

Drivelines and Axle Shafts



Figure 1



Figure 2

Drivelines and Drive Shafts

Most every type of vehicle utilizes some sort of drive shaft or driveline. Both driveshafts and drivelines have one purpose: to transmit engine torque from the transmission to the drive wheel(s).

One way to identify and clarify the differences between what a driveline and a driveshaft is, is the type of flex joint used. The image on the left (above), is of a U-joint. U-joints are traditionally used on drivelines which are of a long hollow tube design. Drivelines are common to RWD light duty pick-ups and some SUV's. The image on the right is of CV or

constant velocity joint. These are found on driveshafts, which are short solid shafts that are common to FWD vehicles.

Drivelines and driveshaft are the topics of this chapter.

Drivelines

Another name for a driveline is propeller shaft or “prop shaft.” The tube section of most every propeller is hollow and is often packed with cardboard which absorbs noise and vibrations.

Here are three various drivelines. The *top* driveline is large in diameter and is made of aluminum. It's a *rear* driveline from a 2002 GMC pick-up truck.

The other two drivelines are *front* drivelines of what are often found on many full size 4WD (four-wheel drive), RWD (rear wheel drive) platform vehicles.

Note that the *middle* driveline has U-joints (universal joints) at each end while the *bottom* one has a double cardan joint (two back-to-back U-joints) on the left end and a CV joint on the right.



Figure 3

Rear wheel drive (RWD) platform cars, pick-up trucks, and full-size SUVs (sport utility vehicles) utilize a driveline to transmit engine torque from the transmission to the rear differential. If the vehicle happens to be 4WD (four-wheel drive), there will be two drivelines, one for each of the differentials. Drivelines are long, about 4 inches/100 mm in diameter, utilize U-joints (or at times a rubberized CVT joint), and are found primarily on RWD platform vehicles.

Drive Shafts

Front wheel drive (FWD) cars and crossover utility vehicles (CUVs) will have two drive shafts that transfer engine torque from the transaxle to each of the front drive wheels. Both CUVs and SUVs that are AWD will also use a driveline to power the rear differential and will have two drive shafts to power send power from the rear differential to the rear wheels. Drive shafts are common with front wheel drive vehicles. Driveshafts are usually short and use CV (constant velocity) joints at each end. They are also referred to as “half shafts” and CV shafts in the automotive industry.

One thing that both drivelines and drive shafts must be able to do is to shorten and lengthen while transmitting torque. This is necessary because both the engine and transmission are mounted to a rigid vehicle frame, whereas the vehicle's wheels are connected to the suspension and must be able to move up and down. For power to get from a rigidly mounted power train to the drive wheels, both driveshafts and drivelines must be able to change their drive angle and drive length. Thus, a driveline must be able to telescope in and out in order to allow for such changes to occur as the vehicle encounters bumps and dips when driven.

This video below explains how a shaft can lengthen and shorten by means of a slip yoke.

Driveshaft, Universal & Constant Velocity Joint Training Module Trailer



Figure 4

Constant Velocity Shaft

Figure 4 is of a half shaft or CV shaft. These shafts have been around for many years and are also found on outdoor recreational vehicles. As described earlier these drive shafts have a CV joint at each end.

Fixing a CV Shaft

The two most common reasons as to why these shafts get replaced are due to a torn grease boot and when there is a clicking noise every time the vehicle encounters a turn. CV shafts are most often replaced as an entire assembly. Torn boots allow the grease inside the boot to leak out and allow water and debris to enter. With no grease, the steel balls and other joint components wear rapidly.

The industry has learned over the years that replacing only a CV boot does not guarantee against a future clicking noise and worn CV joint issue. Hence, the practice of replacing the entire assembly became the best solution.

The reason for replacing the entire shaft instead of just one joint or just the boot is because a new shaft is a more reliable repair for both the consumer and the service technician. In the past, it was common to service only the worn joint or a torn boot. Today, joints are not sold separately since it is more cost effective for the customer to pay a technician for his or her time to simply remove and replace the shaft.

The time it takes to clean the joint and replace the boot in the end is more costly than to simply replacing the entire shaft.

One thing about replacing a CV shaft is when possible, a technician should buy a *new* shaft and not a reman (remanufactured) shaft, there is a difference. A reman shaft is comprised of used parts so therefore, it's not new. The used components may have been

inspected and appear to be okay in the remanufacturing process, but they often do not perform up to specification when put back into use. Some remanufactured shafts will make the famous *clicking noise during a turn* on the first test drive immediately after the repair. This can be most frustrating to the technician and to the customer. However, when servicing older vehicles, a reman shaft may be the only option that is available. In this case, a reman shaft must be used. The recommendation is, use a new shaft whenever possible.

Driveline Service

When it comes to servicing drivelines, as pictured below, the repair practices are different compared to CV shafts. With drivelines, U-joint replacement may be all that is needed and is the most common type of repair. If there are other issues with the driveline, like worn slip yoke splines then the driveline will need to be sent to a driveline shop that can replace the slip yoke. If ever the driveline becomes bent, the only option is driveline replacement.

Of course the other common repair when dealing with a worn slip yoke or a bent driveline is to purchase a salvage yard unit. This is often the most economical choice.



Figure 5

U-Joint Service

U-joint service requires some skill to perform. The author of this chapter has one policy about U-joint service: DO NOT use a hydraulic press during any part of the service. Many drivelines, especially the yokes, have become bent when a hydraulic press is used, thus ruining the driveline. Students using a hydraulic press for this kind of service will replace the driveline at their expense.

Here are two different videos that show three different approaches to replacing a U-joint. Enjoy.

U-Joint Service Hammer and Vise Method

How To Replace U-Joints Two Ways

The Components of a Driveline

To get more familiar with the components that make up a driveline, study the various parts as identified below. This particular driveline is a two-piece driveline since it is comprised of two sections: the slip yoke section and the tube section.

1. U-joint
2. Yoke
3. Slip yoke-this has matching teeth to match the splines on the driveline.
4. Splines
5. Tube
6. Yoke
7. Double Cardan joint (back-to-back U-joints)

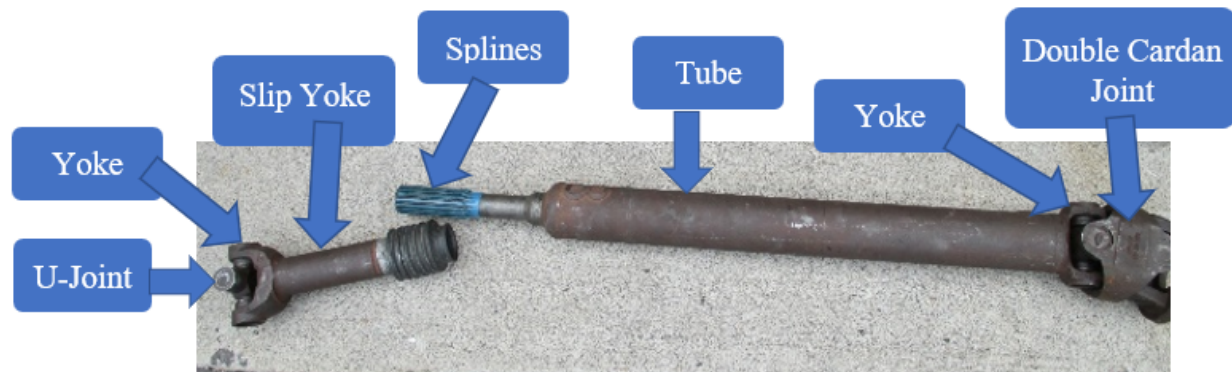


Figure 6

Driveline Angles

The video below explains the working angles of a driveline. It demonstrates many important principles about driveline geometry. There is substantial information explained here, so prepare to take some notes, as these will be on this chapter's test. Enjoy.

