

TIRE PRESSURE CHECK

Tire pressure should be checked weekly, every time the vehicle enters the shop, or on every PM service. Many PM forms require you to record the pressure on every tire. If a tire on any axle is more than 20 percent below its rated pressure (80 psi on a 100 psi tire), it should be considered flat and be inspected, as in the following section of this chapter.

CAUTION *Never air up a flat tire during a PM inspection while the tire is on the vehicle. If it has been run flat, it could have sidewall damage that could cause the tire to explode when inflated.*

Adjust air pressure to the recommended level, keeping your body away from the tire's sidewall during inflation. Better still, use a remote inflation gauge with a foot valve.

CHECK VALVE STEMS AND CAPS

On the PM service, always check for damaged or inaccessible valves.

Valve stems should be aligned at 180 degrees (or as close as possible) on dual wheels.

INSPECT TREAD DEPTH

Tire tread depth should be measured and recorded on every PM service.

Measure tread depth in three places on each tire at equal intervals. Take each measurement in the major tread groove nearest the center of the tire. Do not measure on a wear bar. Record the smallest tread depth measurement that you find. If tread depth measures less than 2/32 inch (1.6 mm) on steer tires or 1/32 inch (0.8 mm) on any other tire, replace it.

Inspection Procedures for Tires Suspected of Having Been Run Underinflated or Overloaded

INSPECT DEFLATED SUSPECT TIRES MOUNTED ON THE RIM

Look for

- Cuts, snags, or chips exposing body cords or steel
- Distortions or a wavy appearance by using an indirect light to cause shadows left by any sidewall irregularities

Feel for

- Soft spots in the sidewall flex area
- Distortions or wavy appearance
- Protruding filaments indicating broken cords

Listen for

- Any popping sound when feeling for soft spots or when rolling the tire

If you identify any of the above conditions, the tire should be scrapped and taken out of service. If no other condition is present and a tire contains cuts, snags, or chips exposing body cords or steel, it must be referred to a full-service repair facility to determine if it is repairable and not a source of a potential **zipper.** A zipper rupture is a circumferential rupture in the mid sidewall of a steel cord radial tire. It can be caused by weakened steel cables in the tire's sidewall, caused by running underinflated or flat (defined as a tire that carries less than 80 percent of proper inflation). The resulting rupture and air blast can explode with the force of as much as three-quarters of a pound of dynamite, leaving a 10- to 36-inch gash in the sidewall that looks like a zipper.

If none of these conditions are present, place the tire/rim/wheel assembly in an approved inflation safety cage.

CAUTION *Remain outside of the tire's trajectory and do not place hands in safety cage while inspecting tire or place head close to safety cage.*

INSPECT SUSPECT TIRE INFLATED TO 20 PSI

Look for

- Distortions or a wavy appearance

Listen for

- Any popping sound

If any of these conditions are present, the tire should be made unusable and scrapped.

If none of these conditions are present, dismount the tire to visually and manually inspect it both inside and outside.

INSPECT SUSPECT TIRES AFTER DISMOUNTING

Look for

- Bead rubber torn to the fabric or steel
- Cuts, snags, or chips exposing body cords or steel
- Distortions or a wavy appearance using an indirect light source that produces shadows left by any sidewall irregularities
- Creasing, wrinkling, cracking, or possible discoloration of the inner liner
- Any other signs of weakness in the upper sidewall

If any of the above conditions are found, the tire should be scrapped. If no other condition is present and a tire contains cuts, snags, or chips exposing body cords or steel, it must be referred to a full-service repair facility, to determine if it is repairable and not a source of a potential zipper.

If none of these conditions are present, the tire may be returned to service.

Inspection Procedures for All Tires Returning to Service

These procedures include used, retread, or repaired tires, regardless of being suspect or not suspect of being run underinflated or overloaded.

