What You Need to Know About
Mounting Radial Tires on Classic Vehicle Rims

Over the past 100 years, tires, and the wheels that support them, have gone through significant changes as a result of technical innovations in design, technology and materials. No single factor affects the handling and safety of a car's ride more than the tire and the wheel it is mounted on and how the two work together as a unit.

One nagging question that has been the subject of a lot of anecdotal evidence, speculation, and even more widespread rumor is whether rims designed for Bias ply tires can handle the stresses placed on them by Radial ply tires. And the answer is - it depends. It depends on how the rim was originally designed and built as well as whether the rim has few enough cycles on it, and how it has been driven. But most importantly it depends upon the construction of the tire and how it transmits the vehicle's load to where the rubber meets the road.

In this paper, we want to educate you on the facts - not the wives tales or just plain bad information - about how Bias and Radial tires differ in working with the rim to provide a safe ride.

Why is there a possible rim concern between Radial and Bias Tires?

The fitting of radial tires, to wheels and rims originally designed for bias tires, is an application that may result in rim durability issues. Even same-sized bias and radial tires stress a rim differently, despite their nearly identical dimensions. Stresses that exceed any rim's design limits can result in rim failure with possible tire & vehicle consequences. The following discussion examines the basic causes of "uniquely radial" rim stresses and it identifies some likely results of that stress.

When radial tires began to be widely accepted, engineers and customers noted occasional rim cracking failures that led to higher strength standards for light truck and large agricultural tire applications. Rim cracking was not prevalent in all wheels of that era (1970s), but wheels and rims of earlier years (with different design standards and many, many usage cycles) were not, and indeed could not, be fully tested for use with every possible radial. Therefore, it is likely that "all" old rims, and even some new rims to old designs, may not perform satisfactorily with these newer technology tires….even if compatible sizing makes it very easy to install the radials.

Understanding Radial and Bias Tires

The terms radial and bias actually describe two different ways to make a tire's structure out of similar, rubber-covered, fabric cords of nylon, polyester, rayon, or steel. The bodies of all tires are made from layers of such cords and the layers are called plies. Within each body ply, tire cords lie parallel to each other, encased in rubber, and each cord distributes stresses along its length to its ends which are anchored around steel hoops called beads. Because the beads also hold the tire tightly to the rim, the bead areas transfer body tire cord stresses to-and-from the rim. Radial tires, and bias belted tires, have additional belt plies located only beneath the tread area and the cords of those plies are anchored only in rubber. See figures 1 and 2.

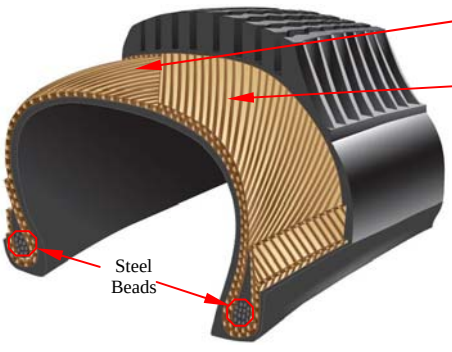


Fig. 1 - Bias Tire

The ply cords of the bias tire's body go from bead-to-bead at an angle and alternating ply layers have opposing angles. To travel from bead-to-bead at an angle, each bias cord is much longer than that of a similar radial tire's cord.

The ply cords of the radial tire body have a short path from bead-to-bead, directly across the tire from side to side.

Note the "unanchored" ply cords layered at opposing bias angles under the tread of the radial. These make the radial's stabilizing "belt" and are similar to the belts in bias-belted tires.



Fig. 2 - Radial Tire

In a bias tire, plies always come in pairs so the angled cords in each ply are counter-balanced by the next ply's cords going the opposite direction (2 ply, 4 ply, 6 ply etc.). Bias ply layers create a much stiffer structure (like plywood's alternating wood grain layers) than a radial tire's body. If a sufficiently strong cord is available, a radial tire can operate with only one body ply and the cross-angled belt plies add stiffness only under the tread area.

It is said that a tire's inflation air carries the load, and that seems obvious since higher inflation pressures in any tire (up to its maximum pressure) will allow more load. However, the additional pressure is merely stiffening the tire assembly by increasing tension in the body plies. When applied to a vehicle, the construction characteristics of radial and bias tires result in visually different loaded sidewall appearances. This different is noticed as an increased bulge for a radial when compared to a bias tire. The bulge differences cause unique rim stress results for bias and radial tires.

How does a Radial bulge create more rim/wheel stress than a Bias bulge?