Drive Shaft Angles Explained

U-Joint Angularity

The next pages will address terms like **double Cardan, driveline angle, U-joint working angle,** and **drive yoke parallelism.** You may wish to take some notes about these terms.

Universal joints operate on a principle that is not easily understood at first. Let's begin by stating that as the driveline and U-joint assembly rotates, it does not rotate in a constant manner. The driveline's rotational speed fluctuates. A U-joint oscillates (speed fluctuates) as it rotates. Additionally, there needs to be two U-joints on a driveline, one at each end, for one important reason: the U-joints at each end of a driveline work together in order to produce speed consistency to the drive yokes. This all sounds confusing, so you need to watch this next video for about 2 minutes in order to visualize U-joint action for yourself.

Drive Shaft Velocity

Did you get that? In order for both the output and the input yokes to rotate at a constant speed, they need to be parallel to each other. **Unequal** drive yoke angles **will not** produce a uniform rotational speed at the driven yoke as shown.

Drive Yolk Locations

Another thing to point out is that there are two different drive yokes. First, the one circled below in **red** is an inner yoke and gets welded to the driveline itself during manufacturing, which makes it part of the driveline; therefore, this yoke will speed fluctuate along with the driveline as it rotates. The other drive yoke is the one that attaches to the transmission or to the differential. This outer yoke rotates in a steady or constant fashion.

Watch the same video (Drive Shaft Velocity) again but this time, start at the *1:40 mark* and stop at the *2:00 mark*. This is worth repeating, because this video demonstrates how the *outer drive yokes* rotate at a *constant speed*.



Figure 8

The point of Figures 9 & 10 is to emphasize the different drive yoke locations. The yoke in figure 9 is an outer yoke and is connected to a transmission. This is the yoke that rotates at a *constant* speed.

The “Driveline yoke” in Figure 9 is the yoke that rotates in a speed fluctuation manner.

The point of Figure 10 is this yoke, which connects directly to a differential or to a transmission, are the yokes that rotate at a constant speed.

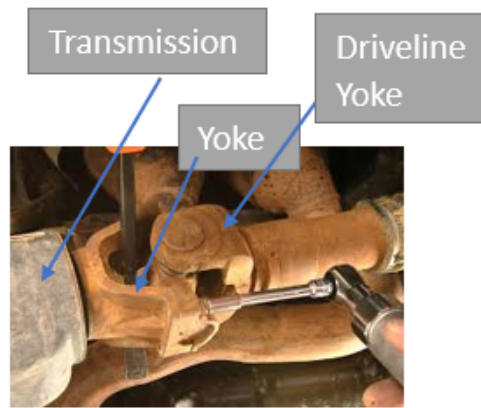


Figure 9

Two angles to know about

One is *U-joint operating angle*. The point is, the steeper the angle at which the U-joints operate, the greater the speed fluctuation action. The recommended range for U-joint operation angle is somewhere between **2-10 degrees**.

Second, another dynamic is *driveline angle*. In regard to this, **the** absolute maximum acceptable drive angle is **20 degrees**.

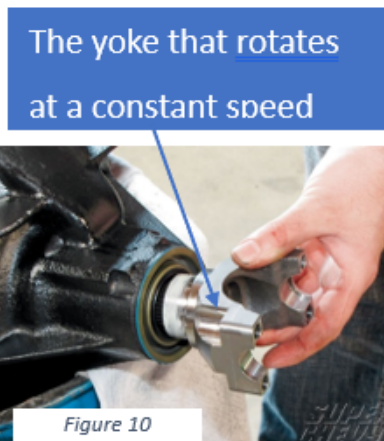


Figure 10

Phasing

Figure 11 demonstrates what “**in phase**” means. The red line through the *top* driveline shows how the U-joints are lined up with each other. The *bottom* driveline U-joints are not in phase. In phase means the drive yokes at each end of the propeller shaft are on the same plane, which is to say they are *in line* with each other.

An out of phase U-joint condition is only possible on two-piece drivelines not one-piece unless the driveline has become twisted.



Figure 11

To summarize, when a two-piece driveline slip yoke splines slide together in a manner that the U-joints are not aligned with each other, the propeller shaft will not operate smoothly.



Figure 12

This driveline, Figure 12, is a one-piece design. The only way this type of driveline can become out of phase is if the tube becomes bent or twisted since the drive yokes at each end are *welded* in place.

Review

Let's review what we have learned thus far about U-joints and propeller shafts. Especially as to what it takes for a driveline to operate vibration free.

1. The two outer drive yokes must be *parallel* with each other, within *1 degree*.



2. Driveline drive angle should not exceed **20 degrees**.

3. Preferred U-joint working angle is between **2-10** degrees. In extreme cases 15 degrees is considered the maximum acceptable.
4. The drive yokes at each end of a driveline must be **in-phase** with each other.

*Something that didn't get mentioned earlier is, U-joints shouldn't have any looseness about them, or they are considered worn out. If there is any perceptible movement or play in a U-joint, it should be replaced.

When it comes to **parallelism**, things that can affect drive yoke parallelism are transmission mount condition, the state of the suspension's springs, and if the vehicle has been lowered or lifted.

This video "Driveline Troubleshooting" explains **phasing** and **U-joint angularity** well.

Driveline Troubleshooting

As shown in the video, an **out of phase** driveline causes a vibration or speed variation. The last part of the video shows how important it is that the drive yokes are parallel to each other. Hence, phasing and drive yoke working angles are important for vibration free driveline operation.

There has been some repetition in this chapter about driveline angle, U-joint operating angles, drive yoke parallelism and phasing. The purpose is to emphasize the very principles that so many in the industry do not understand. This is your opportunity to gain insights about these rarely understood concepts, which will set you apart from many service professionals.

Consider this speed fluctuation image, Figure 13. It demonstrates the oscillating action of U-joints. The whole point of this image is to demonstrate the need for driveline yokes to be in phase so that these oscillations can "cancel each other out" so that the driveline can operate smoothly. In other words, when in phase, the U-joints at each end of a driveline speed up and slow down at the same time which enables these actions to cancel each other out. When driveline yokes are not in phase it causes stress (vibrations) to the driveline's U-joints, because they cannot speed fluctuate at the same time.

