Tire diameter critical on 4WD, AWD vehicles

Tires may bear the same size markings and meet industry design guidelines, yet have slight differences in circumference that can affect rolling speeds enough to damage vehicle drivetrains.

For example, one dealer faced a situation with a newer Cherokee still under factory warranty.

They followed the vehicle owner's instructions, installed a pair of BFGoodrich tires on the Cherokee's front wheels, leaving two half-worn, original equipment Goodyears on the back. Although all four tires bore the same size designation, damage to the vehicle's transfer case occurred.

In this instance, the servicing auto dealership refused to repair the damage under warranty, citing a portion of the Cherokee owner's manual that states that the vehicle "must be equipped with the same size and type tires of equal circumference on all four wheels."

Certain combinations of special aftermarket tires and wheels, the manual continued, "may change tread measurement, resulting in difficult transfer case shifting, changes of steering and suspension geometry, and inaccurate speedometer readings. This can cause unpredictable handling and stress to steering and suspension components."

The car dealer said the tires needed to be "exactly alike" to prevent the occurrence of such problems.

Does this mean all four tires must be identical? Or can they simply be equal in circumference?

Dealers can't assume interchangeability of different brands of tires bearing the same size designation. Does this mean you can install tires only in sets of four on four-wheel-drive vehicles? Is it necessary to use a measuring tape to make certain all four tires are exactly alike in circumference? What tolerances in regard to tire circumference are allowable to avoid potential problems?

Another dealer ran into difficulty fitting different brand tires on an all-wheel-drive Chevrolet Astro.

They believe uniformity in tire circumference is even more critical in the case of all-wheel-drive vehicles, such as the Astro, than with their four-wheel-drive counterparts. All-wheel-drive vehicles, unlike 4X4s, run constantly in four-wheel drive, rather than occasionally on demand.

The owner initially purchased a pair of Sigma-brand touring tires then returned at a later date to replace the vehicle's remaining two.

By that time, the dealership no longer had Sigma brand tires in stock, so they installed a pair of Cooper Classics bearing the same size designation.

About four months later the Astro's owner telephoned to say the vehicle was at a Chevrolet dealership, where a considerable amount of work had been done to the vehicle's drivetrain in an unsuccessful attempt to cure an "extreme handling problem."

Finally, the auto dealership's technicians took the wheels off another vehicle and installed them on the customer's Astro. The handling problem disappeared. Closer examination of the Astro's tires disclosed a difference of 1.5 inches in the diameters of the two brands of tires.

Fortunately most of the expensive drivetrain work was done under warranty. But they will be doubly careful when fitting tires to such vehicles from now on.

Dealers in other areas also have reported having similar experiences.

Not all tire-related drivetrain problems have resulted from variations in the circumference of highway-type tire designs. Some have stemmed from size differences in other types of tires, such as temporary spares or deep-tread winter designs.

Chrysler Corp., in 1998, recalled approximately 65,000 Jeep Grand Cherokees in order to replace their temporary spares with full-sized tires.

In announcing the recall, the auto maker said the mini-spares, which were smaller than the vehicle's conventional P225/70R16 or P245/70R15 tires, could result in the build-up of excessive heat in its QuadraTrac transfer case, forcing fluid out of the units' seals and creating a "potential fire hazard."

Meanwhile, in similar although apparently unrelated incidents in Tokyo earlier this year, two unidentified four-wheel-drive cars actually did catch fire due to transmission malfunctions blamed on the use of winter tires in combination with conventional highway designs.

The difference in rolling speed between the rear-mounted winter tires and the conventional highway tires on the front was perceived as slippage by the vehicles' differential systems, causing the viscous coupling in their transfer cases to divert increased engine power to the vehicle's front wheels.

Under the stress of repeated intermittent cycling in this fashion, the viscous fluid used in the transfer case became increasingly overheated until it ultimately ignited, fire department officials said. Both fires quickly were extinguished and no injuries were reported.

Asked how this could occur, Randy Yost, a technical integration engineer for drive quality at General Motors Corp., explained that the transfer case "transfers" power from one axle to the other similar to the way a limited-slip differential transfers power from one wheel to another on the same axle of a two-wheel-drive vehicle.

He said some transfer cases accomplish this using a "viscous coupler," a sealed unit containing a heat-sensitive fluid that stiffens when heated, thereby locking the differential and applying torque to the other axle.

Mr. Yost said General Motors has taken steps to eliminate potential problems in its vehicles.

Can passenger and light truck tires bearing the same size designation vary in diameter by an inch or more? Yes, particularly when comparing new and worn tires. But appearances can be deceiving.

Take, for instance, the General AmeriHways and Michelin XH4. Place one of the General AmeriHways alongside one of Michelin XH4s and the two tires would appear to vary in diameter by as much as an inch and a half—the AmeriHway being the taller and narrower of the two.

Yet when inflated and carefully measured, the two tires' diameters turned out to be only 0.62 inch different—not 1.5 inches.

The newer General AmeriHway was 27.11 inches in diameter, whereas the partially worn Michelin XH4 measured 26.49 inches. Both tires, however, were within industry size guidelines.

