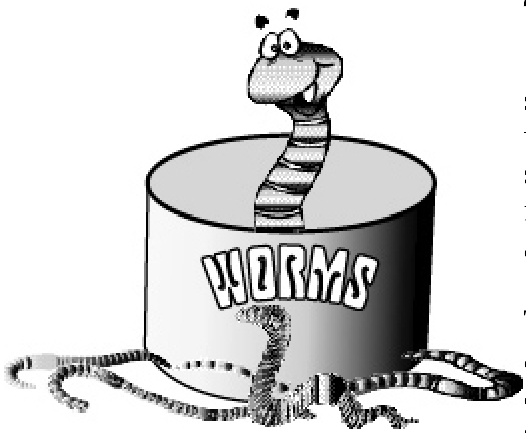
UNEXPECTED RESULTS

by Greg Frick
Inland Empire Drive Line Service, Inc.



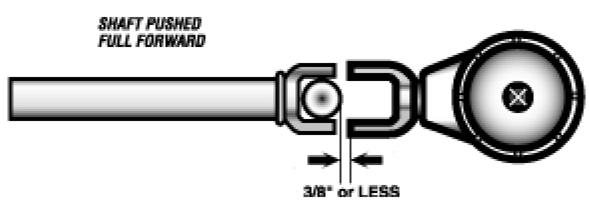
This article is about drive shafts and what they can do to and for your car.

Anyone who has ever bolted a modified part on a car knows that some surprises can be expected. Most of these parts changes and upgrades fit, do exactly what is expected and perform beautifully. The surprises often show up somewhere else for no apparent reason. Read on for some surprising results of two popular modifications: trailing arms and rear-end gear ratio changes.

Trailing arms are changed in the Impala family of cars to move the axle aft, centering the rear wheels in the wheel well. As you move the axle aft you are pulling the transmission yoke out of the transmission by an equal distance. When the project is finished and you drive your car there will be no indication of any problem…for a while. Eventually the transmission tail shaft bushing will wear and become the cause of a transmission overhaul. Here is how this will creep up on you.

Pulling the yoke out of the transmission moves the front u-joint aft. This gives the force created by the joint angle a longer lever to use in applying itself to the tail shaft bushing. The now greater force wears the bushing faster opening up space between the yoke sleeve and the bushing. Space between these parts allows the whole front of the drive shaft and rear of the transmission output shaft to orbit. Orbiting instead of rotating increases the wear rate even more. By the time you feel a vibration the bushing is history. As time and miles go by the orbiting drive shaft and transmission tail shaft stress the rear transmission bushing, which then wears. Wear in this bushing allows the centerline of the transmission's internal parts to bow slightly causing everything to wear. Eventually when the clutch packs fail they can take their mating parts with them. You will learn about these internal damages during the transmission rebuild and resulting bill. This whole sequence of events is the completely unexpected result of an innocent, unrelated, parts change.

Whether you car is stock (tolerance stack up being a fact of manufacturing life) or modified it will pay you to check your drive shaft for proper fit. Put the car on a drive on rack or on jack stands. With the cars weight on the suspension as you would drive it, disconnect the shaft from the pinion yoke. Push the drive shaft forward till it bottoms into the transmission. You should be able to drop the rear u-joint cleanly past the pinion yoke without resorting to a tool of any kind. Any clearance up to 3/8 inch is fine.



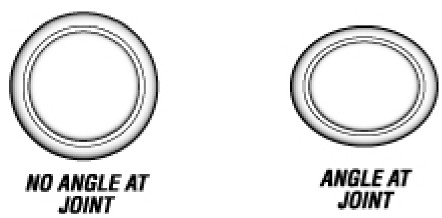
More than 3/8 inch clearance and you are running short by the excess. The greater the excess clearance, the sooner you will be headed for the transmission shop. The cure for this is very simple. You can have your drive shaft re-tubed to the proper length or you can buy a complete replacement shaft. Both Inland Empire Drive Line and Summit Racing Equipment sell replacement stock length shafts and shafts made to compliment various manufacturer's trailing arm kits.

Changing the gear ratio in the rear end of your car can have immediate, irritating consequences. Suppose you have a 2.73 rear end and want to go to a 3.42 instead. This change will increase the speed of the drive shaft by 20% at any given road speed. The speed sensor will then fool your cars E.C.M by 20% causing it to lock the torque converter prematurely. At low road speeds this can cause the car to feel like you have forgotten to put the clutch down. At higher road speeds you may suddenly develop a new pulsating vibration that is very mysterious. At very high road speeds the drive shaft may even leave the car altogether. To understand what is going on here you need to be aware of u-joint behavior and engine torsional vibrations.