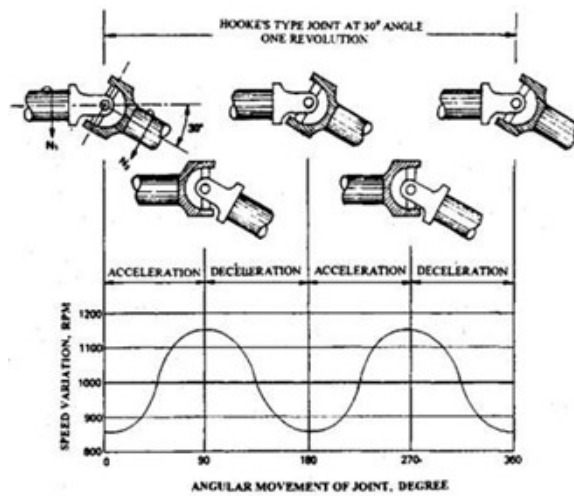


Figure 13

Drive shaft speed fluctuations do not occur with CV, constant velocity joints. As their name suggests, they always rotate at a *constant speed*. CV joints, however, have a few disadvantages which are:

1. They are more costly to manufacture.
2. They have less torque delivery capability (can slip) as compared to U-joints.

Let's bring this all together with the topic of **two-piece** drivelines. Study the image below and you will see that the *front* "prop shaft" operates at a different angle as compared to the *rear* "prop shaft." Once again, what matters most for vibration free operation is:

1. The drive yokes of both prop shafts are in-phase, individually and with each other.
2. The transmission's output yoke and the differential's rear pinion yoke are within 1 degree parallel.
3. The driveline angles are not steep—nothing close to the 20-degree maximum.
4. U-joint working angles are low as well

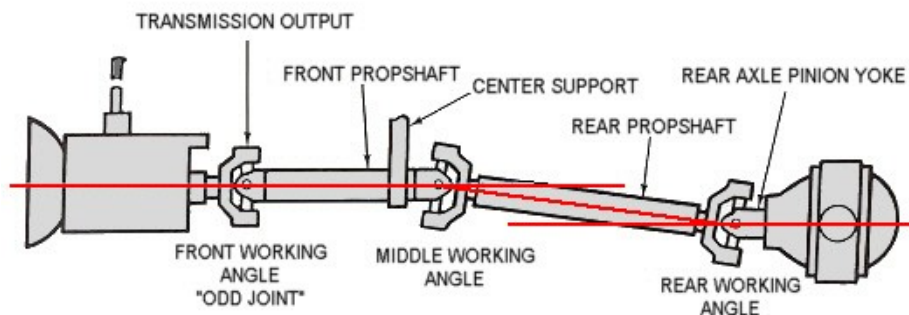


Figure 14

The point of this Figure 15 is not about driveline angle, but it is about the *parallelism* of the two drive yokes that connect a transmission to a differential.

Study the thin **red** colored lines of each of the four driveline images. The two top drivelines are correct and will operate smoothly. In order to do so, the outermost yokes need to be within *one degree* of each other.

The third and fourth driveline end yokes are not parallel to each other and therefore will cause driveline vibration, just as if the U-joints were not in phase.

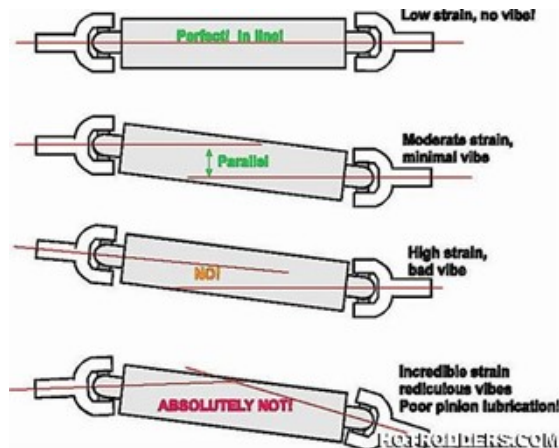


Figure 15

This principle is not always understood by folks who lift their 4x4's. The point here is this, when there is a driveline vibration, they blame driveline phasing. What they fail to realize is that the *two* drive yokes need to *be parallel* to each other.

Figure 16 is an image of what a U-joint is comprised of. Universal joints more correctly called **Cardan joints**, are considered to be one of the oldest designs of flexible rotating couplings known to man. A Cardan joint consists of a one-piece cross that has four smooth machined **trunnion** areas. These trunnions support several precisely manufactured **needle bearings** that in turn support four **caps**. The bearings require grease in order to give long service life. Most U-joints on today's vehicles are sealed meaning they cannot be greased, but when a U-joint gets replaced with an aftermarket part, quite often a grease Zerk is provided so that the joint can be lubricated.



Figure 16

Additionally, the caps must be retained in place with **retaining clips** in order to keep the joint from flying apart as it rotates at significant speeds.

One person that is thought to be the inventor of the universal joint is **Robert Hooke** who lived in the 1600's. He analyzed and discovered that such a joint design rotates in a speed variation manner.

The first person in history associated with actually suggesting this joint for transmitting 'motive power' was **Gerolamo Cardano**, an Italian mathematician. He lived in the 1500's and it is not certain whether or not he produced a working model. As mentioned above a more correct name for U-joints is **Cardan** to Cardano's credit.

U-Joint Wear and Replacement

The items that wear on a U-joint are the needle bearings and the trunnion surface area. The needles can become worn enough where it will cause a "*clunk*" noise when the vehicle is first put into gear from Park to Drive or Reverse. The clunk occurs because as torque is suddenly applied to worn U-joint needle bearing, the slack or looseness in the U-joint is what causes the clunk noise. This noise is loud enough to be heard by the driver the passenger compartment

Wear is caused whenever the universal joint needle bearings become dry of lubricant which allows rust to occur which disintegrates the needles. The first sign of rusty needle bearings is the U-joints tend to "squeak" as the shaft rotates slowly, the vehicle is driven at very low speed.

In extreme wear and tear situations, the **cross** can break, thus eliminating its ability to transfer power all together. Whether a joint is worn or is broken, a driveline can be restored to good working order by U-joint replacement so long as the drive yokes on the driveline are in good condition.

This [movie](#) demonstrates U-joint service using what is known as the Tiger Tool.

Search: 'Service U-joints in minutes using the Tiger Tool 10105 U...' if this video does not load:-

When replacing a U-joint, ensure that all **clips** are installed securely. If a clip is left out or is not installed properly, the joint cap will pop out of place while the vehicle is driven which causes the driveline to detach and rotate wildly under the vehicle. This causes damage to the fuel tank and other under car items.

