Bicycle Quarterly

The following article is reprinted from *Bicycle Quarterly,* "The Magazine about the Sport We Love."

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Optimizing Your Tire Pressure for Your Weight

by Jan Heine

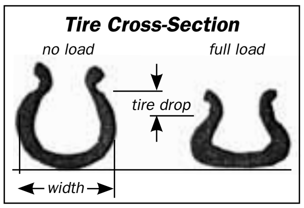
Inflating your tires to achieve 15% tire drop will optimize your bicycle's performance, comfort and handling. Our tests of tire resistance have shown that tire resistance is high at very low pressures. As pressures increase, tires roll faster, but the performance levels off at a certain pressure. Beyond this point, higher inflation brings only negligible performance improvements.[1]

Optimum pressures

Riding your tires at this "cut-off" pressure optimizes both comfort and performance. At lower pressures, you roll slower. At higher pressures your bike is no faster, but much less comfortable.

Our tests of the same tires at various pressures determined the optimum pressure for each tire **for our rider/bike combination**. How does this translate for other riders and other tire widths?

I compared our results with Frank Berto's charts for tire drop, and found that the "cut-off" pressure corresponds roughly to a tire drop of 15%. Perhaps not coincidentally, 15% is the tire drop recommended by several tire manufacturers.[2] Tire drop is the amount the bicycle is lowered as the tires deform under the load of bike and rider.



Tire drop

Measuring tire drop is not easy. Fortunately, Frank Berto already has done it for us. The chart below shows the pressures required for different rider/bike weights to achieve a tire drop of 15% with tires of various widths. Berto measured this for 700C tires, but the values apply to other tire sizes as well. Note that the weights are wheel loads, not the weight of the entire bicycle.

Determining the wheel loads of your bicycle

Depending on your bike's weight distribution, achieving the optimal 15% tire drop may require different pressures in your front and rear tires. To determine your weight distribution, place one wheel of your bike on a scale, the other on a block, so that both wheels are level. Have a helper hold your bike upright, and sit on your bike (with any load you will carry) in your standard riding position. The helper notes the reading of the scale. Then turn the bicycle around and repeat for the other wheel. Use these wheel load readings to determine your inflation pressure for each wheel.

As a first approximation, you can use the values we measured for a variety of bicycles:[3]

Bike	Load	Weight distribution	
		Front	Rear
Randonneur bike	front	45%	55%
Racing bike	-	40%	60%
City bike	rear	35%	65%