Yet even this small difference in diameter obviously was enough to create a serious problem for the four-wheel-drive vehicle's transfer case.

How much difference in tire/wheel circumference is allowable? Dick Gratz, service engineer in the tire/wheel group at GM's proving ground in Milford, Mich., serves as the auto maker's service and quality liaison to GM servicing dealers.

He said the maximum difference in wheel circumference between front- and rear-mounted wheels that most four-wheel-drive systems can tolerate without difficulty is "plus or minus four revolutions per kilometer" or 6.4 revolutions per mile.

In the case of the General AmeriHway and Michelin XH4 mentioned earlier, the smaller of the two tires will complete more than 17 more revolutions per mile than its larger counterpart—considerably beyond 6.4-revolutions-per-mile.

The difference in diameter that could result in drivetrain damage—amounts to a scant 0.22 to 0.23 inch, or just less than a quarter of an inch.

Some may view this as similar to the rule of thumb many use when selecting truck tires for dual applications—namely, that there should be no more than a quarter-inch difference in the diameter of the paired tires.

Most, but not all, vehicle owners are alerted by the increased noise and consult a dealership or other service outlet before damage to the transfer case actually occurs.

The tire dealer is faced with two alternatives:

1) Installing only four new tires on four-wheel- and all-wheel-drive vehicles; or,
2) Matching, or coming as close as possible to matching, all four tires in terms of circumference.

No doubt the surest method of maintaining uniformity in circumference is to measure each tire. Revolutions per mile are calculated by dividing the tire's circumference in inches into 63,360 (the number of inches in a mile).

Comparing tires on the basis of diameter is done by dividing the circumference in inches by pi, a mathematical symbol whose value is approximately 3.14159. Some dealers may wish to purchase a measuring tape designed for this purpose. Such tapes, available from most tire shop jobbers, automatically take the pi factor into account and provide a diameter measurement rather than circumference when wrapped around the tire's center rib.

The bottom line is that dealers are being held to a higher standard by the increased number of vehicles having sophisticated, speed-sensitive drivetrains.

In order to properly meet the tire needs of four-wheel- and all-wheel-drive vehicles, he said, dealers need to insist on installing tires in sets of four whenever possible and become sophisticated in the use of a pi measuring tape to assure tire uniformity when that's impractical.

Unfortunately, dealers are going to get a lot of flack from customers when trying to convince them to replace all four tires instead of just one or two, the same engineer added.

"The customer is going to say: `I don't want to spend the money. You're trying to rook me.´ Then later, after the vehicle's powertrain breaks, that same customer will be back complaining the dealer should have done something to prevent it. It's a no-win situation."

Power Hop on Mechanical Front-Wheel Drive Tractors

Step-by-step procedure to reduce or eliminate power hop on mechanical front-wheel-drive tractors.

The basic strategy in reducing or eliminating power hop is to reduce the tractive effort of the front tires by:

- Stiffening the front tires by either increasing tire inflation or adding liquid ballast.
- Softening the rear tires by reducing tire inflation and removing liquid ballast.

To successfully control power hop, a mechanical front-wheel-drive tractor usually must be equipped with duals or triples on the rear axle.

Step 1: Implement Adjustment and Drawbar Position. Check the individual operating manuals for the implement and tractor to be sure that the implement hitch and tractor drawbar are properly adjusted.

Step 2: Proper Weight Distribution. Check to see if the tractor is properly ballasted. Adjust it according to the manufacturer's recommendations for weight split, total working weight and wheel slip. The weight split usually will be 35 percent front, 65 percent rear.

Step 3: Front and Rear Tire Inflation Pressures. Adjust the inflation pressures in both the front AND rear tires as follows.
(NOTE: BOTH FRONTS AND REARS NEED TO BE DRY!)

Fronts: 2-star or 8-ply tires - INCREASE each tire to 30 psi.
3-star or 10-ply tires - INCREASE each tire to 36 psi.

Rears: Set each tire to the minimum psi required to carry the axle load.

Step 4: Test. Check the tractor for hop and performance. If the power hop is still present and the front tires are dry, proceed to Step 5.

Step 5: Add Liquid Ballast to Front Tires Only. Install liquid ballast in ALL the front tires to 75 percent (normal) fill. The tire is 75 percent filled when the valve stem is in the 12 o'clock position.
(NOTE: KEEP REAR TIRES DRY!)

Step 6: Test. Check the tractor for hop and performance. If the power hop is still present, proceed to Step 7.

Step 7: Increase Liquid Ballast in Front Tires Only. Increase the liquid ballast in EACH front tire to 90 percent fill. After increasing the liquid ballast, keep the inflation pressures in the front tires as follows:

- 2-star or 8-ply tires - KEEP each tire at 30 psi.
- 3-star or 10-ply tires - KEEP each tire at 36 psi.

Keep the weight split at 35 percent front/65 percent rear by adding cast weights to the rear. Do not change the pressures in the rear tires, and keep the rear tires dry.

Step 8: Test. Check the tractor again for hop and performance.

WHEN YOU'RE DONE IN THE FIELD, MAKE SURE TO ADJUST THE FRONTS BACK TO NORMAL PSI PRESSURE.