Drive Lines and Shafts

Let's identify some contributing factors to U-joint wear. They are towing heavy loads, driving through water, harsh and sudden vehicle accelerations, and steep drive line operating angles. Driving conservatively and not modifying the vehicle's suspension are factors that extend universal joint life.

In the light truck and SUV or sport utility world, it's common to see both **one-piece** and **two-piece** drive lines. One difference between them is where the slip yoke is located. One piece drive line slip yokes extend into the transmission end on the driveline. Two-piece drive slip yokes are located somewhere in the middle of the drive line. As mentioned earlier, slip yokes are necessary because a drive line must have the ability to extend and shorten during vehicle operation.

In this picture, the slip yokes are hidden under the black flexible boots. Additionally, some two-piece drive lines have a third U-joint near the slip yoke and **carrier bearing**. Carrier bearings are necessary since a long drive shaft can cause clearance issues and can get bent when off roading.

Pick-up trucks with extended beds often have two-piece drive lines that include a carrier bearing.

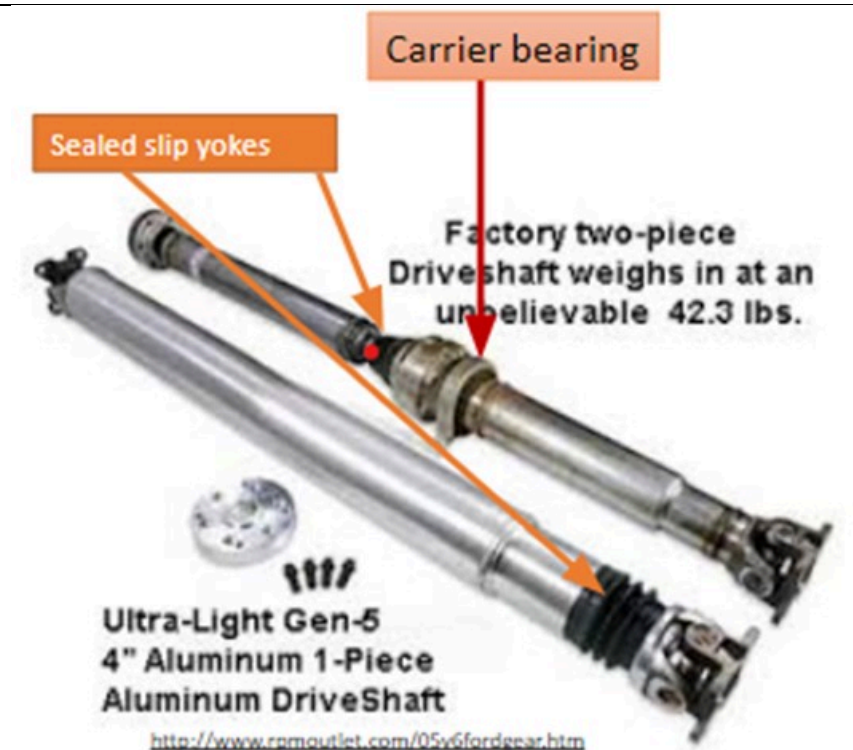


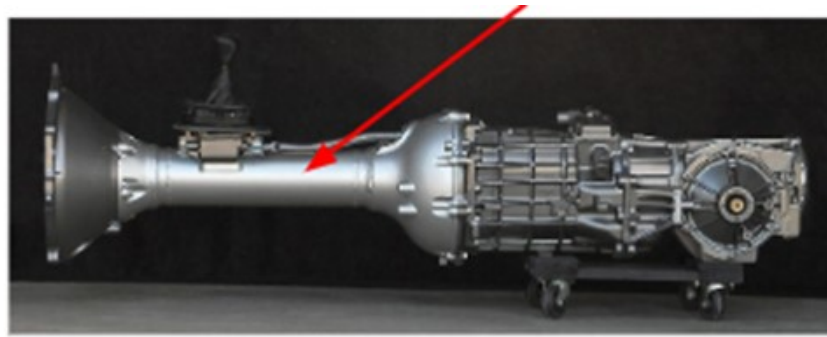
Figure 17

Torque Tube

Another drive line design you may not be aware of is a **torque tube**. These are only found on high-end sport cars. A torque tube is a type of driveline that has either one universal joint or a rubber flex joint at one end of the shaft. The driveline is housed inside the torque tube. Note in figures 18 it shows that the tube bolts directly to both the transmission and the Engine. Figure 19 is of a torque tube that bolts between the rear differential and the transmission. Torque tubes act as a stabilizer to prevent the rear differential from twisting or “wind-up” during hard acceleration.

Torque tubes have been around for some time and more recently are standard equipment on C5 and C6 Corvettes.

Note the angular beams – figure 19 – that extend from the torque tube back to the differential housing. These give added support to prevent differential wind-up. The objective of this system is to send all of an engine’s available torque directly to the drive wheels.



<https://rick486.wikisite.com/dobbertinperformance/copy of 06 type 1 front engine>

Figure 18



<http://www.eaglemountain.se/del5.htm>

Figure 19

Axel Shafts

Front wheel drive (FWD), All-wheel drive (AWD), and many 4x4 pick-up trucks utilize drive shafts/half shafts with CV joints. As the name implies, the shaft and the CV joints rotate at a constant speed, there is no speed fluctuation. Therefore, there is no concern for joint parallelism or phasing with **CV joints**. Another advantage of CV joints is that **the shaft** that they are fastened to can operate at steeper angles, up to **35 - 40 degrees**. Consequently, CV joints have fewer reasons to experience drive shaft vibration as compared to drivelines with U-joints.

CV shafts or half shafts move or articulate with the front wheels as the vehicle is steered during turning maneuvers, and they do so smoothly.

Some drawbacks to CV joints are that they are more costly to manufacture because of their complexity, and believe it or not, they are weaker in regard to transferring torque. In short, U-joints have a greater capacity to deliver torque, and this is why U-joints are still popular today on full size pick-up trucks.

The shaft of a CV or axle shaft is usually made of solid steel, not a hollow tube.

Constant Velocity Joints

There are two popular CV joint designs. Rzeppa design, which is made up of **six** steel balls, is used in most every instance on outer CV joints. Inner CV joints are either Rzeppa six ball type or they may be three-roller design known as a tripod. Tripod joints are designed to slide in and out in order to allow the shaft the ability to lengthen and shorten.

Figure 20 shows both design types. The Rzeppa design is given more detail because it has more complexity.