INSPECT DISMOUNTED TIRES (INCLUDING USED, RETREADED, OR REPAIRED)

Look for

- Bead rubber torn to the fabric or steel
- Cuts, snags, or chips exposing body cords or steel
- Distortions or wavy appearance using an indirect light source that produces shadows left by any sidewall irregularities
- Creasing, wrinkling, cracking, or possible discoloration of the inner liner
- Any other signs of weakness in the upper sidewall

Feel for

- Soft spots in the sidewall flex area
- Distortions or a wavy appearance
- Protruding filaments indicating broken cords

Listen for

- Any popping sound when feeling for soft spots, or when rolling the tire

If any of the above-mentioned conditions are present, the tire should be scrapped. If no other condition is present and a tire contains tears cuts, snags, or chips exposing body cords or steel, it must be referred to a full-service repair facility, to determine if it is repairable and not a source of a potential zipper.

If none of these conditions are present, place the tire/rim/wheel assembly in an approved inflation safety cage.

CAUTION *Remain outside of the tire's trajectory, and do not place hands in safety cage while inspecting tire or place head close to safety cage. After properly seating the beads, with the valve core removed, adjust the tire to 20 psi using a clip-on chuck with a pressure regulator and extension air hose.*

INSPECTION OF MOUNTED TIRES INFLATED TO 20 PSI

Look for

- Distortions or a wavy appearance

Listen for

- Any popping sound

If any of the above-mentioned conditions are present the tire should be scrapped.

If none of these conditions are present, with valve core still removed, inflate the tire to 20 psi over the recommenced operating pressure. During this step, if any of the above conditions appear, **immediately stop inflation.**

INSPECT MOUNTED TIRES INFLATED 20 PSI OVER OPERATING PRESSURE

Look for

- Distortions or a wavy appearance

Listen for

- Any popping sound

Any tire suspected of having been underinflated and/or overinflated must remain in the safety cage at 20 psi over operating pressure for 20 minutes.

If any of these conditions are present, the tire should be scrapped.

If none of these conditions are present, before removing the tire/rim/wheel assembly from the safety cage, reduce the inflation pressure to the recommended operating pressure. **emain outside of the tire's trajectory.**

Tire Wear Conditions and Causes

Irregular wear reduces the useful life of a tire and can lead to tire failure. Irregular tread wear is a symptom of a problem with a vehicle, a tire, or a tire maintenance practice.

Tire tread wears away because of friction with the pavement. Tread should wear down uniformly all the way around the circumference of the tire and all the way across the tread face. When this does not occur, the tire has irregular wear.

When you see a tire with irregular wear, you should find the underlying cause. If you only replace the tire, you have not solved the problem that caused the irregular wear in the first place. To solve the underlying problem, you must see the irregular wear when the tire is still on the vehicle.

Some irregular wear patterns look the same all the way around the tread of the tire. Other wear patterns are not consistent all the way around, but occur in various spots. The underlying causes of the two categories are different.

During routine maintenance, you can check for tire wear caused by misalignment by running your hand across the surface of the treads. This can be compared to running your hand over the surface of a cheese grater. If the treads have a sharp edge as you move your hand in one direction and not in the other, it is an indication that the tire is **scrubbing** (being

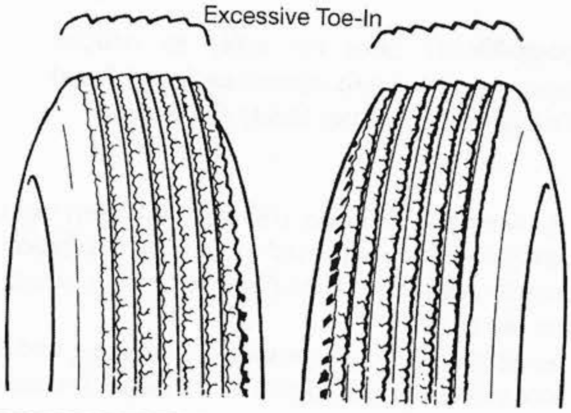


Figure 8-23 Excessive toe-in wear pattern. *(Courtesy of Mack Trucks, Inc.)*

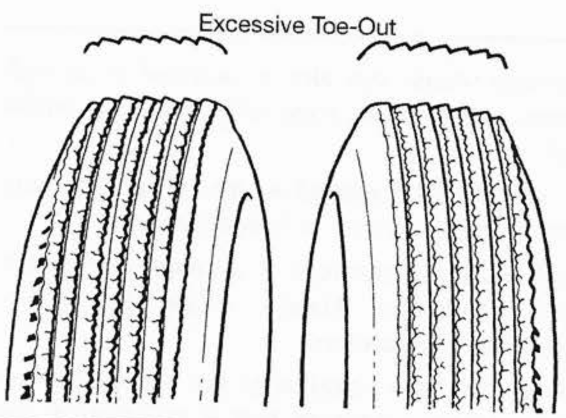


Figure 8-24 Excessive toe-out wear pattern. *(Courtesy of Mack Trucks, Inc.)*

dragged sideways) in the direction of the sharp edge (see **Figure 8-23** and **Figure 8-24**).

