SERVICE MANUAL SECTION

PROPELLER SHAFT

s06001, Formerly CTS-5143S

02/13/2001

Table of Contents

DESCRIPTION

GENERAL

A propeller shaft is a cylindrical assembly used to transmit torque from the transmission to the axle by rotation.

Propeller Shaft Components

Refer to Figure 1 to identify propeller shaft components.

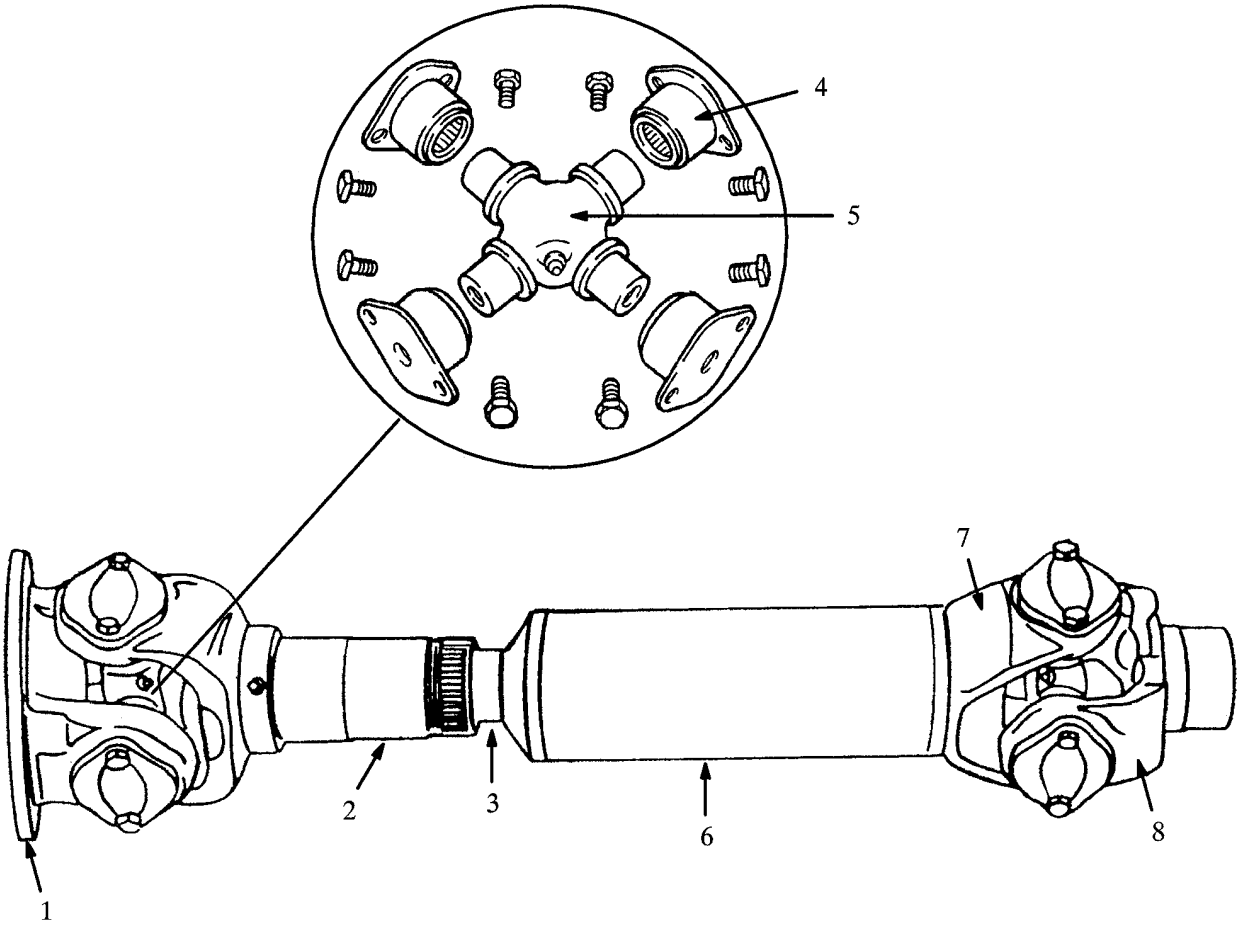


Figure 1 Propeller Shaft Components

1. FLANGE YOKE
2. SLIP YOKE
3. SLIP SHAFT
4. BEARING CAP
5. CROSS
6. TUBING
7. TUBE YOKE
8. END YOKE

1. OPERATION

The basic function of a propeller shaft is to transmit power from one point to another in a smooth and continuous action. In trucks, the propeller shaft is designed to send torque through an angle from the transmission to the axle (or auxiliary transmission.

The propeller shaft must operate through constantly changing relative angles between the transmission and axle. It must also be capable of changing length while transmitting torque. This is accomplished through universal joints, which permit the propeller shaft to operate at different angles, and slip joints, which permit contraction and expansion of the axle to take place.

1.1. UNIVERSAL JOINTS

Universal joints, or U-joints (Figure 2), are mechanical linkages in a propeller shaft that allow operating angle changes while transmitting torque.

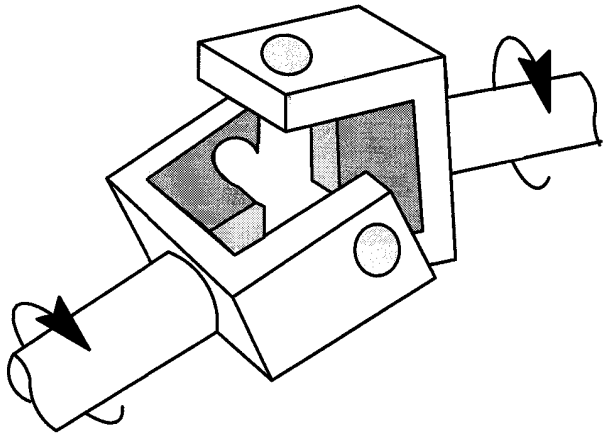


Figure 2 U-Joint

1.2. SLIP JOINT

A slip joint is an internally splined yoke and an externally splined tube stub shaft used together to permit propeller shaft extension and retraction (Figure 3).

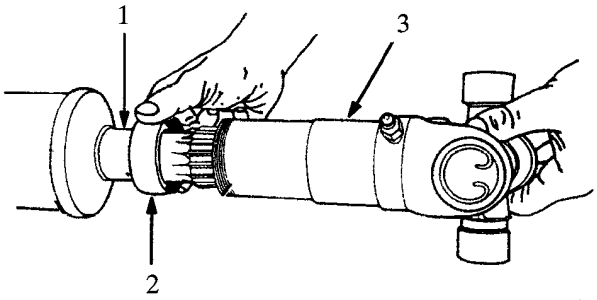


Figure 3 Slip Joint

1. STUB SHAFT
2. DUST SEAL
3. SLIP YOKE

1.3. CENTER (CARRIER) BEARING

Center or carrier bearings (Figure 4) are designed to support long propeller shafts and to smooth out the delivery of power to the axle. The center (carrier) bearing used on International vehicles utilizes ball bearings with the bearing housing enclosed in rubber.

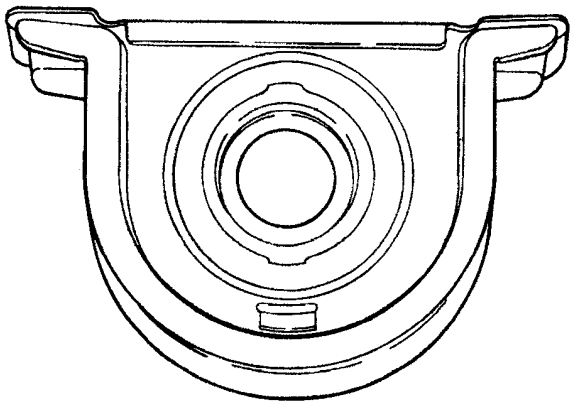


Figure 4 Center or Carrier Bearing

2. MAINTENANCE

2.1. SERVICE CHECKS

The propeller shaft should be carefully inspected at each lubrication interval. Check for such things as loose yokes, universal joint wear, propeller shaft tube bends and missing slip yoke welch plugs. These items can cause vibration, or universal joint and center bearing failure.

1. Check output and input end yokes at the transmission and axle for looseness (Figure 5). If loose, remove propeller shaft and tighten to specifications. Refer to GROUP 02 - FRONT AXLES, GROUP 13 - TRANSMISSION, or GROUP 14 - REAR AXLES in the CTS-5000 Master Service Manual for torque specifications.

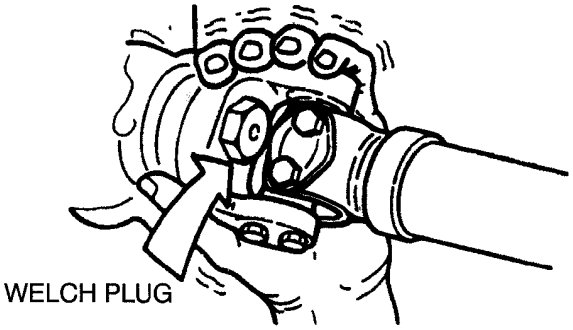


Figure 5 Check Output and Input End Yokes For Looseness

2. Check for excessive movement of end yokes at the transmission output, and axle input or output shafts in their supporting bearings (Figure 6). Refer to GROUP 02 - FRONT AXLES, GROUP 13 - TRANSMISSION, or GROUP 14 - REAR AXLES in the CTS-5000 Master Service Manual for limits.

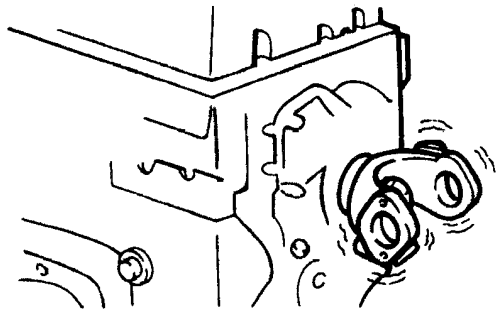


Figure 6 Check For Excessive Movement of End Yokes, Axle Input or Output Shafts

3. Check for looseness across universal joints; it should not exceed .006" (.152 mm) Figure 7).

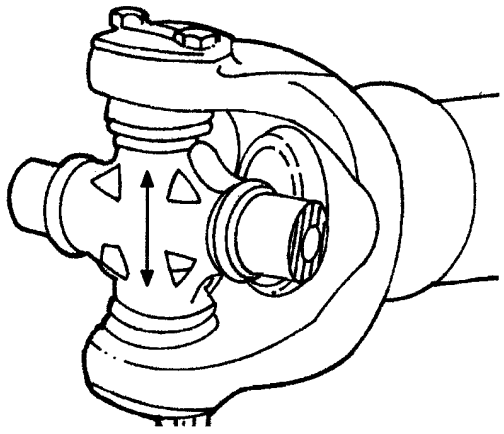


Figure 7 Check For Looseness Across Universal Joints

4. Check slip joint for excessive movement as shown in Figure 8, If looseness between slip yoke and tube stub shaft exceeds .012" (.305 mm), replace the slip joint.