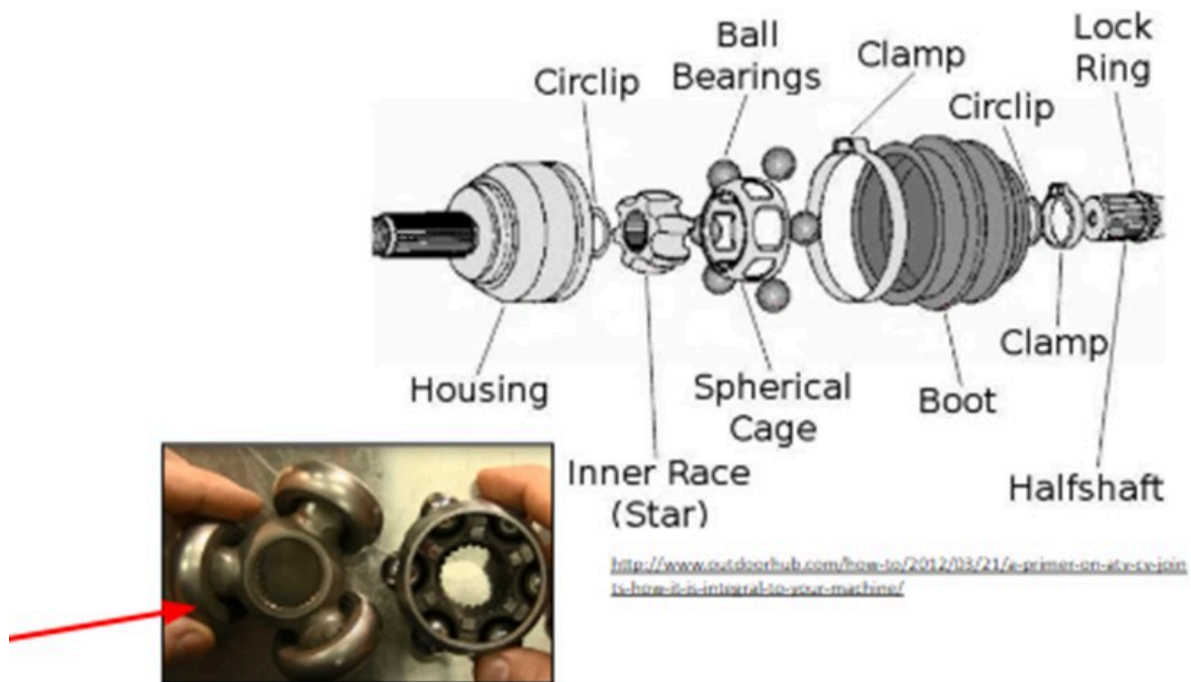


Figure 20

With both design types the inner parts of a CV joint are enclosed in a flexible rubber boot that keeps the lubricant in and dirt and water out. The grease that lubricates and is basically sealed inside the boot is called **EP** (extreme pressure) grease. This high-grade grease is a specific type of grease, and it allows the joint to give lasting service.

As a vehicle is driven, the grease inside the boot gets warm, thins out, and for the most part **liquefies**. This liquefaction enables the grease to lubricate all of the joint's moving components. Since the front wheels of a car propel and steer the vehicle, this tends to cause the **outer CV boots** to deteriorate sooner than do **inner CV boots**. The outer boots flex repeatedly while the shaft rotates and as the front wheels are steered during cornering maneuvers. CV boots are known to crack and break open.

When a CV boot cracks or tears open, the grease inside slings out, which allows dirt and water to get into the working members of the joint. This accelerates joint wear and eventually leads to the rhythmic "clicking" or click, click type noise that outer CV joints are known to make whenever the vehicle is steered during a turn, the sharper the turn the more chance of such noise.

Some technicians will test for worn CV joints by driving the car in reverse while steering the wheels sharply. Sometimes driving forward during relatively sharp turns isn't enough

to reveal a worn joint, but doing so in reverse seems to be a way to catch early signs of joint wear.

If a clicking noise is heard while maneuvering through a turn to **the right**, the problem or worn joint is the left CV joint. The principle is: if a joint is worn, then the joint where most of vehicle's weight is imposed will make noise. When this occurs, half shaft replacement is recommended. The point here is there is no immediate problem, and such noise can exist for some time.

Lastly, the clicking noise results when enough wear has occurred between the steel balls and the grooves that they travel across inside the joint.



Figure 21

Inner CV joints, sometimes called **plunge joints**, have their own wear symptoms. Here are some associated noise descriptions that occur when **inner** CV joints become excessively worn.

1. When a subtle or **small vibration** is felt throughout the front end of the vehicle at certain highway speeds, often at speeds above **60mph**. This is often an indicator that an inner joint has some excessive wear. Let's continue the diagnosis by stating, this vibration will disappear the moment the brakes are tapped or when neutral is selected while traveling at high speeds. If the vibration disappears because torque is released from the joint, then it means that an inner CV joint has become worn.
2. Another indication of inner CV joint wear is when a **single clunk** type noise is heard whenever the vehicle is accelerated from a stop. It won't be repetitive like an outer joint's click, click but it will produce one clunk.
3. In **cases of extreme** inner joint wear, a sudden and violent vibration in the front end of the vehicle will occur while driving. This excessive vibration will disappear for a time but only after the vehicle is brought to a complete stop and neutral is

selected (releasing torque on the joint). However, when the car is driven again to a higher speed, the violent vibration will reoccur (because the drive shaft has become off center in relation to the joint). This indicates that an inner joint is allowing the shaft to “leave center.” In other words, the drive shaft doesn’t stay centered in the joint while it rotates. When a shaft can’t spin in true alignment of the CV joint assembly, intense vibrations can occur.

4. Occasionally, a CV joint can wear out so completely that the joint becomes incapable of delivering any engine torque to the drive wheels. When a CV joint fails in this way, the vehicle will not be able to move. This condition is often misdiagnosed as transmission failure. Be sure to inspect the CV joints when there is no vehicle movement when placed in gear. Video 1 shows such a CV joint condition.

Video 1

Another joint classification is outer CV joints are a **‘fixed’** joint; this means the joint cannot telescope. As stated earlier, six-ball VC joint design is referred to as a **Rzeppa** joint (pronounced ‘*sheppa*’). Rzeppa is the name of the engineer that developed this joint design in 1927. To his credit, Rzeppa has been the most proven and popular design.

There is another joint design known as **Countertrack**. It utilizes eight balls and is patterned after the Rzeppa joint. Countertrack joints are smaller and lighter than the larger type Rzeppa joints and can operate at angles as high as **52 degrees**. Countertrack joints seem to be popular with recreational vehicles.

Video 2 is an 8-minute video that points out some **wear** characteristics of both inner and outer joints. Search: ‘CV joint movie’ if it fails to load.

Video 2

Torque Steer

Torque Steer is a flawed condition that occurs with some FWD vehicles that occur only during hard acceleration. There are a few things that contribute to this condition. One cause of torque steer occurs when a difference in tire traction between the two front wheels exists. Quite often it’s as simple as unequal tire inflation or there is a major difference in tread condition.

The second cause of torque steer is due to vehicle design, meaning the two front CV half shafts are different in length. What this leads to is the shorter shaft delivers torque to its wheel more effectively than the longer shaft is able to. This is not typically a serious issue and is only slightly noticeable, but to some consumers they feel it makes the car a bit unpredictable while accelerating. This is something that many people don’t really notice but others do.

