

All About Tire Inflation

By Frank Berto

Most riders simply inflate their tires to the suggested maximum pressure shown on the sidewall. There is a better inflation pressure for most riders. This article helps you to pick your optimum tire pressure and the right tire size to match your weight and riding conditions.

ROLLING RESISTANCE AND CORNERING FORCE

Tire inflation affects rolling resistance. Higher pressure tires roll easier. For a 170-pound rider on a 30-pound bike, the difference between 75 psi and 150 psi is about 10% reduction in rolling resistance. Depending on your speed, this is about a 4 % reduction in the total effort to keep the bike moving. Wind resistance is the main negative component.

Inflation pressure has a more significant effect on cornering force. In this example, 75-psi tires would give a cornering force of about 130 lbs and 150-psi tires would give a cornering force of about 123 lbs. That's a 6% reduction for a perfect road surface. (This is based on testing on a steel drum. Over-inflated tires would corner worse on normal paved roads.)

COMFORT

Shock absorption, puncture resistance, and "feel" are the important differences. Dr. Dunlop invented the pneumatic bicycle tire more than 100 years ago. The chain-driven geared "safety" bicycle and the pneumatic tire were the key technical breakthroughs that created the 1890s bicycle boom. With enough over-inflation, you can experience the same ride that the cyclists got in the 1880s from solid rubber tires.

PUNCTURE RESISTANCE

Under-inflated tires get more impact punctures because, upon riding into an unyielding object, the tire compresses so much that the inner tube gets pinched between the edge of the rim and the rock, pothole, railroad track or whatever you've hit. You can identify this puncture because it produces two small holes several millimeters apart. This is why it's also known as a "snake bite."

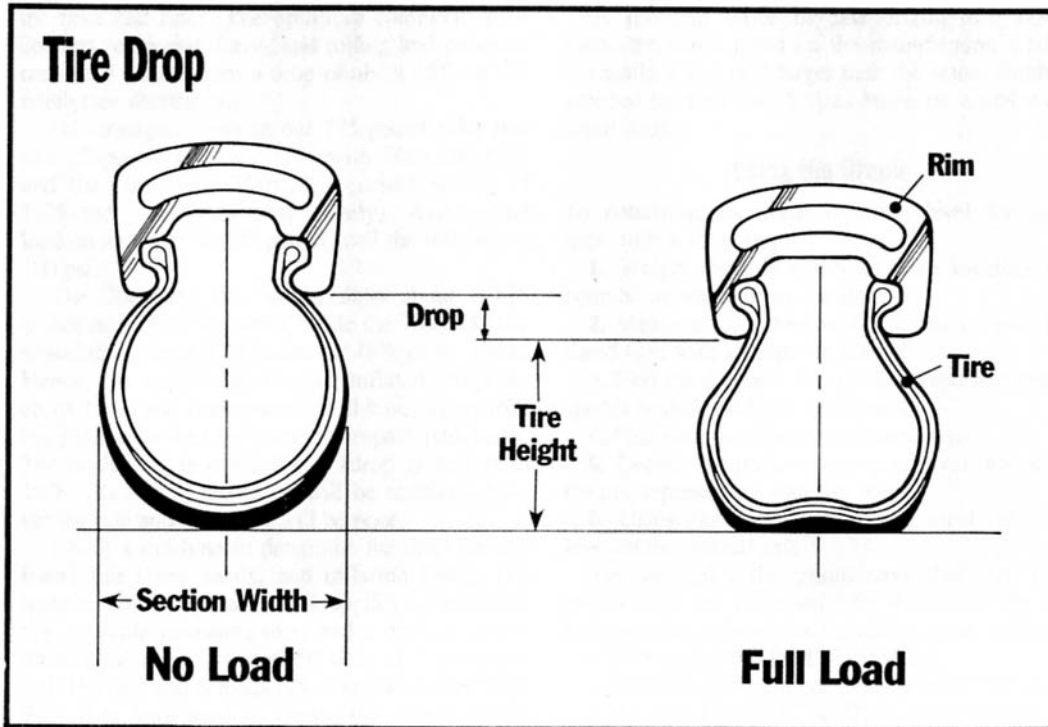
DETERMINING TIRE SIZE AND INFLATION

I originally wrote this article for *Bicycling* magazine when Ed Pavelka was in charge of the content and they published technical articles. Later, *Bicycling* stopped publishing material based on engineering tests. It was a self-fulfilling prophecy. Readers who were interested in technical articles stopped subscribing. Now they say that their readers aren't interested in technical articles.