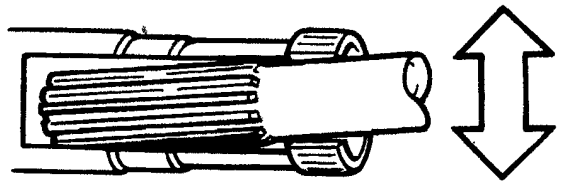


Figure 8 Check Slip Joint For Excessive Movement

5. Check propeller shaft for missing balance weights and dented or bent tubing. Carefully remove any foreign material from the shaft.

6. Welch plugs used in slip yokes should be inspected to be sure they are not loose or missing (Figure 9). If they are, repair or replace and check slip shaft length to be sure that the tube stub shaft is not hitting the welch plug and knocking it out.

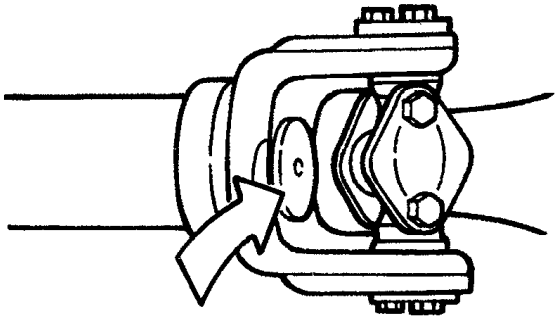


Figure 9 Inspect Welch Plugs

7. Loose center (carrier) bearing assembly mounting bolts should be tightened. Deteriorated or oil soaked center bearing insulators should be replace.

3. REMOVE

WARNING – To avoid personal injury always set parking brake (air brake equipped vehicles) and block wheels to prevent vehicle from moving.

3.1. FULL ROUND END YOKES

1. Block the wheels.

2. Mark the slip joint with a marking stick or paint to assure proper alignment upon reassembly.

3. Place jack stands under propeller shaft to support it during removal.

4. Carefully bend tabs of the locking straps (if equipped) away from the bolt heads with a chisel (Figure 10).

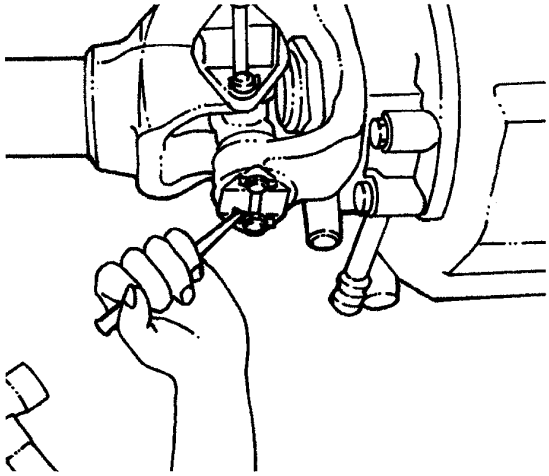


Figure 10 Bend Tabs of Locking Straps Away From Bolt Heads

5. Remove the four bolts from the two bearing assemblies connected to the transmission or axle end yoke (Figure 11).

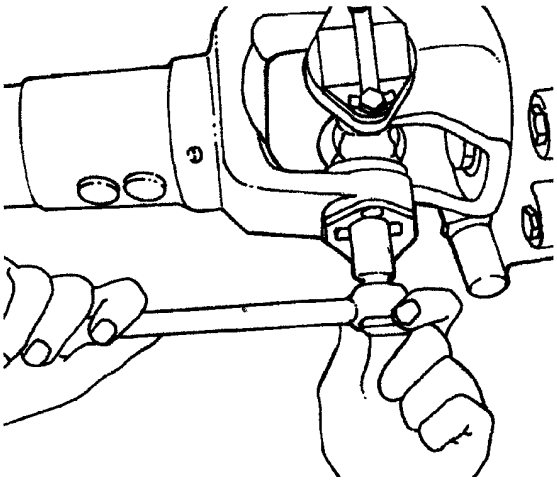


Figure 11 Remove Bolts From Bearing Assemblies Connected to Transmission or Axle End Yoke

6. Remove the bearing assemblies from the yoke using a universal joint service tool.

7. Free the cross from the end yoke by tilting it while collapsing the propeller shaft (Figure 12).

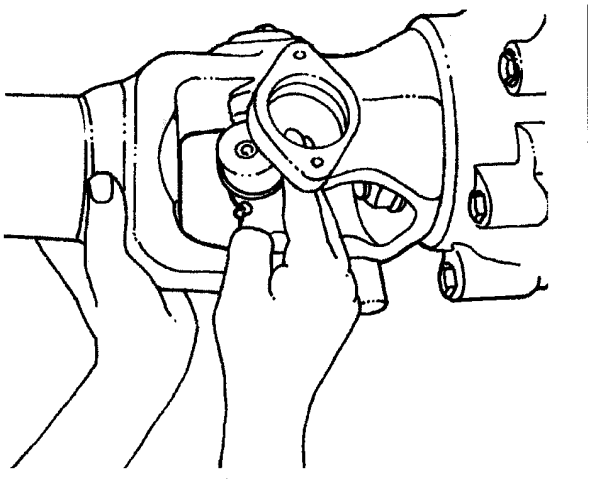


Figure 12 Free Cross From End Yoke

3.2. HALF ROUND END YOKES

1. Block the wheels.
2. Mark the slip joint with a marking stick or paint to assure proper alignment upon reassembly.
3. Place jack stands under propeller shaft to support it during removal.
4. Remove the four bolts securing the bearing straps to the transmission, propeller, or axle end yoke (Figure 13).

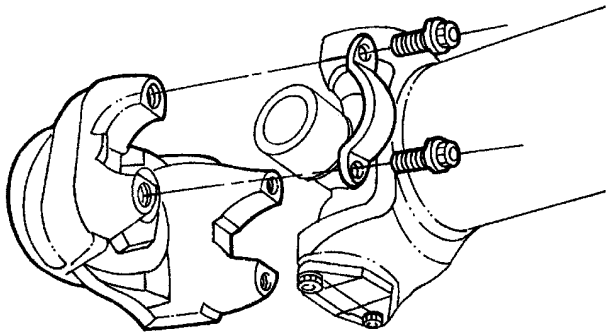


Figure 13 Remove Bolts Securing Bearing Straps

5. Holding propeller shaft tightly, tap the yoke on the propeller shaft and remove bearing and cross from the end yoke while compressing shaft.

3.3. CENTER (CARRIER) BEARING

1. Block the wheels.
2. Mark the slip joint with a marking stick or paint to assure proper alignment upon reassembly.

3. Place jack stands under propeller shaft to support it during removal.

4. Separate the propeller shaft that the center bearing is mounted to from transmission end yoke, or propeller shaft end yoke.

5. Remove the center bearing mounting bolts from the center bearing bracket.

6. Remove the propeller shaft from the vehicle (you may be required to disassemble a slip joint).

4. DISASSEMBLE

4.1. SLIP JOINT

Remove the dust cap from the slip yoke (it could either screw or snap on) and slide the slip yoke off the stub shaft.

4.2. OUTSIDE/INSIDE SNAP RING YOKE UNIVERSAL JOINT

1. Remove each snap ring by pinching the end together with a pair of pliers (Figure 14).

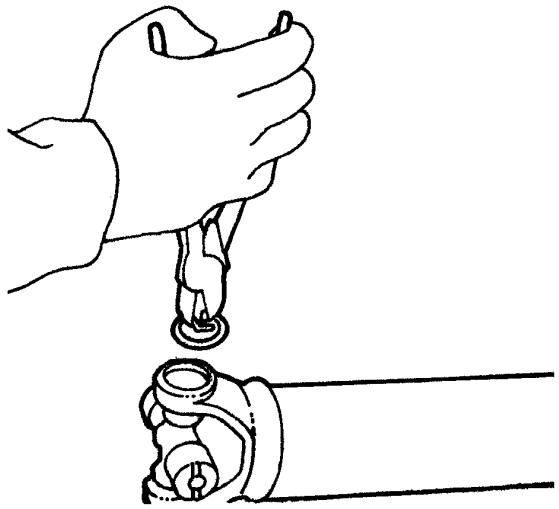


Figure 14 Remove Snap Rings

NOTE – If a ring does not readily snap out of the groove in the yoke, tap the end of the bearing cap lightly to relieve the pressure against the ring.

2. Set the yoke in the arbor press with a piece of tube stock beneath it. Position the yoke with the lube fitting pointing up to prevent interference during disassembly. Place a solid plug on the upper bearing assembly and press it through to release the lower bearing assembly (Figure 15).

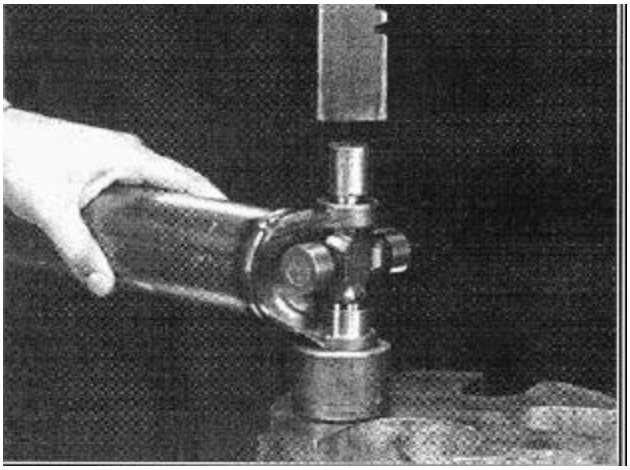


Figure 15 Press Plug Through Upper Bearing Assembly to Release Lower Bearing Assembly

3. To remove the opposite bearing assembly, turn the yoke over and straighten the cross in the open cross hole. Then carefully press on the end of the cross so the remaining bearing assembly moves straight out of the bearing cross hole. If the cross or bearing assembly is cocked, the bearing assembly will score the walls of the cross hole and ruin the yoke.