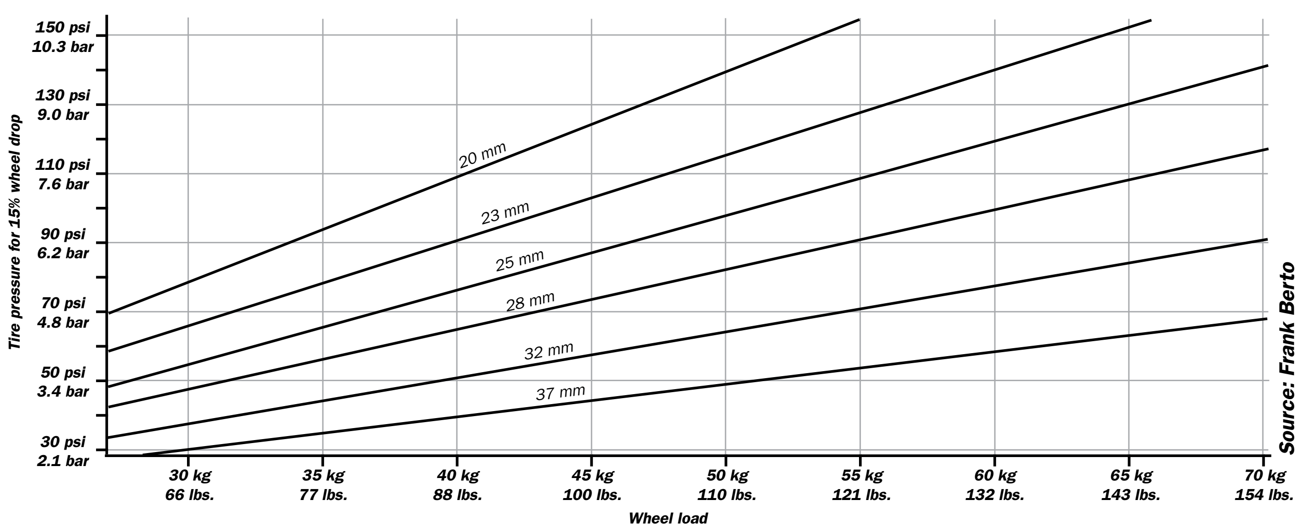
Over- and underinflation

The table below shows that narrow tires require very high pressures, otherwise the tire drop exceeds 15%. On the other hand, wide tires do not require high pressures for optimum comfort and speed. Inflating tires to the maximum pressure recommended by the manufacturer tends to underinflate narrow tires and to overinflate wide tires.

Conclusion

Tire pressures that correspond to 15% tire drop will optimize your bike's performance and comfort on average road surfaces. On very rough roads or unpaved roads, it may be useful to reduce the pressure. On very smooth roads, increasing the pressure slightly may improve the performance of your bike.

Notes:
This article was reviewed by Frank Berto.
1 At higher pressures, internal losses due to flexing of the casing decrease, but suspension losses due to vibrating and bouncing of the bike increase. See Heine, J. and M. Vande Kamp, 2006: The Performance of Tires. BQ Vol. 5, No. 1, p. 1.
2 Berto, F., 2004: Under Pressure. Australian Cyclist March/April 2004, p. 48.
3 Heine, J., M. Vande Kamp, A. Wetmore and A. Spence, 2007: Optimizing Bicycles for Carrying Heavy Loads. Bicycle Quarterly Vol. 5, No. 3, p. 37.
4 For tires mounted on rims of appropriate width for the tire width.



Tire inflation for 15% wheel drop in relation to wheel load and actual tire width.[4] Example: Rider and bike weight: 100 kg. Weight distribution: 45%/55%. Wheel loads: 45 kg/55 kg. Tire pressures for 20 mm tires: 125 psi/155 psi. Tire pressures for 37 mm tires: 45 psi/53 psi. For heavy riders/bikes, narrow tires require very high inflation pressures, and wide tires are a better choice.

PSI RX

Tire pressure and load

by Jan Heine

With optimal tire pressure you get both the best performance and most comfort from your bicycle. What is the optimal tire pressure for your bike, both when riding empty and when touring with camping gear? Tire makers print either a maximum pressure or a recommended range on the sidewalls of their tires, but these generalized values provide little guidance about what is right for you and your bike.

The Function of Tires

We tolerate pneumatic tires and their inevitable punctures only because the alternative — solid tires — is even less appealing. Pneumatic tires use air to absorb road shocks. This not only makes them more comfortable, but also much faster. Have you ever used a handcart with solid tires? Then you know how hard it can be to push, compared to a bicycle with pneumatic tires. To understand how pneumatic tires work, we need to look at two different types of resistance.

Suspension losses

A bike that vibrates and bounces from one bump to the next is lifted up time and again. Lifting the bike requires energy. Part of this energy is absorbed in the rider's body and, on a touring bike, by the luggage. The rest is returned as the bike rolls off the bump. When you accidentally ride into the rumble strips that separate many U.S. highways from the shoulder, you are not only very uncomfortable, but you also slow down immediately as energy is absorbed in your body. By smoothing out the bumps, pneumatic tires save energy.

Deformation losses

The downside of a soft and squishy tire is the deformation of the tire as the wheel rotates. Most of the energy necessary to bend the tire casing is returned as it springs back into shape at the rear of the contact patch, but some of it is lost to friction within the tire and is no longer

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available to drive the bicycle forward.