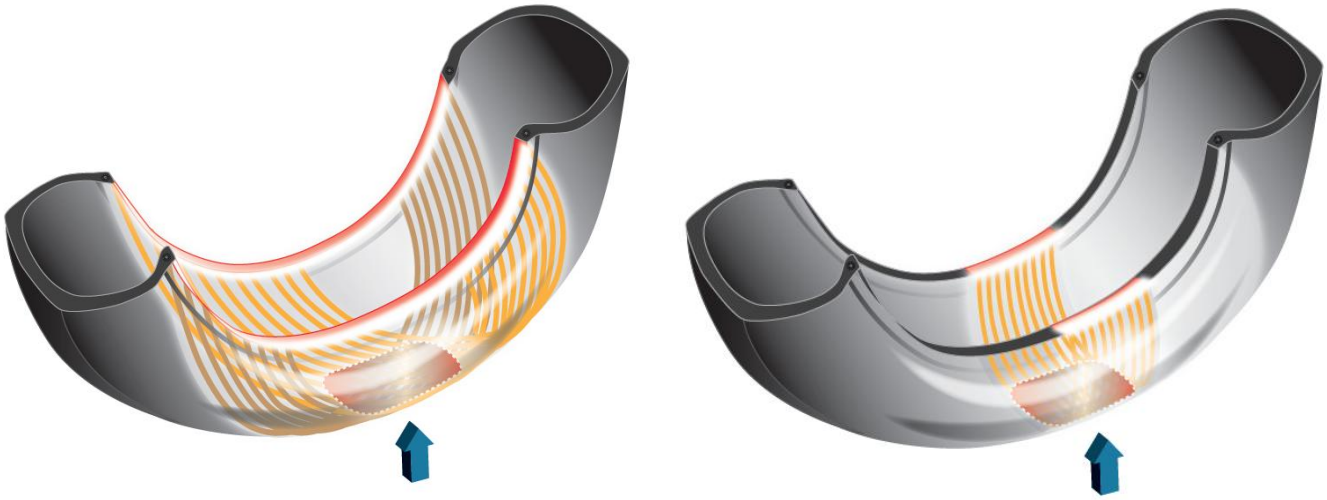
When a vehicle's tire is in use, the vehicle's weight transfers to the ground from its axle-to-the-wheel and then wheel-to-the-ground contact. Technically, the axle, wheel, and tire all deform when loaded but only the tire shows visible deflection by bulging. Additionally, the temporary flattening of the rounded tread surface against the flat road at the tire's "contact patch" causes the body ply cords to bend in the rubber around them.

Bias tire cords cannot bend or bulge independently because they are rubber-bonded to adjacent ply cords (above and/or below) that go in the opposite, reinforcing direction. Therefore each bias cord transfers some of its stress to each of the cords that crosses it. The bias illustration in figure 3 shows that every cord in the contact patch crosses others and ends far away as it travels from side-to-side in the tire. So, a bias tire's bulge starts in the contact patch area, but continues along the sidewall following various cord paths throughout the tire, and finally affecting the rim all along the red shaded area.

Radial tire cords can bend and bulge independently by stretching and/or compressing the rubber between them because (except in the belt and bead areas) there is no other reinforcement between the cords. The radial illustration in figure 3 shows that every cord from the contact patch crosses no others and ends directly above the patch. So, a radial tire's cords do their bending and bulging in the very limited contact patch area and they affect the rim primarily in the small red shaded area.

The radial tire therefore concentrates its wheel-to-ground loading stress in a much smaller portion of sidewall than a bias tire does, and extreme bulging is the result.

Fig. 3 – Bias and Radial tire body ply cord paths from the contact patch area (targeted by the blue arrows) to their ends at the tire bead/rim area



Bias Tire

Radial Tire

Figure 4 is a cross sectional view of a mounted tire and wheel in the rim flange area. Specific areas of the wheel are noted as stress points (S1-S4) where the metal changes direction which would form natural hinge/fatigue points under stress. This layout depicts the "loaded and deflected" sidewalls of same-sized bias and radial tires as if they shared the same wheel and tire bead (red circle).

Vehicle weight would create large forces down on the rim wherever the tire and wheel touch. The bead is designed for a tight/airproof seal on the rim which results in a compressive force beneath the bead denoted by force arrow **F** (same direction as vehicle weight forces**)**. Smaller forces **P,** from inflation, are applied to the inside of the tire (shown only on the bias tire for simplicity) and they transfer through the tire to the rim.