4. Remove the cross by sliding it through the side of the yoke, and tilting it outward while removing it from the yoke.

4.3. FULL ROUND YOKE UNIVERSAL JOINT

1. Place propeller shaft on v-blocks or in bench vise with soft jaw covers.

> CAUTION – **Do not distort tube with excessive grip while in vise.**

2. Carefully bend tabs of the locking straps (if equipped) away from the bolt heads with a chisel.

3. Remove the four bolts from the bearing assemblies connected to the propeller shaft end yoke.

4. Remove the bearing assemblies from the yoke using a universal joint service tool.

5. Remove the cross by sliding it to the side of the yoke, and tilting it outward while removing it from the yoke.

4.4. CENTER (CARRIER) BEARING

Press the center bearing assembly and both slingers off the stub shaft (Figure 16). The center bearing is serviced as a complete assembly, therefore separating the "U" shape bracket from the rubber cushion is not required.

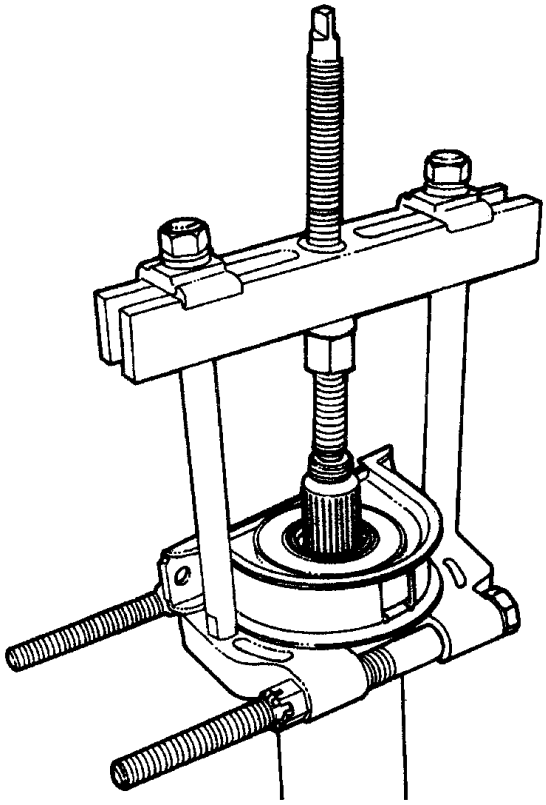


Figure 16 Press Center Bearing Assembly and Both Slingers Off Stub Shaft

5. CLEAN AND INSPECT

Inspect cross bearing surfaces and end surfaces for brinelling or end galling (Figure 17). If any is found, a cross and bearing kit must be installed.

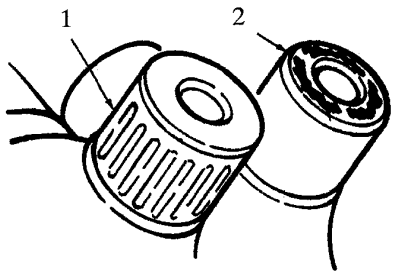


Figure 17 Inspect Cross Bearing Surfaces and End Surfaces

If there is no apparent damage to bearing surfaces, the bearings and cross can be cleaned and reused.

After cleaning, work a small quantity of lubricant into each bearing cap and place the assembly on its journal of the cross to check wear. Replace cross and bearing if worn.

CAUTION – Never mix new and old bearings, caps or crosses. Always replace the cross and bearing caps as a unit.

Inspect yoke bearing cross hole surfaces for damage such as raised metal due to nicks or stress. Stress or twisted yoke lugs must be replaced. Raised metal can be removed with a half round or rattail file.

5.1. FULL ROUND YOKE INSPECTION

Check the yoke lug cross holes with a No-Go Wear Gauge and then use an alignment bar to inspect for damage by sliding through both cross holes simultaneously. The alignment bar will identify yoke lugs that have taken a set because of excessive torque. The raised metal or distorted lugs can be a cause of premature cross and bearing problems.

At this time, clean the cross holes of the yokes on the transmission and axle and inspect with an alignment bar gauge as described above.

If after proper cleaning of the cross holes, the alignment bar will not pass through simultaneously, the yoke lugs are distorted and the yoke or yokes should be replaced.

CAUTION – Use a journal locator to avoid nicking journal cross trunnions or damaging oil seal slingers.

5.2. HALF ROUND YOKE INSPECTION

Check the yoke for cross hole alignment using an alignment gauge. Place the correct bushing in each lug ear, allowing a .03 to .06 inch clearance between the tang and the bushing

Assemble bearing straps and bolts, tightening bolts a minimum of 30 ft-lbs. (41 N·m). Insert the alignment gauge into one cross hole. If the gauge enters and passes through the opposite cross hole, alignment is correct. If the alignment gauge will not enter the opposite cross hole, re-inspect for burrs.

If, after proper cleaning, the alignment gauge still does not pass through both cross holes, the yoke lugs are distorted and the yoke should be replaced.

6. ASSEMBLE

Assembly is merely reverse order of the disassembly operations. On joints without a lubrication fitting, repack reservoirs in the cross journal ends with the recommended lubricant. Make sure the reservoir in each cross is filled. With the rollers in the cap, fill it about $\frac{1}{3}$ full of lubricant.

As of June, 1993 Spicer 1610 through 1880 series universal joints are supplied with a self locking bolt in place of the lock strap. The proper torque values for these self locking bolts are listed in the TORQUE CHART(See TORQUE, page 34).

6.1. SLIP JOINT

1. Lubricate the splines thoroughly and assemble dust cap and seals to stub shaft. Lubricate the splines thoroughly and assemble dust cap and seals to stub shaft.

2. Align your marks on the stub shaft and slip yoke to prevent excessive vibration.

3. Install slip yoke onto stub shaft and assemble dust cap and seals onto slip yoke.

6.2. SNAP RING YOKE UNIVERSAL JOINT

1. Pack the cross journal cavities with grease before assembly using a grease gun at the lubrication fitting (Figure 18).

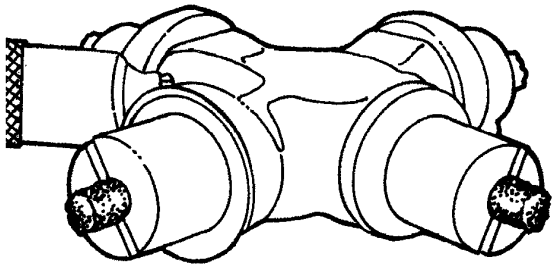


Figure 18 Pack Cross Journal Cavities With Grease Before Assembly

2. Pack the bearing cap about $\frac{1}{4}$ full with grease.

3. Position cross in the propeller shaft yoke with its lube fitting on the inboard side (towards propeller shaft) (Figure 19).

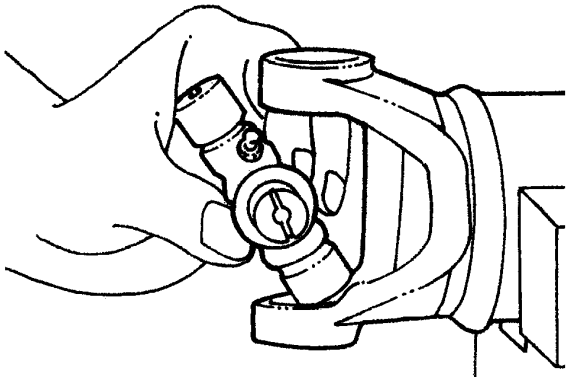


Figure 19 Position Cross in Propeller Shaft Yoke

4. Move one end of the cross so that a journal protrudes out of a cross hole in the yoke.

5. Place a bearing cap onto the journal and align it to the cross hole (Figure 20).

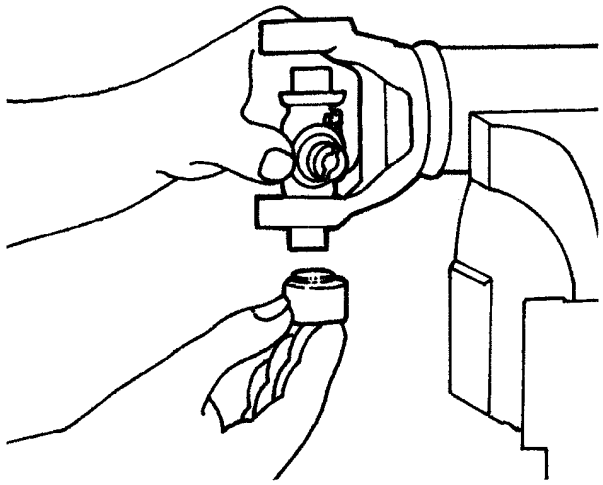


Figure 20 Place Bearing Cap onto Journal

6. Press the bearing cap into the yoke just enough to install a snap ring.
7. Install a snap ring.

   NOTE – When installing the snap ring, be sure that it is seated in the groove.

8. Move the other end of the cross so its journal protrudes out of the opposite cross hole in the yoke.
9. Place a bearing cap onto the journal and align it to the cross hole (Figure 21).

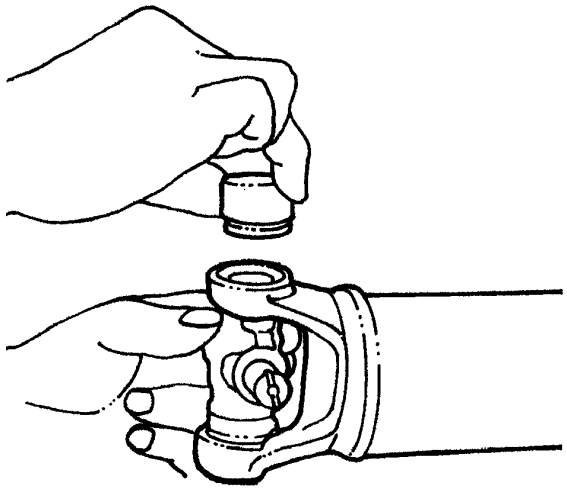


Figure 21 Place Bearing Cap onto Journal

10. Press the bearing cap into the yoke just enough to install the other snap ring.
11. Install a snap ring.

    NOTE – If the joint is stiff, strike the yoke with a soft hammer to free up binding. (Figure 22).

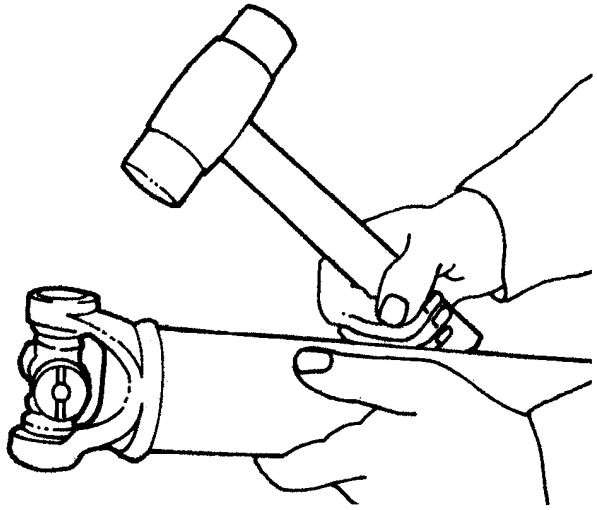


Figure 22 Strike Yoke to Free Up Binding

6.3. FULL ROUND YOKE UNIVERSAL JOINT

1. Before assembly, remove the four bearing caps and inspect the journal ends for check valve. If one journal has a check valve, they all should have a check valve.