Without getting too deep into the laws of physics, let’s just say that when the two drive shafts are different in length, torque behaves slightly differently when the car is accelerated. While accelerating at speeds under 20 mph, the front suspension and the engine and transaxle assembly twist a bit unequally because the drive shafts are different in length. This puts a little more power to the shorter shaft which causes a slight pull to that side.

The good news is, today the vehicles that are equipped with **electric steering** (something that has been quite common since 2012) can actually detect this problem and can **compensate** for this condition. When unequal torque is detected, the steering system actually steers the wheels ever so slightly in the opposite direction in order to eliminate the effects of torque steer.

To review, torque steer is a condition that occurs during hard **acceleration** at lower speeds on FWD vehicles where the two half shafts are unequal in length or when there is a traction difference between the two drive wheels. This condition is, at times, noticed on vehicles that have **hydraulic power steering**. Electric steering systems do not experience torque steer.

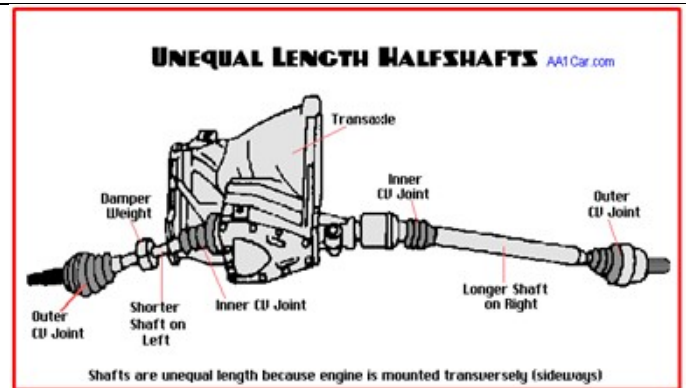


Figure 22

One way that some manufacturers try to eliminate torque steer is to add an **intermediate shaft**, see the right-hand diagram in figure 23. The addition of such a shaft increases the purchase price of the vehicle, therefore intermediate shafts are not usually found on less expensive compact cars. However, they are found on mid-size cars and CUVs – Honda Accords, Toyota Camrys, Ford Edge, Explorers, etc.

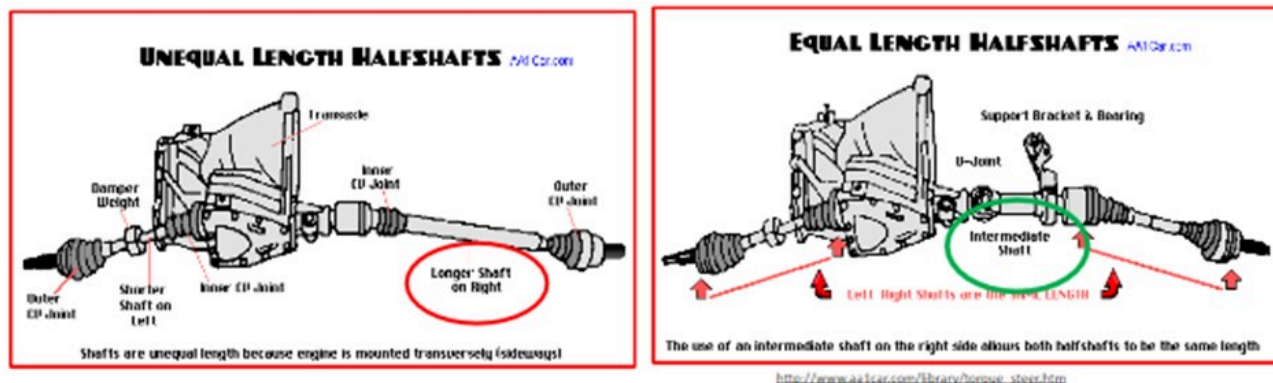


Figure 23

An intermediate shaft acts like an extension of the transaxle's final drive which enables both CV shafts to be the same in length and most importantly, the same in drive angle.

Other approaches to compensating for torque steer:

1. The most expensive option is to design the vehicle so that the transaxle is located at the vehicle's **center**. This is simple in theory and is the most effective method of eliminating torque steer, but it adds cost to the vehicle. It is much less expensive and more compact to design the transaxle as most often is the case, with one CV shaft longer than the other.

2. Another option, which is the least expensive and is found on many compact cars, is to make the longer shaft **larger in diameter**. This is shown in the left picture of figure 23. The shaft is actually labeled as "Longer Shaft on Right." The reason for this difference in diameter is that the longer shaft operates at less of an angle. Therefore, it needs to cover more distance, since more torque tends to go to the shorter shaft. This option is not as effective as an intermediate shaft, but it is an attempt by engineers to compensate for how torque behaves during acceleration when the half shafts are of different lengths.

3. Something else seen with compact cars on one of the CV axle shafts is to use a **vibration damper**. This is simply a round rubber piece that gets attached around the shaft to absorb some shaft vibrations. The arrow in figure 24 points to a vibration dampener. Vehicles come from the factory with a damper, but quite often replacement shafts from an aftermarket part distributor do not come with one. Apparently, a damper's importance isn't great enough to include them on replacement shafts.



Figure 24

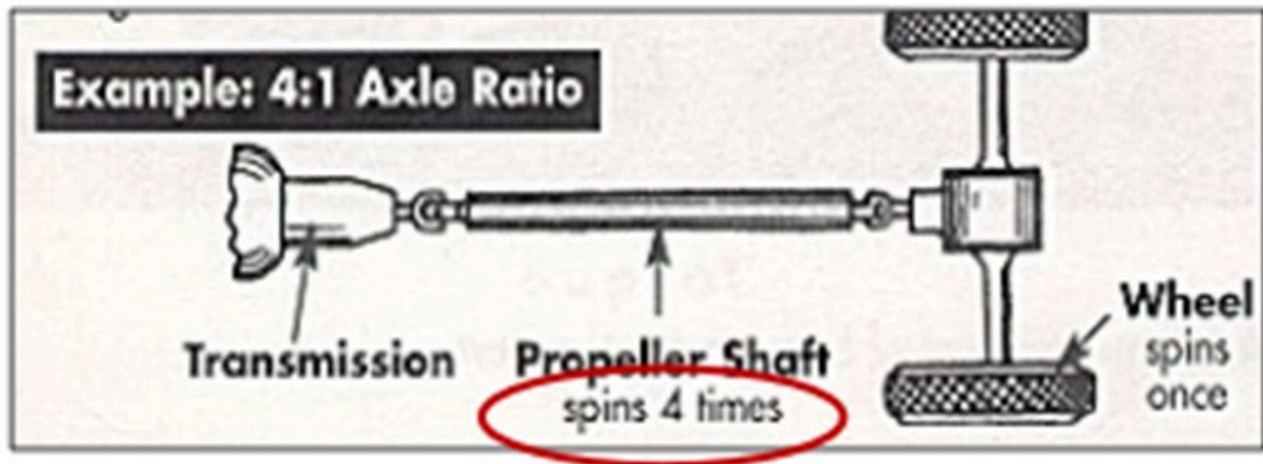
Shaft rotational speed differences

Here's one insight that many don't consider which is driveline and drive shaft **rotational speed differences**.