The radial tire's greater bulge (described earlier) is obvious, but examination shows that this allows the radial to contact the rim flange at point "**R**" compared to "**B**" for the bias tire. The radial's additional flange contact allows some loading forces and inflation pressure "**P"** to be applied further from the stress points S1 – S4 than the bias tire would.

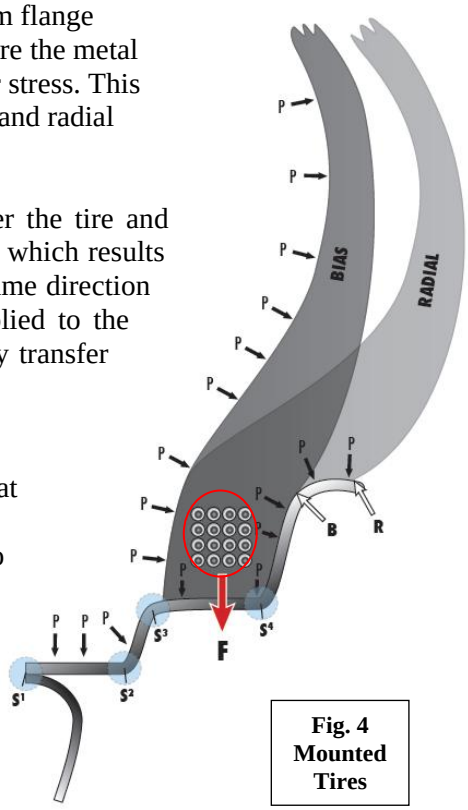


Fig. 4 Mounted Tires

So, from the tire bulge discussion we know that radial tires concentrate loading stress in a small bulge area while bias tires distribute it over a large area. Now we know that the radial bulge also moves loading and pressure forces further from the rim's stress points. These combined radial characteristics increase stress in areas S1-S4, much as you would feel increased shoulder stress if you had a weight in your hand that got heavier as you also moved it further from your body.

What are the possible results of radial tire rim stress?

As was noted earlier, wheels do actually deform slightly as they roll and this bending occurs at points like S1-S4 in Fig 4. Radials can add bulge-induced stress at those same points which increases the possibility of fatigue cracking in these areas. Additionally, wheel stress caused by a radial's improved handling actually results in additional flange area and stress point loading as the tire distorts & rolls sideways.

The most likely failure mode for an overstressed rim is circumferential cracking at one or more stress points. Areas S1-S4 in Fig 4 are typical stress points, but other wheel center designs, wire wheels, and composite wheels (like alloy/steel combinations) present many other possible stress cracking opportunities. Whenever a rim cracks, safety can become an issue and total wheel failure is a major vehicle control problem.

What can be done to check for rim cracks?

Small cracks may offer no symptoms in a tube-type product, since air leakage will not occur unless the crack's motion nibbles through the tube. So, only vigilant physical wheel examination offers a way to catch early cracking in a tube-type application. Small cracks in a tubeless application will result in immediate, noticeable air leakage.

A key to discovery is to remember that cracking is a possibility and don't always assume that air loss is a puncture or a valve issue. Most importantly, don't "correct" a leak by periodically adding air as a crack could be growing in your wheel. With reasonable inspection and careful maintenance, it is likely that rim cracking issues with any tire (radial or bias) can remain limited to a nuisance issue rather than a safety concern.

Summary - *What you should take away from this explanation is that*:

- The tire industry makes radial and bias tires that can be mounted on the same rims.
- Not all wheels and rims were designed for radial tires
- Construction features of radial and bias tires make them bulge differently when deflected
- The radial's localized bulge puts more stress on the rim flange than a bias tire does
- Rim fatigue and cracking can happen to any wheel from normal flexing, cyclic loading, and cornering
- Radial stressing of the rim can accelerate metal fatigue and rim failure that is uncommon with bias tires.
- Failures will usually occur where wheel materials change direction (e.g., flange to bead seat, bead seat to well, well or base to wheel center, etc.).
- Evidence of cracking may be visually obvious or it may be indicated by air leakage.

Recommendations

1. Remember that not all rims are suitable for new technology radial tires.
2. A radial application checklist for vintage cars should include:
   - Are my wheels a pre-1975, primarily bias design?
   - Did my wheels come from the factory with radials?
   - If my rims are old, do I know how to look for cracking issues?
   - Should I replace my wheels with newer, radial compatible items?
3. If in doubt about your rims' ability to endure radial tires….consider only bias tires
4. If radials are applied, check your wheels often for possible cracking
5. Use qualified technicians to mount, service, and inspect your wheels and tires