For more information along with pictures on tire wear conditions and causes, go to www.kaltire. com and select truck tires and wear conditions.

Tire Out-of-Service Criteria

(Taken from the North American Standard Out-of-Service Criteria by the Commercial Vehicle Safety Alliance, April 1, 2006)

ANY TIRE ON A FRONT STEERING AXLE(S) OF POWER UNIT

1. With less than 2/32 inch (1.6 mm) tread when measured in any two adjacent major tread groves at any location on the tire
2. When any part of the breaker strip or casing ply is showing in the tread
3. When sidewall is cut, worn, or damaged to the extent that the ply cored is exposed
4. Labeled "Not for Highway Use" or carrying other markings that would exclude use on steering axles
5. Visually observable bump, bulge, or knot apparently related to tread or sidewall separation

Exception: A bulge due to a section repair is allowed, not to exceed 3/8 inch (1 cm) in height. This bulge may sometimes be identified by a blue triangular label in the immediate vicinity.

6. Tire has noticeable (can be heard or felt) leak, or has 50 percent or less of the maximum inflation pressure marked on the tire sidewall.

Note: Measure tire pressure only if there is evidence the tire is underinflated.

7. So mounted or inflated that it comes in contact with any part of the vehicle
8. Front Steer Axle(s): Weight carried exceeds tire load limit. This includes overloaded tire resulting from low air pressure.
9. Passenger Carrying Vehicle: Regrooved, recapped, or retreaded tires on front steering axles

ALL TIRES OTHER THAN THOSE FOUND ON THE FRONT STEERING AXLE(S) OF A POWER UNIT

1. Tire has noticeable (can be heard or felt) leak, or has 50 percent or less of the maximum inflation pressure marked on the tire sidewall.

Note: Measure tire air pressure only if there is evidence the tire is underinflated.

2. Bias Ply Tire: When more than one ply is exposed in the tread area or sidewall or when the exposed area of the top ply exceeds 2 square inches (13 sq. cm)
3. Radial Ply Tire: When two or more plies are exposed in the tread area or damaged cords are evident in the sidewall or when the exposed area exceeds 2 square inches (13 sq. cm) in the sidewall
4. Any tire with visually observable bump or knot apparently related to tread or sidewall separation

Exception: A bulge due to a section repair is allowed not to exceed 3/8" (1 cm) in height. The bulge may sometimes be identified by a blue triangular label in the immediate vicinity.

5. So mounted or inflated that it comes in contact with any part of the vehicle. (This includes any tire contacting its mate in a dual set.)
6. Weight carried exceeds tire load limit. This includes overloaded tire resulting from low air pressure.

Exception: Does not apply to vehicles being operated under the special exclusion found in Federal Motor Carrier Safety Regulation.

7. So worn that less than 1/32 inch (0.8 mm) tread remains when measured in any two adjacent major tread grooves at three separate locations on the tire.
8. Seventy-five percent or more of the tread width loose or missing in excess of 12 inches (30 cm) in circumference