What figure 25 indicates is, RWD drivelines spin about four times **faster** than FWD drive shafts. Why is this? Think of where the final drive or differential gears are located in a FWD vehicle versus a RWD vehicle. A RWD's transmission does not house the final drive gears like a transaxle does.

Another topic to point out here is **shaft balance**. Since CV axle shafts are shorter and spin at slower speeds, there is less of a concern with shaft balance as compared to

RWD drivelines. As mentioned earlier, RWD drivelines spin faster and are much longer compared to CV shafts.



http://www.carlist.com/autoglossary/autoglossary_40.html

Figure 25

Drive Lines and Vibrations

Figure 26 shows an example of what too much torque can do to a driveline.



<http://www.dieseldplace.com/forum/76-specialty-forums/125-drivetrain-2001-2010/11463-cv-half-shafts-truck-pulling.html>

Figure 26

Drive line vibration. Here are some tips in regard to driveline vibration. If a vibration is felt at vehicle speeds near or above 50 mph, first ensure all four wheels are in balance, second - that the U-joints have no perceptible slack in them, (if either of the U-joints are worn, it can cause the shaft to be out of center and simulate a bent shaft). Third, look for dents on the drive line tube and fourth, inspect to see that driveline tube is bent.

To measure to see if a driveline is **bent** use a dial indicator to measure in at least two different places. **1.** At the very center of the driveline, approximately **.040" (1 mm)** is the max allowed (see figure 27). **2.** The second place to measure is at either of the two ends of the driveline about six inches from where a welded yoke exists. Maximum run-out specification for this is **.015."**



Figure 27

Figure 28 shows a **balance weight** that the manufacturer welded in place. Out of balance driveline can be the cause of a vibration issue. Only a driveline shop can check driveline balance, but you can at least check to see or look for evidence for the possibility that a balance weight has come off.

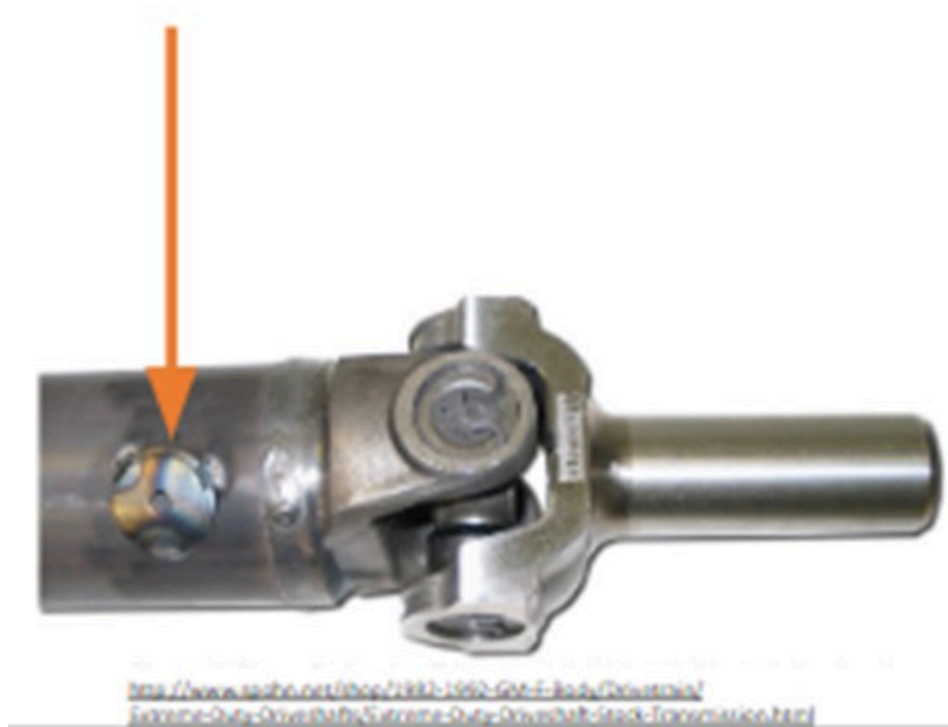


Figure 28

Here are two videos that will help you understand more about drive line wear issues.

This 1:39 minute video demonstrates a driveline vibration issue, and the fix is simple! Enjoy.

Video 3

Video 4 below demonstrates how to check for **U-joint** wear and binding.

Search: “Ford Quick Tips #56: The Most Accurate Way to Check Driveshaft U-joints” if the link does not work.

Video 4

Here is one last insight about drive line **noises & vibrations**. Driveshaft **splines** (the blue colored teeth in figures 28 and 29) can become dry of lubricant or can be worn excessively. Worn spline teeth are inspected for looseness much like U-joints:

1. Block the vehicle’s wheels so that the vehicle **cannot roll**, and then place the vehicle in **neutral** with the engine off. This removes all torque from the driveline.
2. Now, while under the vehicle, grab hold of the driveline to see if the U-joints or the slip yoke (splines) have any movement. Tug and twist the drive line aggressively at each of the U-joints and at the slip joint.



Figure 29



Figure 30

Slip Yokes

In regard to spline teeth found on a slip yoke a small amount of play or movement is tolerable; which is not the case with for U-joints as described earlier. As shown in Video

4, U-joints should also be checked for binding, none is allowable. To check for a U-joint binding issue the driveline needs to be removed from the vehicle. When it comes to slip yoke teeth, slide the slip yoke off and examine the splines closely and lubricate them. Quite often, all they need is some grease. Dry spline teeth can make some strange noises, especially at slow driving speeds.

If no problem can be found after inspecting and lubricating the splines and if the U-joints check out yet noise still exists, perhaps the problem is elsewhere such as in the differential.

Diagnosing Drive Lines

Drive line diagnosis sometimes includes driving the vehicle (if it has part-time 4WD) in 2WD, 4WD, HI, and 4WD LO modes. Doing this just may reveal a noise that might be coming from the transfer case. If a noise changes when it is driven in the various transfer case modes, try removing the front driveline and then drive the vehicle again. You may have to reinstall the front driveline and then remove the rear driveline for further testing. The idea is to see if either drive shaft has any impact on the noise that is being diagnosed.

Drive shafts and drivelines are simple components, but they require service as with all drivetrain mechanisms.

In this chapter, axle shaft, drive line operation and service were explained. These shafts are not complicated components but can be the cause of a noise or vibration concern. Transferring engine torque from the drive train to the drive wheels of a vehicle seems like a simple thing yet these components are often overlooked during the diagnosis of a vehicle concern.

Good luck.