Optimal tire pressure

For the best performance and comfort, you need a tire that is neither too hard nor too soft. Instead of inflating your tires to the maximum pressure, run them at the optimal pressure, where they deflect enough to keep the bike from vibrating too much yet are not so soft that they slow down due to excessive deformation losses.

Tire drop

Tire drop measures how much the tire deflects under the load of rider and luggage (Figure 1). For example, if your tire is 30 mm tall without a load and 27 mm tall once you sit on the bike, your tire drop is 3 mm or 10 percent.

As part of *Bicycle Quarterly's* tire performance tests, we looked at the influence of tire pressure on the speed of a real rider on an average road surface. As expected, performance increased with higher tire pressures, but only up to the point that corresponded to about 15 percent tire drop. Higher pressures no longer brought meaningful performance improvements. Tubular tires even became slower at higher pressures. This means that if you want the optimal speed and comfort from your bike, you should try to obtain a tire drop of 15 percent. With more tire drop (lower pressure), you will be more comfortable but slower. With less tire drop (higher pressure), you will be less comfortable, but not significantly faster, because your bike bounces so much more. Perhaps not coincidentally, many tire manufacturers recommend a tire drop of 15 percent.

Tire Pressure

Measuring tire drop requires a relatively complex setup. Fortunately, Frank Berto has done the measurements for us (Figure 2). His chart shows the tire pressure that results in a tire drop of 15 percent. Obviously, tire drop depends both on the weight resting on the wheel and the air volume of the tire (which correlates to tire width). For the width, you can either use calipers or, as a rough estimate, the markings on the tire. For the weight, place a scale under the front wheel of your bike and a brick under the rear wheel so the bike is level. Sit on the bike, have a helper hold you upright, and read the scale. Then turn the bike around so that its rear wheel rests on

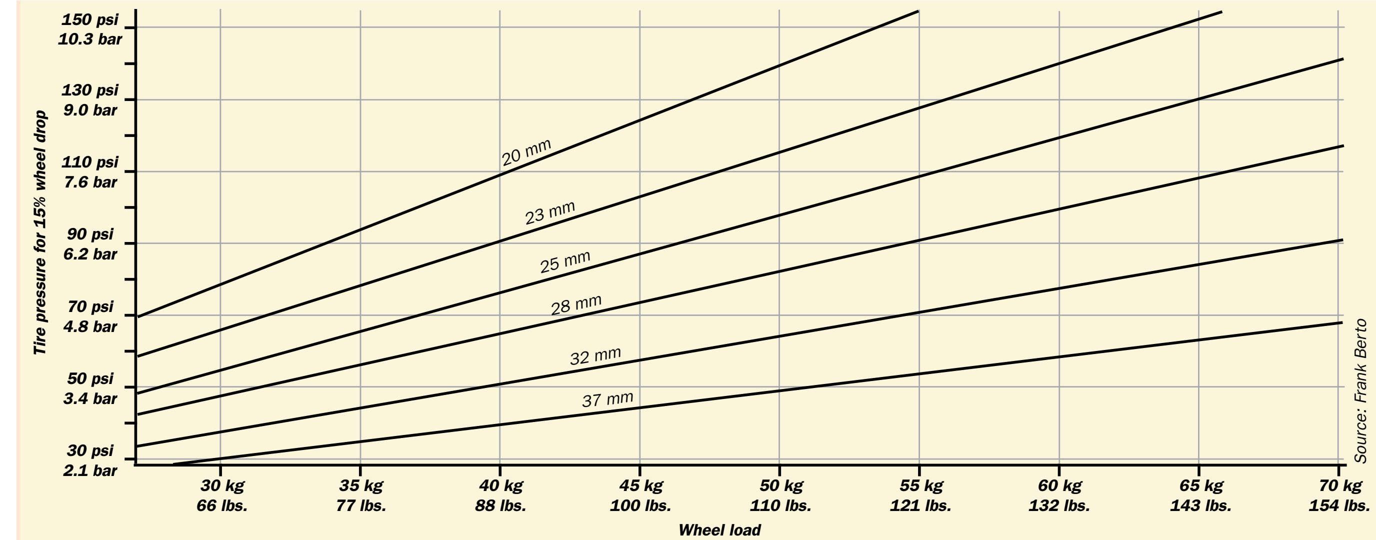


Figure 2. *Tire inflation for 15% tire drop, with various loads and tire widths. The loads are for each wehel not the entire bike.*

