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# FALL NEWSLETTER

## TIRE DURABILITY PERFORMANCE AS INFLUENCED BY OPERATING CONDITIONS

By William J. Woehrle

Tire durability performance is influenced by 3 primary factors: stress, heat, and oxygen. The stress is essentially produced by a combination of inflation pressure, load and speed. An increase in heat will lower (or accelerate) the point at which the stresses produce a failure. Moreover, most of the tire components, and especially their adhesion to one another, are vulnerable to an oxidation or deterioration process.

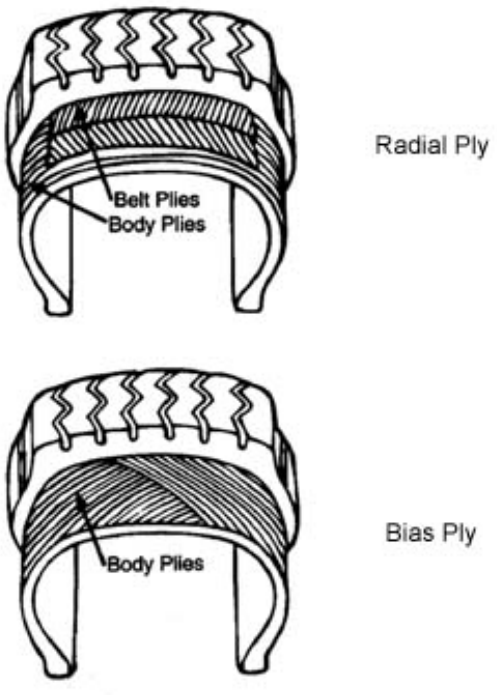


Figure 1
Radial and Bias Ply Construction

### Tire Construction

Most passenger car tires today are of radial ply construction. They are called “radial”, because the body or “carcass” ply cords extend directly out from the rim to the tread, as if they were “radii” of a circle (see Figure 1). The “belts” which run circumferentially around the tire are laid on over the radial plies. Its predecessor, the bias ply tire, has sidewall cords running at angles from the rim to the tread and back to the rim without overlying belts.

### Run Soft Failure

Unfortunately, tire durability is often viewed in the context of (and confused by) a road hazard failure. The notion that a tire can be punctured and go flat is obvious. Likewise, the notion of driving on a tire that is flat or going flat is typically thought of as being both dangerous and avoidable. Unfortunately, in many cases, the avoidance was impossible because the driver did not detect the problem.

As tire deflection increases from the slow but steady decrease in inflation pressure, an extreme over-heating occurs, especially at the fold in the sidewall. Temperatures can reach over 400° F, the melting point of the polyester cords typically used in the radial plies. Destruction of the sidewall is then quick and massive. This has been called a “blow-out”, but the operating pressure at the time may have only been around 5 psi.

There are other causes besides punctures for an unexpected loss of inflation pressure. Valves can leak. Rims can bend or corrode, resulting in a failure of the air seal between the tire bead and rim. In addition, tires lose about 1 psi per month via normal permeation.

## High Speed Failure

Under normal loads and pressures, within self-imposed limits of operating speed, and remaining free of road hazards, a tire is expected to hold together until the tread wears out.

A tire's "speed limit" is selected via a standardized system of speed symbols. Such a symbol, which is optional, is part of the "service description", immediately following the size designation (e.g. "97V"). The various speed symbols and values are as follows:

| *SPEED SYMBOL* | *Km/h* | *mph* |
|---|---|---|
| S | 180 | 112 |
| T | 190 | 118 |
| U | 200 | 124 |
| H | 210 | 130 |
| V | 240 | 149 |
| W | 270 | 168 |
| Y | 300 | 186 |

Should this speed rating be exceeded, the tire will typically fail via a separation at the belt edges. Furthermore, all tires have virtually the same sensitivity to load and inflation pressure, as shown in figures 2 and 3. These relationships have been developed and presented at numerous meetings of the Society of Automotive Engineers (SAE).

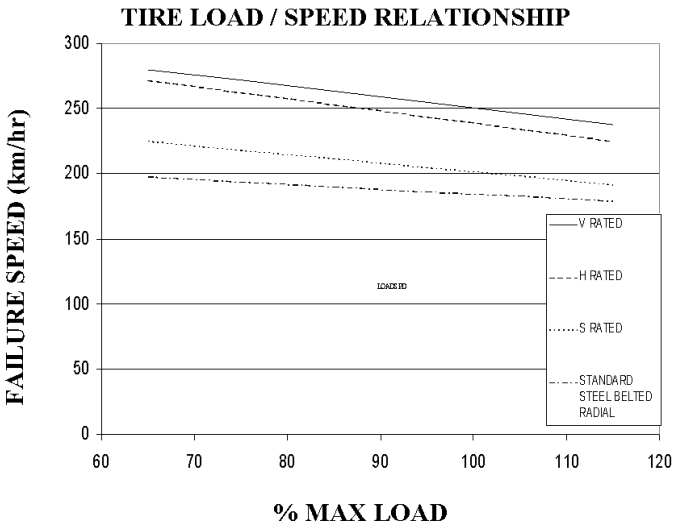


Figure 2

As the temperature at the belt edges increases with increasing speed, it reaches a point which, when combined with the centrifugal and other forces, causes a loss of adhesion and a tearing of the rubber. This delamination usually begins as a bulge. As it grows, cracks will usually emerge. Eventually, it will tear loose in a "peeling" action in about one revolution of the tire, which only takes a small fraction of a second. The failed tire can have a wide variety of appearances, depending on the nature of the tear. If it's through all layers, an instantaneous air loss occurs. On the other hand, the entire tread can be thrown off and the tire will still be inflated.