Drive line balance weight

Figure 31

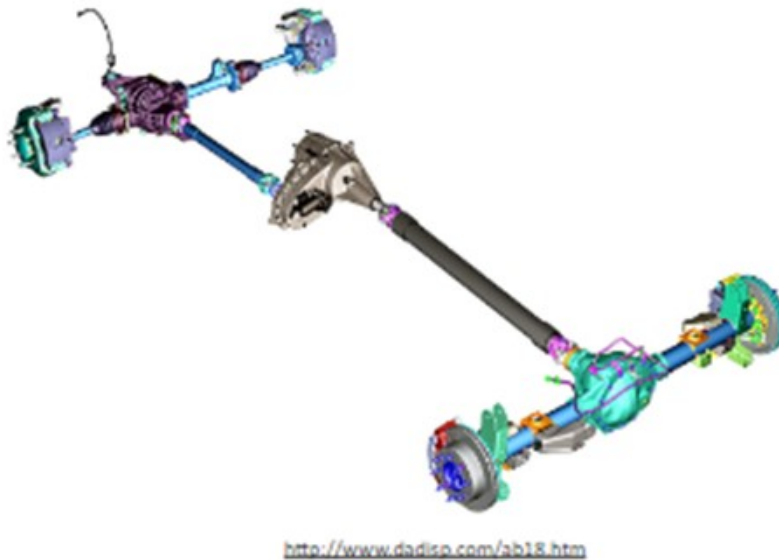


Figure 32

Review Questions

If you wish to test your knowledge of this chapter, answer these questions.

What do the acronyms AWD & FWD stand for?

2. A drive shaft must be able to _____ and _____ as the car is driving over bumps and potholes.
3. A torn CV boot allows what to get inside the joint?
4. By replacing only a damaged CV boot, one cannot guarantee against...?
5. When replacing a CV shaft, try to purchase...
6. When the splines become worn on a RWD slip joint, what should you have a machine shop do?
7. A slip yoke has _____ spline teeth that fit over the external spline teeth.
8. True or False: With RWD drive lines, when a U-joint fails, the entire shaft is usually replaced.

What joint type is comprised of two U-joints back-to-back?

Answers:

All Wheel Drive & Front Wheel Drive.

Shorten and lengthen.

Dirt and water.

Future CV joint noises.

A NEW shaft not a REMAN shaft.

Replace the spline teeth with a new set.

Internal.

False.

Double Cardan.

Review Questions

If you wish to test your knowledge of this chapter, answer these questions.

- Why must the U-joints of a drive line be in phase with each other?
2. Which part of the drive line assembly rotates in a speed fluctuating type fashion?
 3. Which part of the drive line assembly rotates in a consistent fashion?
 4. The drive yokes of a drive line need to operate within _____ parallel of each other in order to prevent drive line vibration.
 5. What three things impact how smooth a drive line rotates?
 6. The steeper the angle a drive line operates at impacts or accelerates what kind of wear?
 7. What are the preferred angles at which U-joints should operate at?
 8. What is the steepest angle a drive line should operate at?
 9. Sagging rear springs or a deteriorated transmission mount can be the cause of drive line _____.

Answers:

To prevent drive line vibrations.

The U-joints and the center section of the drive line.

The drive yokes that attach to the transmission and at the differential.

One degree.

If the drive lines are in a phase, they are parallel with each other, and if the driveline is straight.

U-joint wear.

2 - 10 degrees.

20 degrees.

Vibrations since they impact drive yoke parallelism.

Review Questions

If you wish to test your knowledge of this chapter, fill in the blanks.

1. If U-joint retaining clips are not properly secured, the joint will come apart, which will allow the drive line to tear up or damage the _____ of a vehicle.
2. U-joint needle bearings require _____ in order to provide long service life.
3. Three operating principles that can lead to long U-joint life are:
4. Extended or long two-piece drive lines have a _____ bearing to support the drive line.
5. _____ type of drive line design is found on some muscle cars and helps prevent rear axle wind-up under hard acceleration.
6. A worn U-joint can cause a _____ noise when a vehicle is first shifted into Drive from Park.
7. How many trunnions are found on a U-joint?
8. The reason for a torque tube found on some muscle cars is to?
9. T or F: U-joints are less expensive to manufacturer as compared to CV joints.
10. T or F: U-joints have a greater capacity to deliver torque load as compared to CV joints.

Answers:

1. Underside.
2. Grease.
3. Low operating angles, driving conservatively, and dry road conditions.
4. Carrier.
5. Torque tube.
6. Clunk.
7. Four.
8. Send as much of the engine's available torque to the drive wheels.
9. TRUE.
10. TRUE.

Review Questions

If you wish to test your knowledge of the is chapter answer these questions

True or False: CV joints rotate in a speed fluctuation fashion as do U-joints.

2. CV joints shafts can operate up to how steep of an angle?
3. What does the grease in the CV boot do after the vehicle has been driven for a while?
4. What are two reasons why outer CV boots tear open more often than do inner boots?
5. Can the driving ends of a CV shaft operate at different angles as compared to each other?
6. How is testing for outer CV joint wear done?
7. Why is it a common practice to replace the entire half shaft whenever encountering any kind of CV boot or joint problem?
8. Which CV joint typically has the ability to telescope?
9. An 8-ball CV joint design that can operate at steeper angles is known as a _____.
10. Which joint design can become out of center and cause a violent type of vibration?
11. Which CV joint will cause a single click only on acceleration? It may even cause a high-speed vehicle vibration.

Answers:

1. False.
2. 35 – 40 degrees.
3. Liquefies to lubricate the joint.
4. The CV joint operates at a steeper angle, and it is continually flexing with the wheels that steer the vehicle.
5. Yes!
6. Drive the vehicle forward and in reverse while making some sharp turns – listen for clicking noise.
7. This is the best and most economical repair option.
8. The inner joint.
9. Countertrack joint.
10. Inner joint, Tripod type.
11. Inner joint.

Review Questions

If you wish to test your knowledge of this chapter, answer these questions.

Review questions from the **Toyota video**:

1. Torque steer is when the vehicle seems to have a pull one direction when the vehicle is _____.
2. Torque steer can occur if the two CV axle shafts are not the _____ in _____.
3. What type of vehicle may come with one long and one short CV shaft?
4. What type of vehicles have more of an issue with drive-line balance?
5. The maximum allowance for out of round – when measured at its middle – with RWD drive lines is?
6. From the U-joint video, what must be done in order to determine U-joint binding?
7. How can drive line spline noises often be fixed?
8. A bent drive line is likely to show what type of symptom?
9. A worn U-joint is likely to display what type of symptoms?
10. What might one suspect an issue with if there is a difficulty in disengaging 4WD back to 2WD?

Answers

1. Accelerating.
2. Same in length.
3. An 'econo box' or compact car.
4. RWD vehicles.
5. .040"
6. Remove the drive line and feel the joint's movement by hand.
7. Lubricating the splines.
8. Vibration at vehicle speeds above 50 mph.
9. Mechanical noises such as a clunk or clicking or a dry squeaking noise.
10. One tire may not be inflated properly.



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