Summary

- Wheel assemblies can be broken into wheels, rims, tires, and hubs.
- Trucks use one of two types of wheel configurations: cast spoke wheels or disc wheels.
- Disc wheels can also be divided into stud piloted and hub piloted.
- Cast spoke wheels are tough and can withstand more punishment than disc wheels.
- When mounting the tire rim assembly onto the wheel, ensure that you have the correct studs, nuts, and clamps.
- Whenever a spoke wheel is reinstalled, it must be checked for runout.
- Disc wheels differ from spoke wheels in that the tire rim forms the wheel and mounts to the hub assembly.
- After operating the vehicle approximately 50 miles (80 km), the wheel should be retorqued.
- With stud-piloted wheels, the weight of the vehicle is transferred through to the wheel by the mounting studs.
- With hub-piloted wheels, the weight of the vehicle is transferred through to the wheel by the pilot pads. The nuts and studs just keep the wheel clamped to the hub.
- Wide-base wheels can also be referred to as high flotation, super singles, wide body, duplex, or jumbo wheel.
- Disc wheels are mounted to the wheel hub with threaded studs and nuts or headed studs.
- Wheel bearing adjustment is a simple but highly critical procedure. Always follow the TMC-recommended procedures.
- A preset hub is a preadjusted but serviceable assembly, where a unitized hub is preadjusted and nonserviceable.
- The trucking industry generally uses one of two basic types of tire construction: bias ply and radial tires.
- The size and type of tire can be obtained by the information printed on the sidewall of the tire.
- Mismatching the tire sizes in dual wheel assemblies has the same effects on tire wear as does running with one wheel overloaded or underinflated.
- Tire pressure should be checked weekly, every time the vehicle enters the shop, or on every PM service.
- If a tire on any axle is more than 20 percent below its rated pressure, it should be considered flat.
- Tire tread depth should be measured and recorded on every PM service.

Review Questions

1. The presence of rust on a wheel could indicate:

   A. cracks.

   B. poor mating of inner and outer hub-piloted wheels.

   C. Loose lug nuts.

   D. All of the above

2. Which of the following statements is true?
   A. Dual tires should be matched by tread design and, ideally, tire casings should be matched by manufacturer.
   B. The smaller tire in a dual position should be on the outside of the vehicle.
   C. Steer tires can be of different design as long as the manufacturer is the same.
   D. None of the above

3. According to the TMC a steer with a measured tread depth of ________ or less must be replaced.
   A. 1/4 inch (6.4 mm)
   B. 2/32 inch (1.6 mm)
   C. 4/32 inch (3.2 mm)
   D. 6/32 inch (4.8 mm)

4. Which of the following wheel types uses tires mounted to rims that mount to the wheel using clamps?
   A. Disc wheels
   B. Cast spoke wheels
   C. Hub-piloted
   D. Stud-piloted

5. If a set of dual tires were properly matched, which of the following would be true?
   A. Both tires would have the same nominal size.
   B. Both tires would have the same tread design.
   C. Both tires would have equal wear.
   D. All of the above

6. What is the maximum allowable runout permitted on cast spoke wheels?
   A. 1/16 inch
   B. 1/8 inch
   C. 3/16 inch
   D. 1/4 inch

7. Which type of wheel assembly presents the fewest maintenance and alignment problems?
   A. Stud piloted disc wheels
   B. Cast spoke wheels
   C. Hub-piloted wheels
   D. Any wheels using radial clamps

8. Which of the following methods are used to lock the bearing setting on the axle or spindle?
   A. Jam nuts
   B. Castellated nuts with cotter pins
   C. Split forging nuts
   D. All of the above

9. Which is the preferred method of repairing a wheel seat leak that has glazed the brake shoe linings?
   A. Replace the wheel seal only.
   B. Replace the wheel seal and bearings.
   C. Replace the wheel seal and damaged brake shoes.
   D. Replace the wheel seal and brake shoes on both sides of the axle.

10. Technician A says that an advantage of disc wheels over cast spoke is that they produce fewer wheel alignment problems. Technician B says that, in stud-piloted disc wheel systems, a loose inner nut can easily go undetected, eventually pounding out the ball seat. Who is correct?
    A. Technician A only
    B. Technician B only
    C. Both technician A and B are correct.
    D. Neither technician A nor B is correct.

11. Technician A always inflates severely underinflated tires in a safety cage. Technician B uses a clip-on air chuck with a remote in-line valve and gauge. Who is correct?

A. Technician A

B. Technician b

C. Both technician A and B are correct.

D. Neither technician A nor B is correct.

12. Technician A says that wheel runout on a cast spoke wheel can be eliminated only by removing the wheel rims and breaking down the tires. Technician B adjusts cast spoke wheel runout by chalk-marking high points, then loosening the lug nuts on the chalk-marked side and tightening those 180 degrees opposite. Who is correct?

A. Technician A

B. Technician B

C. Both technician A and B are correct.

D. Neither technician A nor B is correct.