My inflation advice then is still correct today. Nothing significant has taken place in the interval. It was based on discussions with the bicycle tire experts at Michelin, National,

IRC, and Continental. They agreed that "Tire Drop" is the key criteria in matching tire size and inflation pressure to rider weight.

Tire Drop is the distance that the tire sags under the weight of the rider and the bike. For a given tire size and load, the optimum inflation pressure for comfort and rolling resistance produces a Tire Drop of about 15% of W (the Section Width) or about 20% of H (the height from the ground to the rim).



For example, suppose our typical 170-lb rider had two 30-lb bikes, one with 700x32C tires inflated to 100 psi and the other with 700x20C tires inflated to 100 psi. The load on each tire is 100 lb (simplifying things by assuming that each tire carries half the weight).

The tires on both bikes drop under the load until the contact patch is 1 square inch, 100 psi pushing up from the road and 100 psi pushing down from the inner tube. The 20-mm-wide skinny tire drops about 1/4 inch or 18 % of its width. The 32-mm-wide fatter tire drops about 1/5 inch or 10 % of its width. The skinny tire is under-inflated and it will get lots of snake-bite flats. The fat tire is over-inflated. The rolling resistance of the wider tire will be a tiny bit less than the skinny tire but the ride and cornering will be worse.

DETERMINING TIRE DROP

The above example and the accompanying **optimum tire inflation graph** (page 5) are based on real tests. The tire drop test machine was quite simple. A hydraulic jack pushed down on the wheel. A bathroom scale weighed the load and a dial gauge measured the amount the tire dropped.

The *Bicycling* article covered road bike tires. I measured 50 different tires at 7 pressures (40 to 160 psi) and 8 loads (20 to 220 lbs). I plotted tire drop versus load for each tire

and for each inflation pressure. A line across the 15% drop gave the optimum inflation for each tire size and load.

Twenty years ago, there was a serious discrepancy between actual tire sizes and labeled tire sizes. This situation has gotten better. I like to think that my articles for *Bicycling* actually helped, but it might have been the threat of lawsuits. The graph shows seven sizes of road bike tires into from 19C to 37C based on their measured widths.

MOUNTAIN BIKE TIRE INFLATION

There are several problems with tire drop measurements on mountain bike tires. The knobs are part of the tire width and they complicate the measurements. I don't think that the 15% drop criteria is valid for mountain bike tires because most mountain bike rims are narrower, relative to tire width, than road bike rims. Finally, off-road riders aren't looking for lower rolling resistance from higher pressures. They're looking for better traction, cornering, and shock absorption from lower pressures.

So I produced a **minimum tire inflation graph** (page 6) to cover mountain bike tire sizes. The nice people at Continental and Michelin now recommend a minimum inflation pressure versus total weight in their current catalogs. I used their recommendations to produce a second graph for mountain bike tires. Note that this is the *minimum* inflation pressure, not the *optimum* inflation pressure. You should inflate your mountain bike tires at least this hard.

USING THE TIRE INFLATION GRAPH

Stand on a bathroom scale holding your bike ready for the road. That's the load that your tires have to carry. Read the width of the tires on the label. The optimum inflation is where your load intersects your tire size.

For example, the graph says that our typical 170-lb rider on a 30-lb bike (200 lb total weight) should inflate 700x19C tires to 136 psi, 700x20C tires to 126 psi, 700x23C tires to 106 psi, 700x25C tires to 88 psi, 700x28C tires to 76 psi, 700x32C tires to 60 psi, and 700x37C tires to 46 psi.

Which tire size is right for you? It depends on your riding style and your roads. Skinnier tires and rims will be lighter and more pleasant to pedal on smooth roads. Fatter tires will be softer riding and more user friendly on poor roads. They'll also last longer and get fewer flats. Heavier people should use fatter tires.

The numbers aren't precise. Rolling resistance, cornering force, and shock absorption all increase with lower pressures. The ideal compromise is a tire drop somewhere around 15%. 13% would give a higher inflation pressure, less rolling resistance, and a harder feel of the road. 17% would give a lower inflation pressure, more rolling resistance and a more comfortable ride. The graph is consistent between tire sizes. It indicates that most riders under-inflate skinny tires and over-inflate fat tires.

FRONT AND REAR INFLATION

Front tire and rear tire loads aren't the same. Depending on bike dimensions and riding position, weight is distributed about 45% on the front wheel and 55% on the rear wheel for a typical sport tourist riding on the drops. This suggests that you should subtract about 10% from the front tire pressure and add about 10% to the rear tire pressure. This makes a lot of sense because it gives a more comfortable ride and better cornering up front. It also gives less rolling resistance and fewer snake-bite flats on the rear. Alternatively, you might use one size wider tire on the rear wheel with the same inflation. This is the thought process used on old British bikes with 32-spoke front wheels and 40-spoke rear wheels.