## Fatigue Failure

As mentioned above, the basic durability specification for a highway tire is that it should wear out before coming apart. If the reverse does happen, the failure mode will probably be a belt edge separation, similar to a high speed failure. In this case, it's probably a fatigue failure rather than a stress failure. The adhesives are vulnerable to oxidation, as a result of the above mentioned permeation.

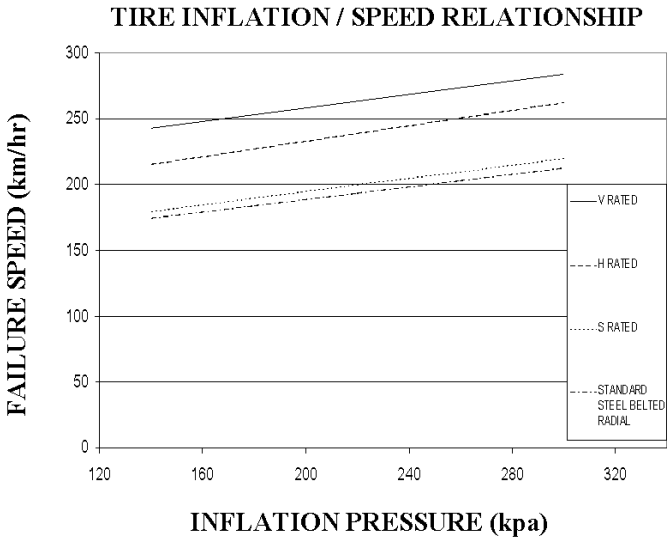


Figure 3

This permeation increases with temperature. If it is 1 psi per month at 75° F, it can be as high as 12 psi per month at 160° F. This compounds the durability problem, since the

lower pressures lead to higher tire temperatures, and vice versa. Accordingly, hot climates are especially challenging for tire durability performance.

What typically fatigues in a passenger car or light truck steel belted radial tire is the adhesion of the steel belt wires to the surrounding rubber. In order to get the steel to adhere to rubber, it must be plated, usually with brass. The adhesion is a very complex chemical bonding, which can deteriorate from an absorption of oxygen, or ozone. Virtually all types of rubber are vulnerable to this process. It can be observed externally on the outer surface a tire or another rubber product as "weather checking". This is "corrosion" in rubber. The result is a lowering of the stress and/or temperature level needed to cause a tire to separate. This translates to a tire coming apart at a lighter load, higher inflation pressure, and /or a lower speed than what would have been required, had this oxidation process not occurred.

This oxidation process occurs over time, as opposed to miles. Furthermore, this "aging" can vary widely, depending on the quality of the tire as well as the environment. There does not appear to be a consensus in the tire industry as to how many years a tire is expected to last. At any rate, should a tire be found to have severe checking in the sidewall region, for example, the overall structural integrity of the tire could be threatened. If it appears bad on the outside, the same could be true on the inside, at the belt edges.

A tire's age can be determined from the serial number, which are the series of letters and numbers immediately following "DOT" on one lower sidewall, near the rim. Usually, it's the inboard facing sidewall. The last set of 3,or sometimes 4 numbers is the date of manufacture code. The last number is the last number of the year in which the tire was made. The first 2 numbers indicate the week. Therefore a serial number ending in "259" would mean that the tire was produced in the 25th week of 1999.

The treadwear performance of today's tires are greater than ever before. When the steel belted radial passenger tire emerged in the American market, it was expected to last 40,000 miles, as compared to the bias tire that would last around 25,000 miles. Today, treadwear experiences as high as 100,000 miles are not uncommon. With such long treadlife comes the increased challenge for the tire to hold together.

**Complexities of Tire Performance**

A seemingly simple product like a pneumatic highway tire is surprisingly complex. Likewise, its challenges can be varied and complex. Accordingly, an accurate evaluation of performance requires a proper assessment of those challenges, together with a thorough understanding of the limitations of the product.

**About The Author**

Associate William J. Woehrle received a BS in Physics from Michigan State University in 1966. He was the Director of Product Evaluation for Uniroyal Goodrich Tire Company for many years. His activities have included the Society of Automotive Engineers Highway Tire Committee, the Rubber Manufacturers Association Tire Engineering Policy Committee, and the Tire and Rim Association.