2. Position the cross so that the lube zerk is in line with the zerk on the slip yoke and pointed inboard (towards) the propeller shaft.

3. Place a cross journal through a cross hole far enough to allow the opposite journal to be tilted and positioned in the other cross hole.

4. Move the cross through the cross hole so it extends beyond the outer machined face of a yoke lug.

5. Lubricate the outer diameter of the bearing caps with anti-seize compound and position bearing cap over journal (Figure 23). The cap must be square and aligned with the cross hole in the yoke so the cap will not bind. If the bearing cap should bind in the hole, tap the cap with a ball peen hammer directly in center of bearing plate.

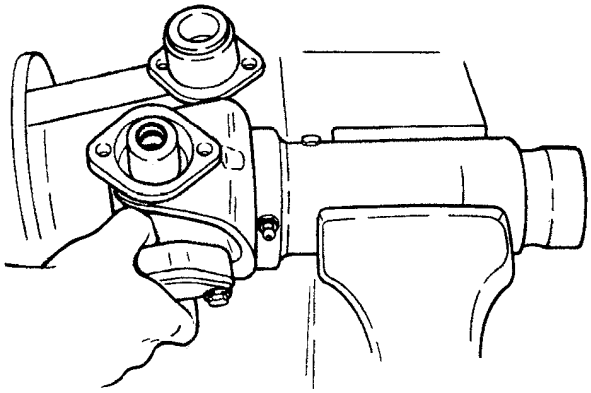


Figure 23 Position Bearing Cap Over Journal

NOTE – NEVER tap outer edges of the bearing plate. When bearing cap is aligned, it can be pressed into place by hand. If bearing cap cannot be pushed in place, it is binding or yoke hole was not properly cleaned.

6. When the bearing cap is seated, line up the cap holes with the holes in the yoke. Assemble the lockstrap (if equipped) and bolts to the yoke lug (Figure 24).

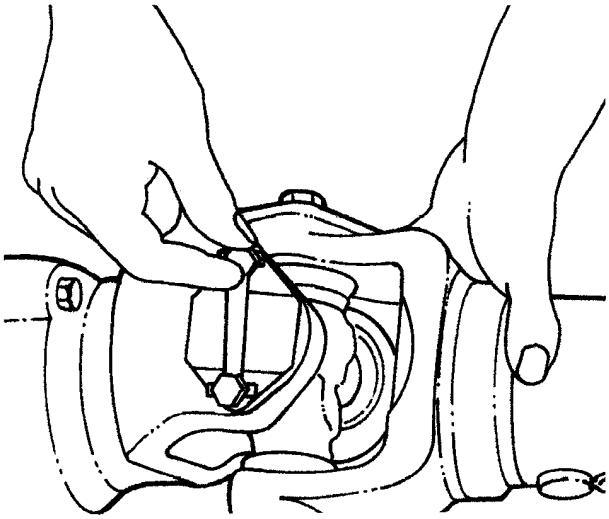


Figure 24 Assemble Lockstrap and Bolts to Yoke Lug

7. Move the cross to the other cross hole so that the journal is beyond the machined surface of the yoke lug. Position the other bearing cap over the bearing surface and slide it into the cross hole in the yoke (Figure 25). Seat the bearing plate on the lug mating surface and assemble lockstrap (if equipped) and bolts. Tighten bolts. Refer to the Torque Chart(See TORQUE, page 34) for torque specifications. If equipped, bend lockstrap tab over to lock the bolts.

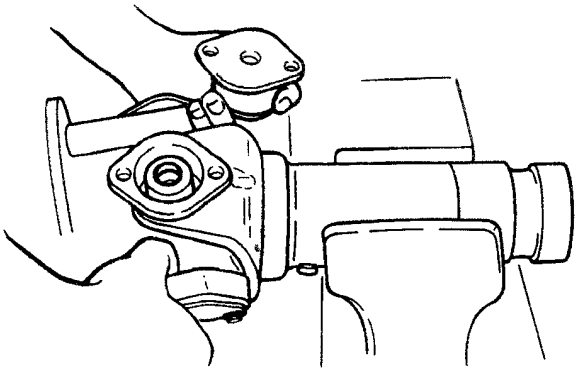


Figure 25 Position Bearing Cap Over Bearing Surface

6.4. CENTER BEARING

Press the center bearing assembly and both slingers onto the stub shaft. The center bearing is serviced as a complete assembly, therefore separating the "U" shape bracket from the rubber cushion is not required.

7. INSTALL

NOTE – All universal joints must be lubricated after installation of the propeller shaft prior to putting vehicle in service.

7.1. FULL ROUND END YOKES

1. Place jack stands under propeller shaft to support it during installation.

2. Rotate the transmission or axle end yoke so that the cross holes are in a horizontal position (Figure 26).

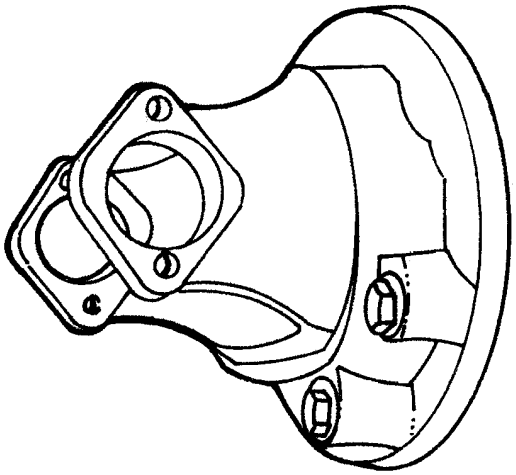


Figure 26 Rotate Transmission or Axle End Yoke so Cross Holes are Horizontal

3. Move the cross on the propeller shaft so that one journal of the cross is pointed outwards as far as it will go by hand (Figure 27).

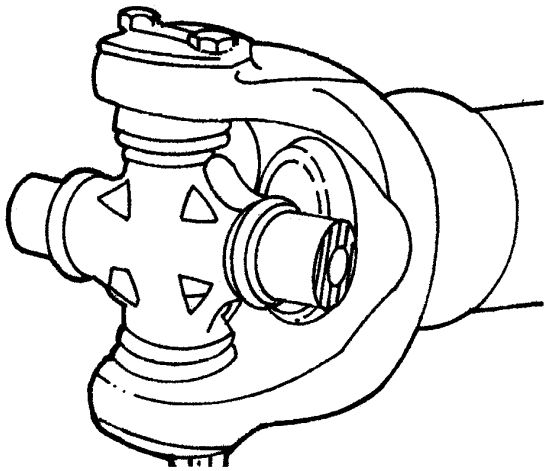


Figure 27 Move Cross on Propeller Shaft

4. Push this journal through a cross hole in the end yoke (Figure 28).

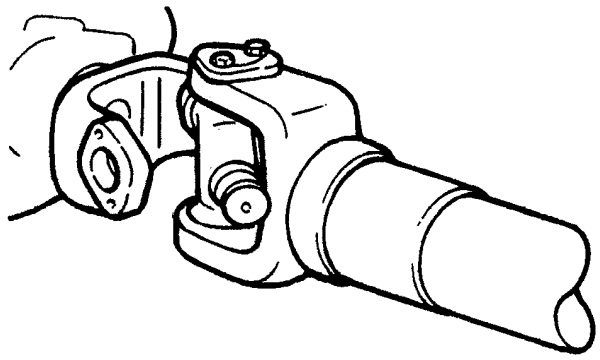


Figure 28 Push Journal Through Cross Hole in End Yoke

5. Tilt the cross so that it is aligned to the center of the opposite cross hole.

6. Move the cross through the cross hole until a journal extends beyond the outer machined face of a yoke lug (Figure 29).

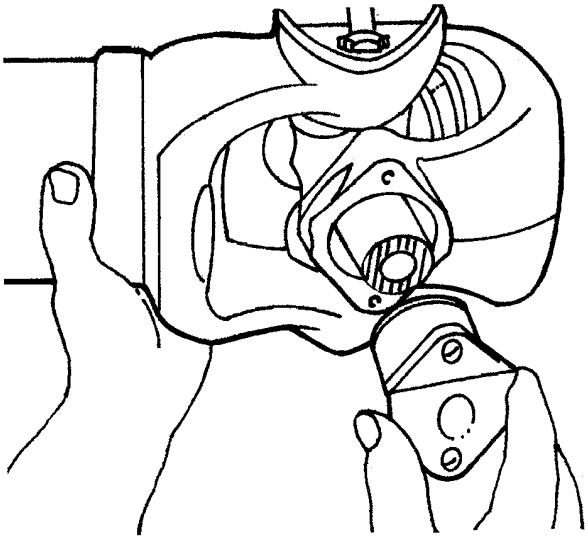


Figure 29 Move Cross Through Cross Hole

7. Lubricate the outer diameter of the bearing caps with anti-seize compound and position bearing cap over journal. The cap must be square and aligned with the cross hole in the yoke so the cap will not bind. If the bearing cap should bind in the hole, tap the cap with a ball peen hammer directly in center of bearing plate.

   NOTE – NEVER tap outer edges of the bearing plate. When bearing cap is aligned, it can be pressed into place by hand (Figure 30). If bearing cap cannot be pushed in place, it is binding or yoke hole was not properly cleaned.

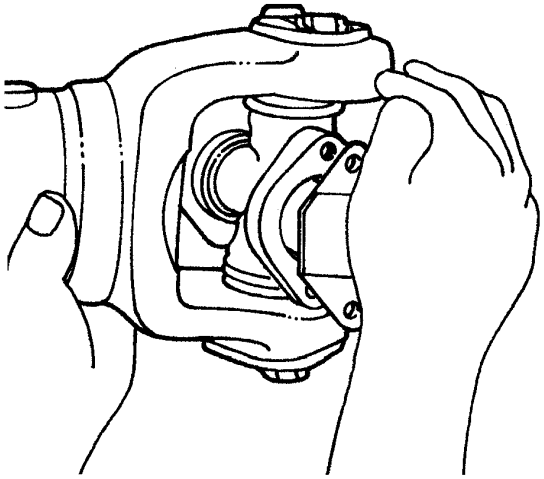


Figure 30 Press Bearing Cap into Place by Hand

8. When the bearing cap is seated, line up the holes in the bearing cap plate with the holes in the yoke. Assemble the lockstrap (if equipped) and bolts to the yoke lug.