MAXIMUM INFLATION PRESSURE

Adding 10% to the recommended pressure for a 700x20C rear tire gives 140 psi. What if the maximum recommended pressure on the sidewall says 115 psi? You have four choices. You can diet to reduce the load. You can run the rear tire at 115 psi, which is less than the optimum inflation. You can select a wider tire, or you can just keep on pumping until you get to 140 psi.

There are several hundred thousand under-employed trial lawyers in the U.S. advertising for plaintiffs so that they can sue anyone with deep pockets for the contingency fee.

Neither Frank Berto nor anybody at a tire company will tell you that exceeding the maximum inflation is safe. However, I can tell you what the maximum inflation pressure on the tire sidewall means. It means that a representative number of tires were mounted on the proper width and type of rim and were inflated to twice the listed pressure and none of the tires blew off. They perform this test with the tires in a water tank.

The key words are *proper* width and *type* of rim. To run high pressures, you have to use narrow rims with narrow tires and wide rims with wide tires, and you have to use hooked-edge or crochet-edge rims. You also need to have rims that were produced with adequate quality control. A tire at the maximum diameter tolerance combined with a rim at the minimum diameter tolerance may blow off at less than the maximum pressure rating. Tires that are easy to mount may blow off at high pressures. There's no free lunch.

You also have to mount the tires correctly and make sure the beads are seated during inflation. To produce the optimum inflation graph, I inflated 50 different tires to 1.5 times their listed maximum pressures. The 135-psi rated tires were inflated to 200 psi. None of the tires blew off but I wore gloves and a face shield during the tests. Personally, I don't like skinny over-inflated tires. I ride something wider and more comfortable.