The universal joints used in your car do two things. Obviously they are used to compensate for component placement by working through an angle. Less obvious is their converting of smooth engine power to pulsating power in the drive shaft. This pulsating power is the reason for the second u-joint working at an equal but opposite angle to the first.

The second converts the power back to smooth and feeds it into the rear end. All this happens because the angle causes the u-joint to travel in an elliptical path.

Path of U-Joint



You can visualize this by looking at a dinner plate straight on. As you tip the plate it appears to go from round to elliptical. You can also see from this plate that the greater the angle the more abrupt the drive shaft's speed changes will be. The point of all this is that your drive shaft always pulsates at twice per revolution and so is somewhat unstable.

Torsional vibration is a fancy term used to describe the actions of your engine's crankshaft. Each time a piston fires the crank is accelerated. In your V-8 this happens 4 times per crank revolution. When in overdrive, your transmission slows this rate to 2.8 pulses per output shaft revolution. The pulsation is fed into your drive shaft that already has a 2 per revolution pulsation. This extra excitation causes all sorts of baffling noise and vibration.

For instance, when your torque converter is locked up the crankshaft is effectively connected to the ground with no slippage anywhere in the system. At low road speeds, with the converter locked early because of a ratio change, the car can rumble and fuss as the engine "lugs". The cure for this is not a different drive shaft. The cure is to have your EMC reprogrammed to return converter lock up to the proper road speed. Tuned Port Induction Specialties in Chaska, Minnesota does this on an exchange basis and other companies may as well.

A different situation develops at higher road speeds. Because of the gear change the drive shaft is turning faster and may resonate at some speed. This is caused by the interplay among the engine torsions, the shaft pulsations and the gear ratio frequency. Assorted odd parts like mirrors may suddenly start vibrating in sympathy as well. Actually throwing the shaft from the car is the worst possible case involving these factors. At some road speed the shaft can reach its "critical speed", a harmonic of its natural frequency, and explode near its center.

All this activity was considered when your car was designed and was placed at some road speed you don't drive. Tuning and balancing these factors is what the OEM engineering staff gets paid to do and now, because of a gear change, it has become your job. What to do?

These higher RPM behaviors can be corrected by changing the drive shaft. A larger diameter shaft can move the point of resonance up in RPM to a place you don't drive. The larger diameter tube will move the critical speed upwards to improve safety. Finally, a larger diameter shaft provides increased strength for hard launches and additional stability at all road speeds. Aluminum shafts are available in 3, and 3 1/2 inch tube diameters. There are 4 inch diameter shafts but there is not sufficient room for them in this family of cars.

Additional new materials have recently been used in building drive shafts. For example, carbon fiber has been used both as a tube stiffener on O.E.M. production shafts and as the only tube by a few aftermarket companies. A true carbon fiber shaft is one in which the carbon tube carries the torque and has no metal substrate. These shafts boast very high critical speeds and eliminate the issue of resonance. Being of a space age material they are the top of the line in both behavior and price.

Please keep in mind that the sample gear change used above will not necessarily cause all the problems discussed. The point is that all gear changes produce unexpected results and some gear changes can produce dangerous results. Use the formula in figure 5 formula to determine the drive shaft RPM at the fastest speed you plan to drive. Then ask your drive shaft supplier what your options are considering critical speed. Remember that drive shaft speed and engine RPM are not the same when running in over drive.

FIGURE 5

$$\text{Engine RPM} = \frac{168 \times TR \times MPH}{tr}$$

WHERE: TR = Rear End Ratio x Trans Final Ratio
tr = Tire Rolling Radius

$$1687 = \frac{68 \times 3.75 \times .7 \times 50}{13}$$

WHERE: 3.75 is Rear End Ratio
.7 is OD
13 is Radius of 26" Tire

Among the automotive engineers of today noise and vibration harshness control is the fastest growing specialty. Often, when bolting on an improved part, or making what used to be a simple gear change, you'll join them. I hope these bits of food-for-thought will help you sort out some otherwise mystifying changes that turn up in your ride.

SOURCES

Inland Empire Drive Line Service, Inc.
4035 E. Guasti Road #301 • Ontario, CA. 91761

T.P.I. Specialties, Inc.
4255 Creek Road • Chaska, MN. 55318

INLAND EMPIRE DRIVELINE®
800.800.0109 | tech@iedls.com