9. Move the cross to the other cross hole so that the journal is beyond the machined surface of the yoke lug. Position the other bearing cap over the bearing surface and slide it into the cross hole in the yoke. Seat the bearing plate on the lug mating surface and assemble lockstrap (if equipped) and bolts. Tighten bolts. Refer to the TORQUE CHART(See TORQUE, page 34) for torque specifications. If equipped, bend lock strap tab over to lock the bolts.

7.2. HALF ROUND END YOKES

1. Place jack stands under propeller shaft to support it during installation.

2. Rotate the transmission or axle end yoke so that the cross holes are in a horizontal position.

3. Holding propeller shaft tightly, position the bearing caps into the end yoke shoulders (Figure 31).

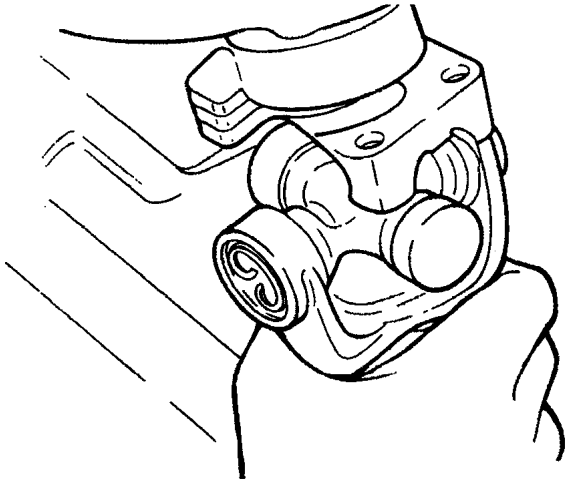


Figure 31 Position Bearing Caps into End Yoke Shoulders

4. Make sure bearing caps are seated correctly (Figure 32).

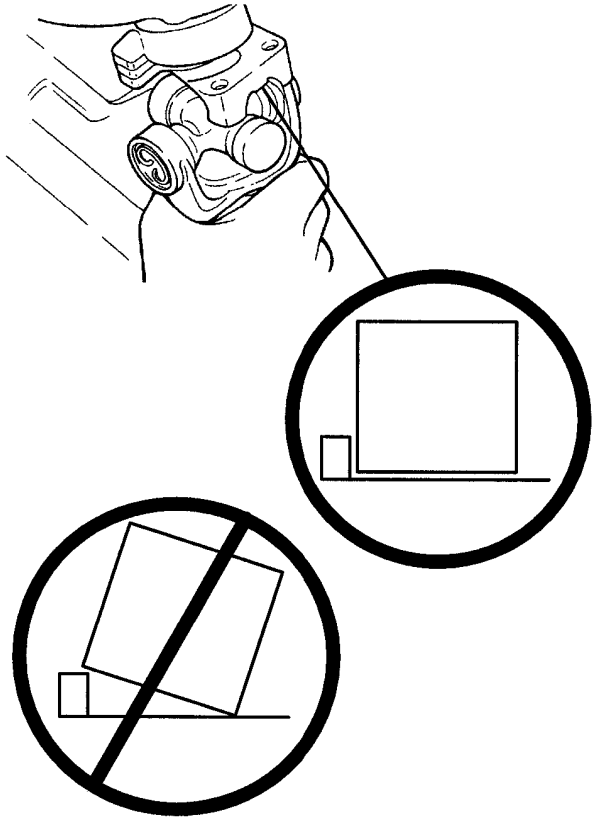


Figure 32 Make Sure Bearing Caps are Seated Correctly

5. Place the straps over the bearing caps. Install the four bolts securing the bearing straps to the transmission, propeller, or axle end yoke.

6. Tighten the bolts. Refer to the TORQUE CHART(See TORQUE, page 34) for torque specifications.

7.3. CENTER BEARING

1. Place jack stands under propeller shaft to support it during installation.

2. Install the propeller shaft with the center bearing on it into the vehicle (you may be required to assemble a slip joint).

3. Install the center bearing mounting bolts to the center bearing mounting bracket.

4. Install the propeller shaft to the transmission end yoke, or propeller shaft end yoke.

8. VIBRATION

8.1. DESCRIPTION

Vibration is the result of a force rapidly moving an object in opposite directions. There are two different kinds of vibration that affect propeller shaft operation, either transverse or torsional. Transverse vibration is a bending movement caused by improper balance. Torsional vibration is a twisting motion most commonly caused by engine power pulses and/or improper universal joint working angles.

Vibration originating in the universal joint and propeller shaft assembly is usually present only at certain speeds and cycle as the shaft speed is raised and lowered. This intermittent characteristic differs from the generally constant noise from other sources of vibration.

The most common causes of propeller shaft vibration are:

A. Universal joint flange or yoke misalignment.
B. Out-of-balance propeller shaft assembly.
C. Propeller shaft out of phase.
D. Excessive flange runout or distorted yokes.
E. Loose flange or yoke nut.
F. Excessive propeller shaft rotational speed.

To correct driveline vibration, the propeller shaft must be checked in such a manner that both balance and alignment are considered. Never change the driveline balance or alignment until a thorough check of the most common causes has been completed.

Driveline vibration can be checked by road testing vehicle, spinning the driveline with vehicle up on floor stands, or by pulling the rear axle shafts and spinning the driveline.

WARNING – To prevent personal injury, be certain that vehicle is positively supported when checking for vibration.

8.2. TYPES OF VIBRATION

Vibration that is felt during vehicle operation will generally fall in one or more categories. Not all vibrations are caused by the propeller shaft assembly.

First you must determine the source of the problem. To assist in finding the source, you must interview the operator to determine what, where and when the vibration is encountered.

Next, road test the vehicle with and without typical loads while recording engine RPM and road speed of disturbance in all transmission and rear axle ranges. If the problem is prevalent when pulling a trailer, it will be necessary to road test with a different trailer and load to assist in defining the cause of the disturbance.

Possible causes of chassis vibration other than propeller shafts are:

- Engine and Accessories
- Steering Looseness
- Clutch, Transmission and Axles
- Tires and Wheels
- Cab and Cab Mounting
- Driveline Brake Drum
- Trailer Disturbance
- Load Retention or Distribution
- Loose or Worn Suspension Parts.

Refer to the appropriate section of the CTS-5000 Master Service Manual for correction of vibration from these areas.

After the aforementioned items have been inspected and it is determined that the vibration is in the propeller shaft, visually inspect for the following:

- Universal Joint Phasing
- Worn Universal Joint
- Damage to Propeller Shaft
- Worn Center Bearing Insulator
- Missing Balance Weights
- Loose Slip Joint
- Heat Discolored Yoke
- Foreign Material on Shaft.

TRANSVERSE VIBRATION

Transverse vibration is the result of a bending movement caused by improper balance (Figure 33). Transverse vibration or out–of–balance will have the following characteristics:

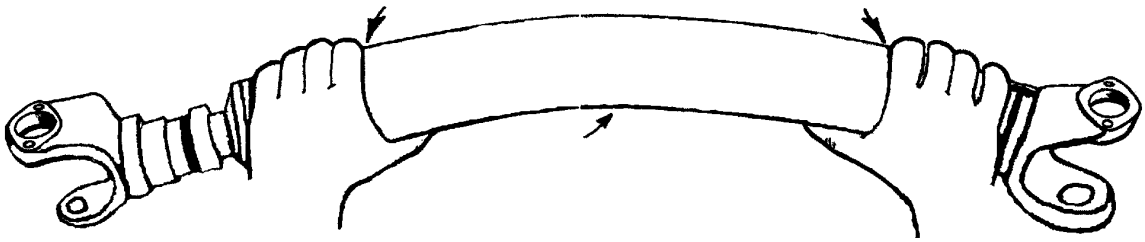


Figure 33 Transverse Vibration

A. You may hear the vibration, but for the most part you will feel it.

B. Force from the imbalance increases with speed. It usually can be felt best at a certain road speed.

C. This kind of vibration is not affected by load on the vehicle. It occurs bob–tail as well as with a trailer.

TORSIONAL VIBRATION

A universal joint has a maximum angle at which it will transmit power smoothly.

Torsional vibration is a twisting motion most commonly caused by unequal universal joint working angles (Figure 34).

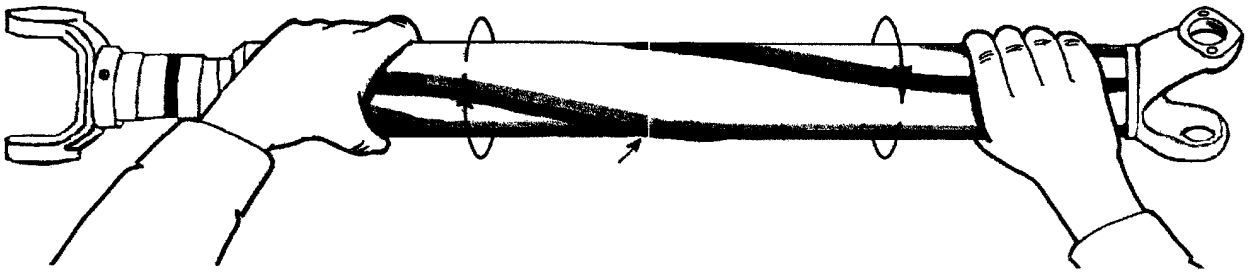


Figure 34 Torsional Vibration

When two shafts connected together by a universal joint are operated at an angle, the driven shaft speed will change in relation to the driving shaft speed. Twice during rotation, the driven shaft speed will increase and decrease compared to the driving shaft speed. This speed fluctuation creates torsional excitation (winding up and unwinding) of the propeller shaft.

With equal working angles, the rear of the shaft will slow down by the same amount that the front speeds up. This results in a propeller shaft that turns at a constant speed without twisting.

Torsional vibration is harder to identify during road testing, but it has certain characteristics:

A. Torsional vibration produces a very noticeable sound.

B. Torsional vibrations can exist at one or more speeds and usually is more severe at low speeds.

C. Torque and load changes will affect the vibration. Normally the vibration will be affected directly by a change in throttle position. Load, as in with or without a trailer, also affects this kind of vibration.

8.3. CHECKING PROPELLER SHAFT RUNOUT (PROPELLER SHAFT INSTALLED)

Excessive companion flange, yoke, and/or propeller shaft runout can create or influence vibration.

Runout checks can be taken with the propeller shaft in the vehicle.

1. Block the wheels (including the front wheels).
2. Place the transmission in neutral.
3. Remove the axle shafts or place jack stands under the axles to raise all of the rear wheels off the ground.
4. Rotate the propeller shaft by hand and read measured runout.

Radial runout of the installed propeller shaft must not exceed .010I (0.254 mm) T.I.R. over the runout specification shown in Figure 35 . Measurements are taken 3 inches (76.2 mm) from the tube ends and in the center of the tube. Be sure to clean surfaces where dial indicator readings are taken.