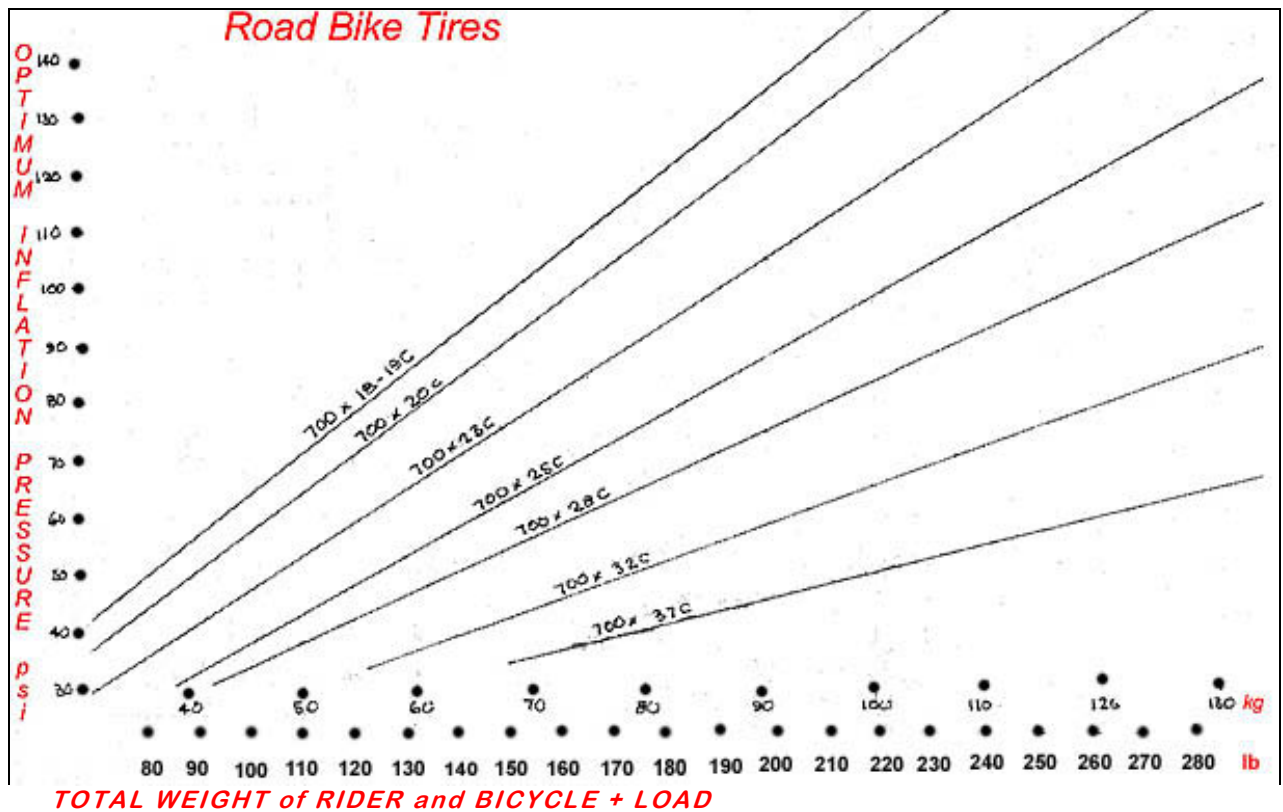
TIRE PRESSURE GAUGES

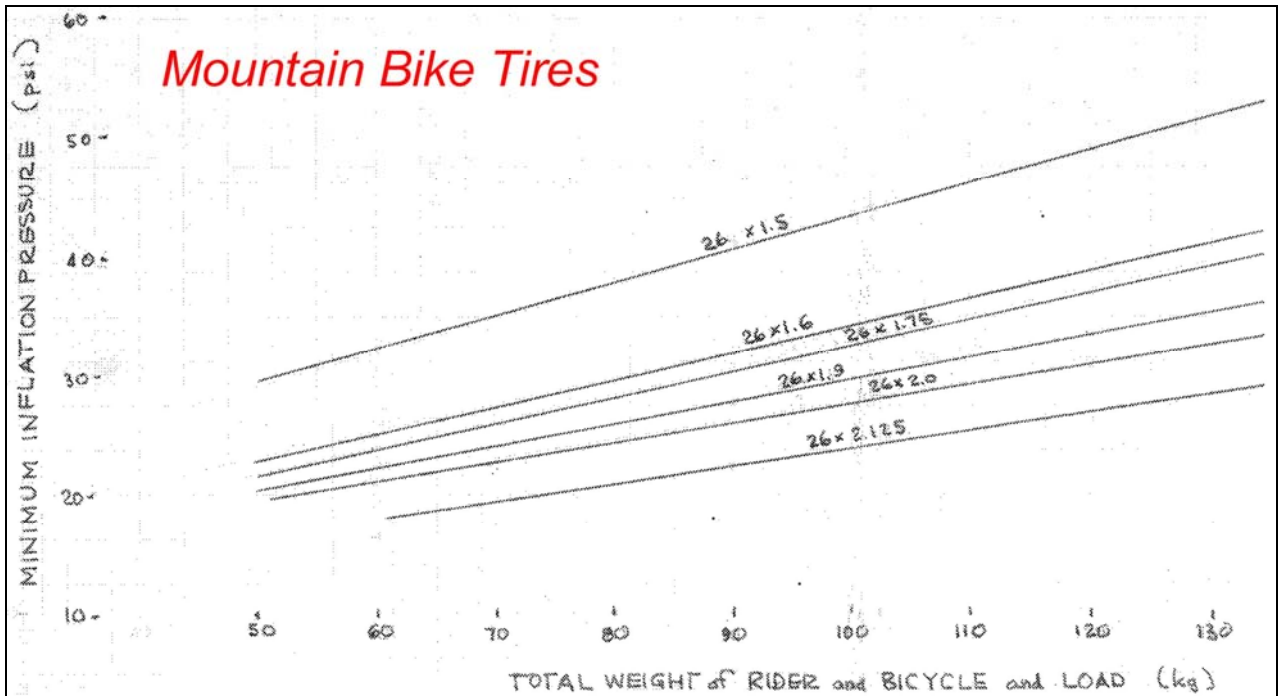
Bicycle tire pressure gauges are inexpensively made to sell cheaply. When I ran a test on gauges I found that most of them were reasonably accurate out of the box. They tend to read high as they wear out. The pressure gauge on a floor pump leads a very hard life. After a few inflations to 100 psi, it probably reads 100 when the true pressure is 80 or 90

psi. If you want accurate tire pressure, buy a new hand gauge and use it to check the calibration of your pump's gauge.

FOR FURTHER READING

Volume 5, No.1 (autumn 2006) of *Bicycle Quarterly* magazine has an article on tire performance that is well worth reading. Editor Jan Heine did coast-down tests on 16 different road bike tires. He found significant differences based on tire construction. He feels that inflation pressure is of relatively little importance. I disagree. Write to heine94@earthlink.net for details on buying this issue or subscribing.





1 kg = 2.2 lbs.

*Frank Berto is a retired engineer and active cyclist living in San Anselmo, California. He's had a long love affair with the bicycle and its technology, particularly its gear system. He was engineering editor of *Bicycling magazine* for many years and is currently writing for *Australian Cyclist magazine*. His latest book is "The Dancing Chain: History and Development of the Derailleur Bicycle."*

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