Power Hop on Four-Wheel-Drive Tractors

Step-by-step procedure to reduce or eliminate power hop on four-wheel-drive tractors.

The basic strategy in controlling power hop in four-wheel-drive tractors pulling implements is:

- Getting as close to a 51 percent front/49 percent rear static weight split as possible.
- Setting tire inflation at the lowest pressure that will carry the static axle load.

IMPORTANT: It is not possible to control power hop if the tractor is not equipped with duals or triples on both axles.

Step 1: Implement Adjustment and Drawbar Position. Check the individual operating manuals for the implement and tractor to be sure that the implement hitch and tractor drawbar are properly adjusted.

Step 2: Axle Weight. Check for proper weight distribution and get as close to 51 percent front and 49 percent rear as possible.

Remove any suitcase weights from the front and add them to the rear (if possible). The front tires must be dry. If needed, hydroinflate ALL the rear tires to 38 percent fill (4 o'clock or 8 o'clock position).

Step 3: Match Inflation to the Load on All Tires. Set the inflation pressure on all tires to the minimum psi needed to carry the static axle load. The individual tire load is determined by dividing the static axle load by the number of tires on the axle.

Step 4: Test. Check the tractor for hop and performance. Most of the time, setting the proper tire inflation pressures will solve the power hop problem. If the power hop is still present, proceed to Step 5.

Step 5: Add 6 psi to the Front Tires Only.

Step 6: Stop & Test. Check the tractor for hop and performance. If the power hop is still present, proceed to Step 7.

Step 7: Add 6 psi to the Rear Tires and Return the Fronts to Normal.

Step 8: Stop & Test. Check the tractor for hop and performance again.

Correcting Lead / Lag - MFWD Tractors

1. Lead/Lag (overspeed/underspeed) is found in mechanical front-wheel-drive tractors and can shorten the life of the front tires as well as cause wear and tear on the tractor's transfer case.

2. Lead/Lag refers to the difference in the speed of the front wheels and the speed of the rear wheels. If the front wheels are faster than the back wheels, the tractor has a *lead* condition. If the front wheels are slower than the back wheels, the tractor has a *lag* condition. If the front and rear wheels move at the same speed, the tractor has zero lead/lag. In MFWD tractors, the front and rear tires are always different sizes so there is always going to be some amount of lead or lag.

3. Ideally the lead is 2 percent. This means the front wheels should be 2 percent faster than the rear wheels. 0 to 5 percent is considered acceptable. On the other hand, no amount of lag is acceptable. A lag condition puts excessive strain on the tractor's transfer case. It also causes the front tires to wear out more quickly than they would under normal operating conditions.

4. Measuring lead/lag requires three people: one to drive, one to count the revolutions of the rear wheel and one to count the revolutions of the front wheel. This should be done on a straight piece of ground with firm soil.

5. Using a piece of chalk, mark both the front and rear tires on one side of the tractor.

6. With front wheels *engaged*, drive the tractor forward. Using the chalk mark, count the number of revolutions of the rear tire and the number of revolutions of the front tire. When the rear tire has made exactly 10 revolutions, stop the tractor. Write down the number of revolutions the <u>front</u> tire made to the nearest tenth of a revolution. Repeat one more time to be sure you have accurately counted.

7. With the front wheels in **neutral** (disengaged), repeat. After the rear tire has made 10 revolutions, stop the tractor and write down the number of revolutions the front tire made to the nearest tenth of a revolution. Repeat to check that your reading is accurate.

8. Divide the number of revolutions of the front tire with the front wheels *engaged* by the number of revolutions of the front tire with the front wheels in *neutral*. Then subtract one. If the resulting number is greater than zero - a positive number - the tractor has a lead condition. If the resulting number is less than zero - a negative number - the tractor has a lag condition.

9. To correct lead or lag, change to front tires with a different diameter. A lead condition of more than 5 percent would call for a front tire with a *smaller* diameter. Any lag condition calls for a front tire with a *larger* diameter. The difference in the diameter should be equal to the percentage of lead or lag. If a tractor has a 6 percent *lead*, use a front tire that's 6 percent *smaller*. For a 6 percent *lag*, use a front tire that's 6 percent *larger.*

<u>IMPORTANT</u> The wear and tear on the front tires and the tractor's transfer case due to lead/lag is increased during on-road travel. It's important to always have the front wheels in neutral when the tractor is driven on-road.

EXAMPLE 1

The number of revolutions of the front tire engaged was 12.4 and the number of revolutions of the front tire in neutral was 11.8. Dividing 12.4 by 11.8, you get 1.051. Subtract one from 1.051 and you get a positive .05. This means that the tractor has 5 percent lead.

EXAMPLE 2

The number of revolutions of the front tire engaged was 13.8 and the number of revolutions of the front tire in neutral was 14.2. Dividing 13.8 by 14.2, you get .97. Subtract one from .97 and you get a negative .03. This means the tractor has about a .3 percent lag.

In Example 1, a 5 percent lead would fall into the acceptable range of 0 to 5 percent, but the 3 percent lag in Example 2 is unacceptable and should be corrected.