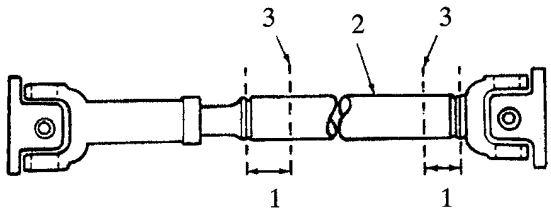


Figure 35 Runout Specifications

1. 3.0" (76.2 mm)
2. 0.015" (.381 mm) T.I.R.
3. 0.010" (.254 mm) T.I.R.

The companion flange mounting nuts and the bolts that attach the propeller shaft to the flange must be tight to assure driveline balance. The least amount of looseness in the flange mounting nuts or the shaft attaching bolts is enough to cause excessive vibration at high propeller shaft speeds. Refer to the TORQUE CHART(See TORQUE, page 34) for the proper torque specifications.

Although it is rare, a distorted yoke can cause vibration. If you know the propeller shaft is straight and balanced, check yoke runout with a dial indicator.

8.4. PROPELLER SHAFT PHASING

Propeller shaft phasing is the alignment of the yokes or flanges with each other (Figure 36). A correctly phased propeller shaft is one in which all of the yoke bores or flange ears are in alignment with each other.

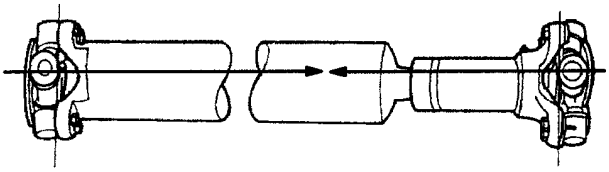


Figure 36 Propeller Shaft Phasing

Propeller shaft phasing can be altered by incorrect reassembly of the slip joint. Improper propeller shaft phasing can produce excessive vibration.

8.5. BALANCING THE PROPELLER SHAFT

There are two methods of balancing the propeller shaft:

A. Rephasing the propeller shaft by rotating it 180' in relation to its current position.

B. Adding a small weight to the propeller shaft.

Rephasing the Propeller Shaft

Before any balance weights are added to the propeller shafts, disconnect the rear propeller shaft at the center bearing and rotate the shaft 180' in relation to the companion flange (vehicles without center bearing, rotate the shaft at the transmission). Reconnect the shaft, then road test the vehicle or spin the driveline and check for vibration.

Adding Weight to Propeller Shaft

Use an adjustable hose clamp and a small metal weight (approximately 1/2 ounce). Clamp the weight to the rear shaft near the center bearing and cut off the excess material of the band as close to the clamp as possible (Figure 37). Road test the vehicle or spin the driveline; then, by moving the weight to various locations on the shaft, find the point of least vibration. Increase or decrease the weight at this point to obtain as perfect a balance as possible. Mark the location of the weight on the shaft and remove the hose clamp and weight. Weigh the weight and add 3/8 of an ounce for the clamp screw and nut. Select a piece of steel of this total weight and tack weld to the propeller shaft at the locating mark. Hold the weld material to a minimum.

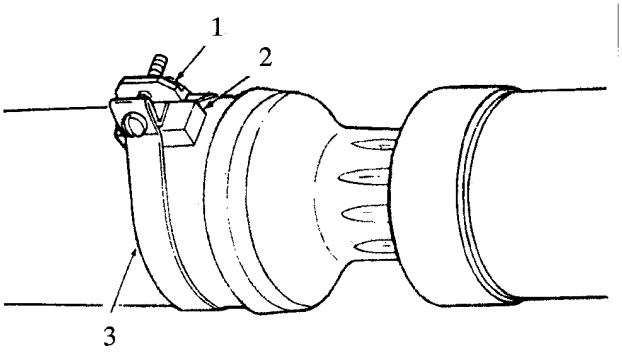


Figure 37 Clamp Weight to Rear Shaft Near Center Bearing

1. CUT OFF EXCESS MATERIAL OF BAND AS CLOSE TO CLAMP AS POSSIBLE.
2. POSITION WEIGHT UNDER HOSE CLAMP BELOW CLAMP SCREW.
3. PLACE HOSE CLAMP AND WEIGHT AS CLOSE TO STUD END OF SHAFT AS POSSIBLE

For vehicles with a single propeller shaft, use an adjustable hose clamp and a small weight (approximately 1/2 ounce). Clamp the weight to the front end of the shaft and cut off the excess material of the band as close to the clamp as possible. Road test the vehicle or spin the driveline; then, by moving the weight to various locations on the shaft, find the point of least vibration. Increase or decrease the weight at this point to obtain as perfect a balance as possible. Mark the location of the weight on the shaft and remove the hose clamp and weight. Weigh the weight and add 3/8 of an ounce for the clamp screw and nut. Select a piece of steel of this total weight and tack weld to the propeller shaft at the locating mark. Hold the weld material to a minimum.

WARNING – When using hose clamps to attach loose weights to a propeller shaft (when checking for vibration), make sure that the weights are clamped securely to the shaft to avoid the hazard of weights flying off.

8.6. CHECKING DRIVELINE ANGLES

Use a magnetic base or electronic protractor to check driveline angles. All information should be recorded on the CTS-1022 Propeller Shaft Analysis Chart(See Figure 51, page 37). Be precise when recording angles.

Driveline Angle Measurement

Use the following procedure for driveline angle measurement:

1. Be sure that the truck is on a level floor and has been moved forward and rearward several times to relieve any internal stress in the suspension.

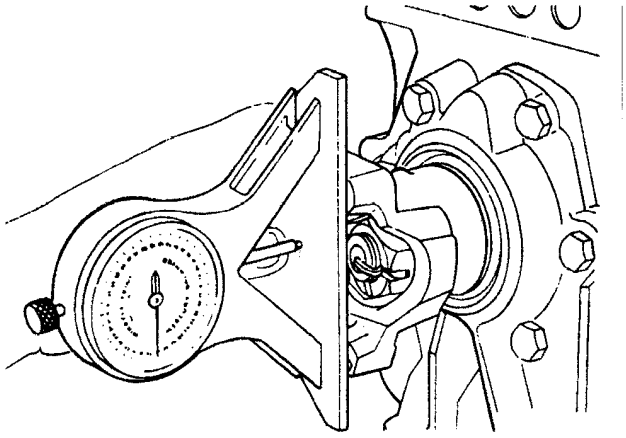
2. Block wheels instead of using parking brake.

3. Inflate the tires to normal operating pressure.

4. If truck is equipped with air suspension, be sure the ride height is adjusted to specification and the air system pressure is 100 PSI or higher while all measurements are being recorded.

   NOTE – DO NOT jack up the truck to level the frame. Frame rake should be checked and recorded the same as all driveline angles. It is not necessary to consider frame rake when determining U-Joint cancellation and joint working angles (JWA).

5. Check and record the angle of the engine and main transmission. This reading can be taken at the rear of the transmission at the yoke or flange (Figure 38). It may also be taken at the engine oil pan rail with ZTSE-4329 Digital Protractor.



OR

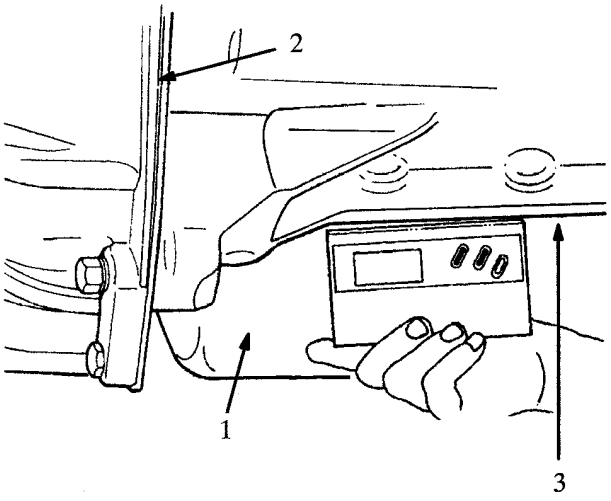


Figure 38 Record Angle of Engine and Main Transmission

1. OIL PAN
2. BELL HOUSING
3. OIL PAN RAIL

6. Check and record the propeller shaft angles between the main transmission and the forward rear axle (Figure 39).

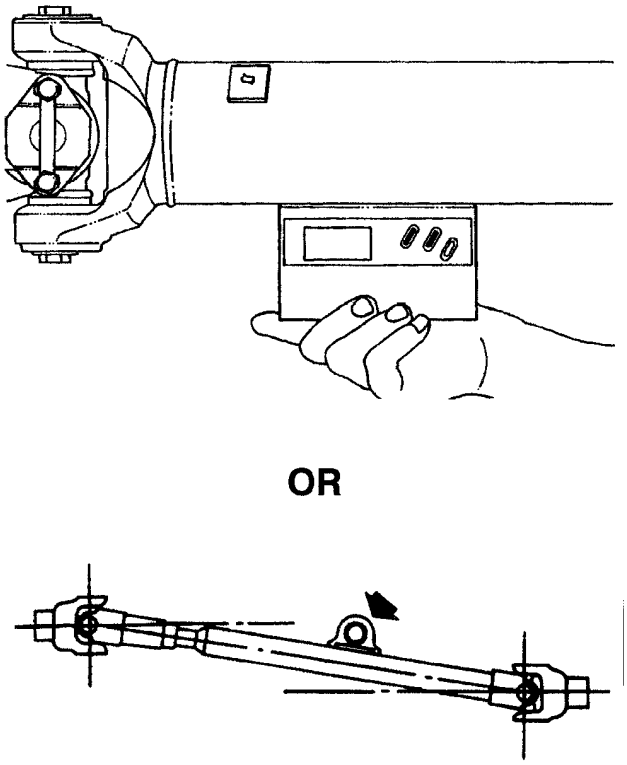


Figure 39 Record Propeller Shaft Angles Between Main Transmission and Forward Rear Axle

7. Check and record the forward rear axle input and output flange angles.

8. Check and record the angle of the driveshaft between the forward rear axle and the rearward rear axle.

9. Finally, check and record the rear axle input flange angle.

The values of all the angles recorded are used to obtain the universal joint working angles (JWA).

The JWA of a U-Joint is the angle formed by the yoke centerlines at the center of the U-joint. When the yoke centerlines form a straight line, the U-joint is said to have 0 degrees working angle. If the centerline of a component or shaft is horizontal, it is at 0 degrees.

When joint working angles (JWA's) are being calculated, it is important to determine if the shaft or component being measured slopes downward or upward. If the front of a propeller shaft or component is higher than the rear (down at the rear), it is a downward slope (Figure 40). The opposite is true for an upward slope (up at the rear).

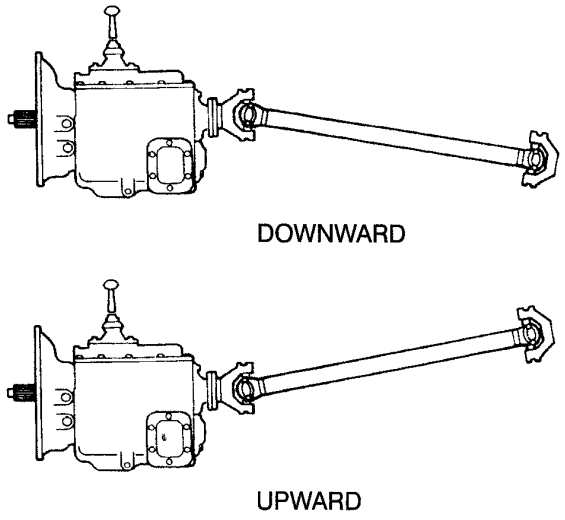


Figure 40 Downward and Upward Slope

If the shafts or components connected to the U-Joint have the same slope (up or down), subtract the larger reading from the smaller reading to determine the JWA.

Refer to Figure 41 . In this example, the propeller shaft angle is 4 degrees down and the main transmission angle is 2 degrees down; the JWA is 2 degrees:

Table 1

Propeller shaft angle =	4
Main transmission angle =	-2
	2

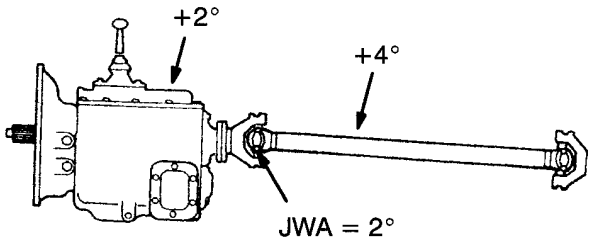


Figure 41 JWA Example

If the shafts or components connected to the U-joint have different slopes, you would add the angles to determine JWA.

Refer to Figure 42. In this example, if the propeller shaft angle is 3 degrees down and the main transmission is 2 degrees up, the JWA is 5 degrees:

Table 2

Propeller shaft angle =	3
Main transmission angle =	+2
	5

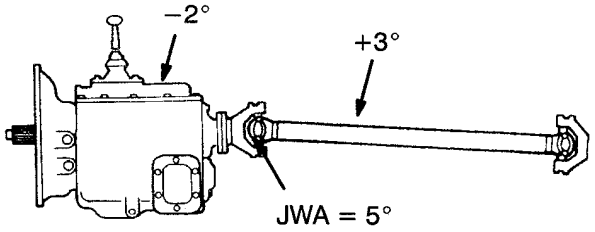


Figure 42 JWA Example

As another example, let's suppose a transmission angle of 3 degrees down and a rear axle angle of 12 degrees down. If the propeller shaft angle is 7.5 degrees down, the JWA of each U-joint would be 4.5 degrees (Figure 43). If the JWA's of a propeller shaft are equal, they are said to have ideal **joint cancellation.**

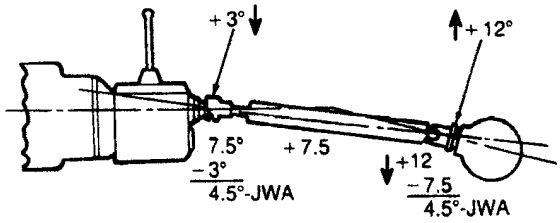


Figure 43 Joint Cancellation

Joint Working Angle Cancellation

As a rule, you will never see ideal joint cancellation. However, if the variation of JWA's in any propeller shaft arrangement is more than 3 degrees, it is considered undesirable. Suspension adjustments may be necessary to correct the joint working angle.

How JWA's Change with Load

The JWA's on some rear axle systems change drastically under a load. This angle change makes it impossible to achieve ideal JWA's in all load positions. Since there is more change with the Hendrickson suspension than the 4-spring or air, let's use it as an example. We know that the JWA's change with load, so the ideal joint cancellation will be achieved somewhere between maximum load and no load.

Refer to Figure 44 . We check angles with no load and find that angles were: forward rear axle +3'30', inner axle shaft +7'30' and the rear rear axle -14'30'. The JWA of the forward joint is 4' and the JWA of the rear joint is 7'.

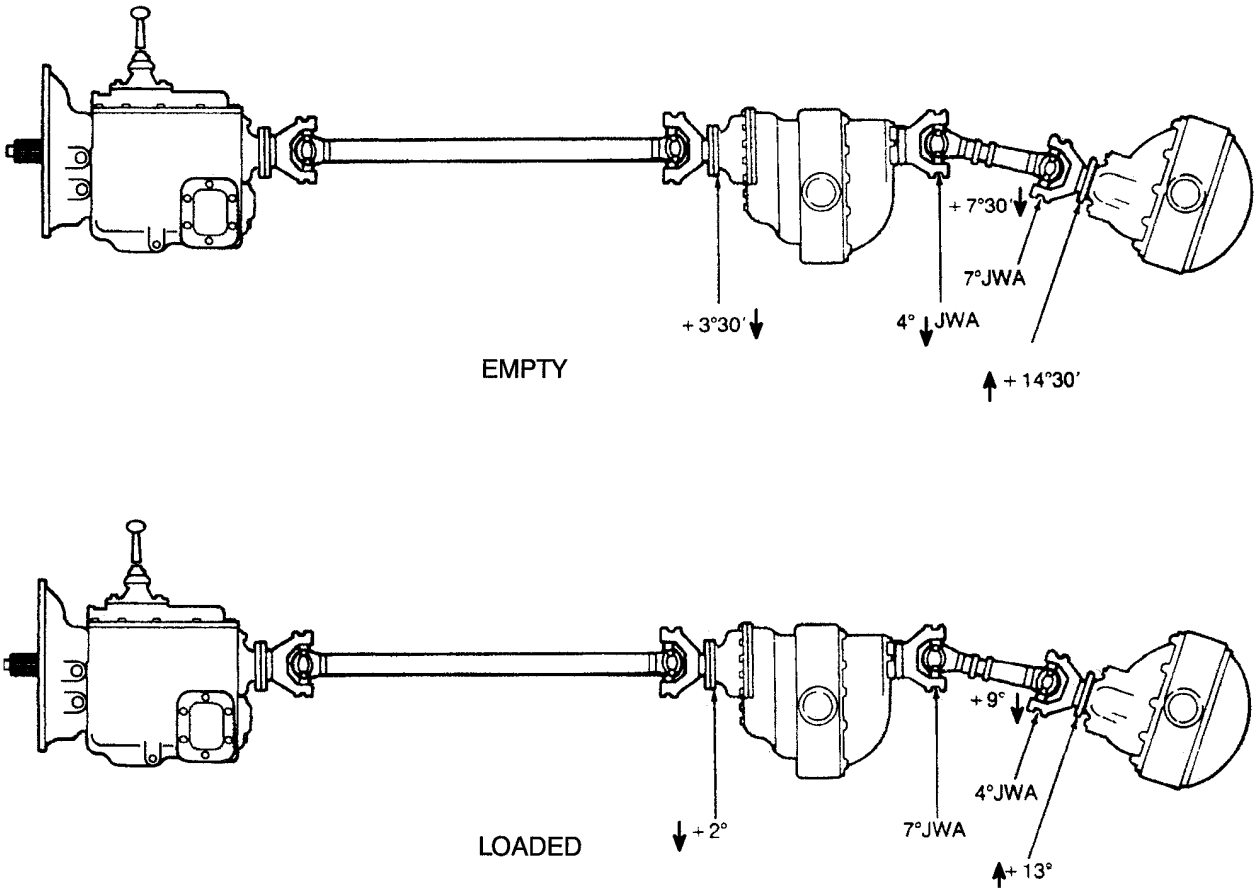


Figure 44 How JWA's Change With Load

Now load the truck to maximum load and recheck angles. Now we find the angles are forward rear axle 2', inner axle shaft 9' and rear rear axle 13'. Now the forward U-Joint working angle is 7' and the rear joint is 4'.

Note that the highest JWA was equal in both load conditions. This U-Joint cancellation is good (3' or less). You should consider the highest JWA to be sure it doesn't exceed the maximum allowed for propshaft speed. Refer to Driveline Universal Joint Operating Angle Chart(See Table 3, page 30) which lists maximum JWA's for driveline rotational speed.

Table 3 Driveline Universal Joint Operating Angle Chart

Driveline Universal Joint Operating Angle Chart	
Driveline RPM	Maximum Working Angle
5000	3'15'
4500	3'40'
4000	4'15'
3500	5'0'
3000	5'50'
2500	7'0'

Table 3 Driveline Universal Joint Operating Angle Chart (cont.)

Driveline Universal Joint Operating Angle Chart	
Driveline RPM	Maximum Working Angle
2000	8'40’
1500	11'30’

9. TROUBLESHOOTING

9.1. TROUBLESHOOTING CHART

Table 4

Condition	Cause	Remedy
Vibration	1. Worn universal joint.	1. Replace U-joint.
	2. U-joint angles too large.	2. Reduce working angles.
	3. Propeller shaft balance.	3. Straighten and balance.
	4. Damaged propeller shaft tube.	4. Replace tube.
	5. Loose O.D. fit on slip spline.	5. Replace slip spline.
	6. Propeller shaft too long for speed.	6. A. Install two piece shaft. B. Use larger diameter tube.
	7. Propeller shaft yoke phasing.	7. Check slip joint for correct phasing. Disassemble slip joint and rotate 180 degrees.
	8. Bearing cap bolts not tightened correctly.	8. Tighten to specifications.,
Vibration (Low Gear Shudder)	Secondary load reaction at shaft support bearing.	A. Reduce U-joint running angles.
		B. Correct slip yoke and slip shaft phasing.
		C. Shim drivetrain components to equalize working angles.
		D. Adjust 2 piece propeller shaft to a 50-50 or 40-60 split.
		E. Reposition shaft support bearing.
Vibration Under Light Load Conditions	Inertia excitation.	Reduce continuous working angles.

Condition	Cause	Remedy
Low Mileage U-Joint Failure	1. Lack of lube or lube intervals	1. Lubricate with proper lube at recommended intervals.
	2. Worn or defective seals.	2. Replace.
	3. Excessive U-joint working angles.	3. Reduce working angles.
	4. Excessive continuous running load.	4. Replace with higher capacity U-joint and shaft.
	5. End galling of cross trunnion or bearing cap.	5. A. Lubricate with proper lube at recommended intervals. B. Use hi-temp grease. C. Reduce U-joint continuous working angles.
Slip Spline Seizure	1. Low or no lubrication.	1. Lubricate with proper lube at recommended intervals.
	2. Slip member working in extreme extended position.	2. Increase prop shaft length.
	3. Excessive torque loads.	3. Replace with higher capacity U-joint and prop shaft.
	4. Contaminated lube.	4. Clean and re-lubricate if serviceable. Replace if necessary.
Shaft Broken in Bending	Prop shaft too long for operating speeds.	A. Install two piece prop shaft.
		B. Use Larger tube diameter.
		C. Reduce U-joint continuous working angles.
Yoke Broken in Hub	1. Excessive torque load.	1. Replace with higher capacity U-joint and prop shaft.
	2. Bending fatigue.	Reduce U-joint continuous working angles.
Broken Cross or Cups	Excessive torque load.	Replace with higher capacity U-joint and prop shaft.
Needle Rollers Brinelled into Cups and Cross	Excessive torque load.	Replace with higher capacity U-joint and prop shaft.
Prop Shaft Support Bearing Failure	1. Lack of lube.	1. Replace
	2. Defective or worn part.	2. Replace
Shaft Support Bearing Insulator Failure	Shaft support bearing misaligned.	Re-align mounting bracket to frame crossmember.
Bearing Cap Seizure in Yoke Cross Holes	Corrosion due to yoke working under load.	During assembly, use anti-seize compound on O.D. of bearing cap.

10. LUBRICATION

Refer to GROUP 10 - LUBRICATION in the CTS-5000 Master Service Manual for recommended lubricants and lubrication intervals.

10.1. UNIVERSAL JOINT

Add lubricant into the grease fitting until it appears at all journal cross bearing seals (Figure 45). This assures removal of dirt particles and other contaminants that may find their way into the bearings. Loosen any cups that fail to purge, or remove U-joint from yoke.

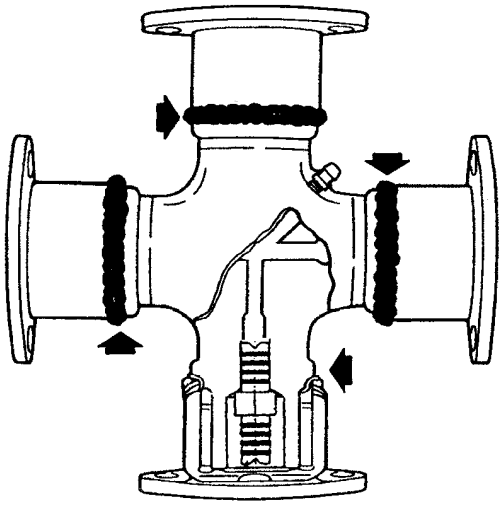


Figure 45 Add Lubricant into Grease Fitting

10.2. SLIP JOINT

Apply grease gun pressure to lubrication zerk until lubricant appears at pressure relief hole in welch plug at sleeve yoke end of spline (Figure 46). At this point, cover pressure relief hole with finger and continue to apply pressure until grease appears at sleeve yoke seal (Figure 47). This will insure complete lubrication of spline.

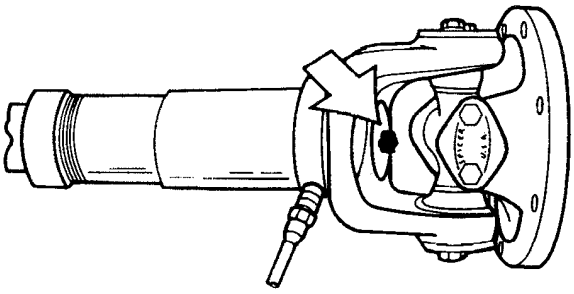


Figure 46 Apply Grease Gun Pressure to Lubrication Zerk

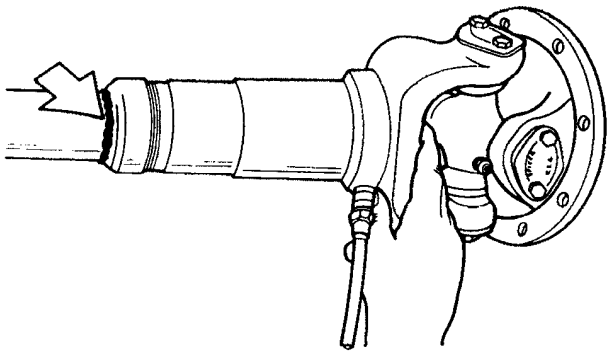


Figure 47 Continue to Apply Pressure

CAUTION – During cold temperatures, be sure to drive the vehicle immediately after lubricating. The slip spline will purge excess lubricant. Failure to do so could cause the excess lubricant to stiffen and force the plug out allowing contaminants to cause spline wear or seizure.

TORQUE

Table 5 Full Round End Yoke Bolt Torque Chart

Full Round End Yoke Bolt Torque Chart			
Series	Thread Size	Ft-Lbs.	N·m
1610	5/16 - 24	26 - 35	35 - 47
1710	3/8 - 24	38 - 48	51 - 65
1760	3/8 - 24	38 - 48	51 - 65
1810	3/8 - 24	38 - 48	51 - 65
1880	7/16 - 20	60 - 70	81 - 95

Table 6 Full Round Self Locking Bolt Torque Chart

Full Round Self Locking Bolt Torque Chart			
Series	Thread Size	Ft-Lbs.	N·m
1610	5/16 - 24	26 - 35	35 - 47
1710	3/8 - 24	38 - 48	51 - 65
1760	3/8 - 24	38 - 48	51 - 65
1810	3/8 - 24	38 - 48	51 - 65
1880	7/16 - 20	60 - 70	81 - 95

Table 7 Half Round End Yoke Bolt Torque Chart

Half Round End Yoke Bolt Torque Chart			
Series	Thread Size	Ft-Lbs.	N·m
SPL90	3/8 - 24	45 - 60	61 - 81
1610	3/8 - 24	45 - 60	61 - 81
1710	1/2 - 20	115 - 135	156 - 183
1760	1/2 - 20	115 - 135	156 - 183
1810	1/2 - 20	115 - 135	156 - 183

SPECIAL SERVICE TOOLS

The Magnetic Base Protractor (Figure 48) can be used to quickly and accurately measure engine angle, propeller shaft angle and rear pinion angle.

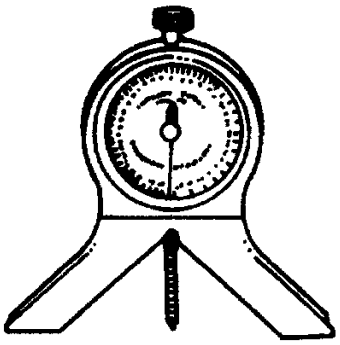


Figure 48 ZTSE-2067 Magnetic Base Protractor

The Digital Protractor (Figure 49) provides instant digital display of level, angle and tilt. Eliminates guesswork by providing a definitive digital display of driveline angle.

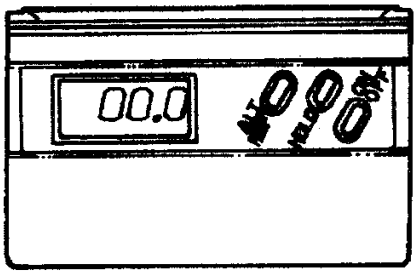


Figure 49 ZTSE-4329 Digital Protractor

The Universal Joint Press (Figure 50) can remove bearings easily, mechanically, without damage to U-joint components, even where space is limited. It applies 7 tons of force to separate the yoke assemblies and remove bearings.

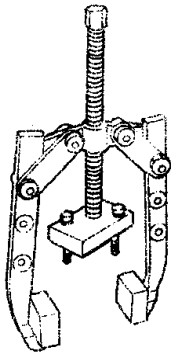
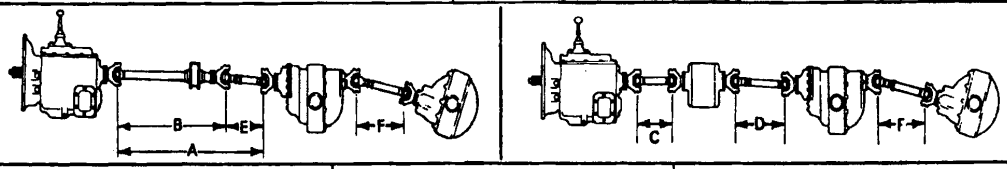


Figure 50 ZTOEM-4186 Universal Joint Press

The Special Tools shown above may be purchased through a Parts Distribution Center.

Customer — Address					
Dealer					
Vehicle Model	Chassis Serial No.		G.C.W.	Mileage	Wheelbase
Engine	Transmission	Aux. Transmission	Park Brake Type Wheel Mounted ☐ Trans. Mounted ☐	Rear Axle	Front Axle
Rear Suspension Code or Type Code _____ Four Spring ☐ Air Suspension ☐ Hendrickson ☐		Front Torque Rod Length: Single —	Left — Rt. —	Dimensions Taken At: Load — ☐ Unladen — ☐	
		Rear Torque Rod Length: Single —	Left — Rt. —	Centerline Spread _____ (measurement forward rear to rear rear axles)	
Frame Angle*	Pinion Angle Forward Rear Axle*		Pinion Angle Rear Rear Axle*		
Engine Angle* (Trans.)	Rear Axle Pinion Angle (for single axle)*	Auxiliary Transmission Angle*		Transfer Case Angle*	

PROPELLER SHAFT IDENTIFICATION Center of Trunnion (front) to Center of Trunnion (rear)	BEFORE			AFTER		
	LENGTH	ANGLE*	↑↓*	LENGTH	ANGLE*	↑↓*
Main Transmission To Rear Axle A						
Main Transmission To Center Bearing B						
Main Transmission To Auxiliary Transmission C						
Main Transmission To Transfer Case C						
Auxiliary Transmission To Rear Axle D						
Auxiliary Transmission To Center Bearing						
Center Bearing To Center Bearing						
Center Bearing To Rear Axle E						
Transfer Case To Front Axle						
Transfer Case To Rear Axle D						
Inter-Axle Shaft #1 (Tandem Axle) F						
Inter-Axle Shaft #2 (Tri-Drive)						



Dimension — Center of Walking Beam to Ref. Line ☐ Walking Beam Length	*Propshaft Downward Slope to Rear ↓ Declination
Dimensions — Center of Universal Joint to Reference Line At: Rear of Main Transmission ☐ Front of Auxiliary Transmission ☐ Front of Transfer Case Rear of Center Bearing No. I ☐ Rear of Center Bearing No. II ☐ Front of Rear Axle Pinion ☐	*Propshaft Upward Slope to Rear Inclination ↑
NOTE: Dimensioning Reference Line is: Bottom of Rail ☐ Top of Rail ☐	
Remarks	

Figure 51 Propeller Shaft Analysis Chart