the scale and repeat the measurement. Depending on how you load the bike, the weight distribution may be very unequal. You can use the values in Fig. 3 as starting points for your bike. For example, if you and your racing bike together weigh 200 pounds, your front tire probably carries about 80 pounds. (40%) and the rear tire carries about 120 pounds. (60%).

To find the ideal tire pressure, follow the line for your tire width until it intersects the weight on that wheel. Now you can read the tire pressure that results in 15 percent tire drop. Round it off to the nearest 5 pounds per square inch (psi). For example, if you use 23-mm tires in the example above, your front tire should be inflated to 80 psi and your rear tire to 125 psi.

Of course, you should not exceed the

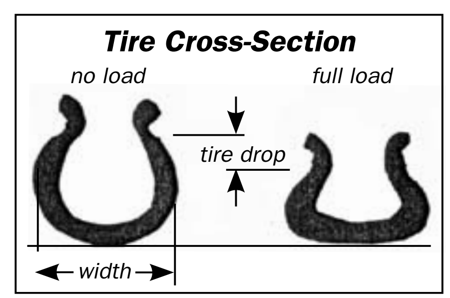


Figure 1.

maximum pressure rating of your tires. If you find that the table suggests a pressure that your tires cannot support, you probably should use wider tires.

Wider tires carry loads better

When you look at the slope of the lines in the chart, you will see that the lines for narrow tires are much steeper than those for wide tires. With wider tires, you don't have to increase the tire pressure by much as you load the bike. If you add a 40-pound load (20 pounds each on front and rear racks) to the bike in the above example with its 23-mm tires, your tire pressures should increase by 25 psi to 105 psi (front) and 150 psi (rear). However, if you use 37-mm tires, the tire pressures should increase only from 35 to 45 psi (front) and from 55 to 65 psi (rear).

Properly inflated, wider tires provide much more comfort. When you hit a bump and your tire drop increases from 15 to 18 percent, the 23-mm tire will give you only 0.69 mm suspension, whereas the 37-mm tire deflects 1.11 mm. The added suspension of the wider tire makes it faster and more comfortable on rough roads. This opens up many backroads to enjoyable bicycle touring.

Tire width and speed

But aren't narrower tires faster? Not really. The key to a fast tire is a supple thin casing that requires less energy to deform than a sturdier thicker casing. For a variety of reasons, many wide tires use heavy-duty casings, which are indeed slow. Wide tires with high-performance casings can be very fast. In *Bicycle Quarterly's* tests, the five fastest tires ranged in width from 24 to 37 mm. Many narrow "racing" tires did not

Bike	Load (8 lbs.)	Weight distribution Front	Rear
Randonneur	front	45%	55%
Racing	-	40%	60%
City	rear	35%	65%

Weight distribution. *Weight distribution for three typical bicycles.*

make it into the top five.

A thin supple casing is faster because it absorbs less energy as it deforms. Thus, it will deform more for a given bump, making it more comfortable than a sturdier tire with a thicker casing (for the same tire width and pressure). The downside of a thin supple casing is reduced resistance to punctures.

When you plan your tour, it is useful to think about tire sizes and pressures. However, once you're on the road, don't obsess about tire pressures, as long as you have enough air in your tires to avoid pinch flats. Especially with wide tires, a few psi more or less make little difference, and you can focus on enjoying the ride. AC

Jan Heine is editor of Bicycle Quarterly, *a magazine about the culture, technology, and the history of cycling. More information can be found at www.bikequarterly .com.*

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

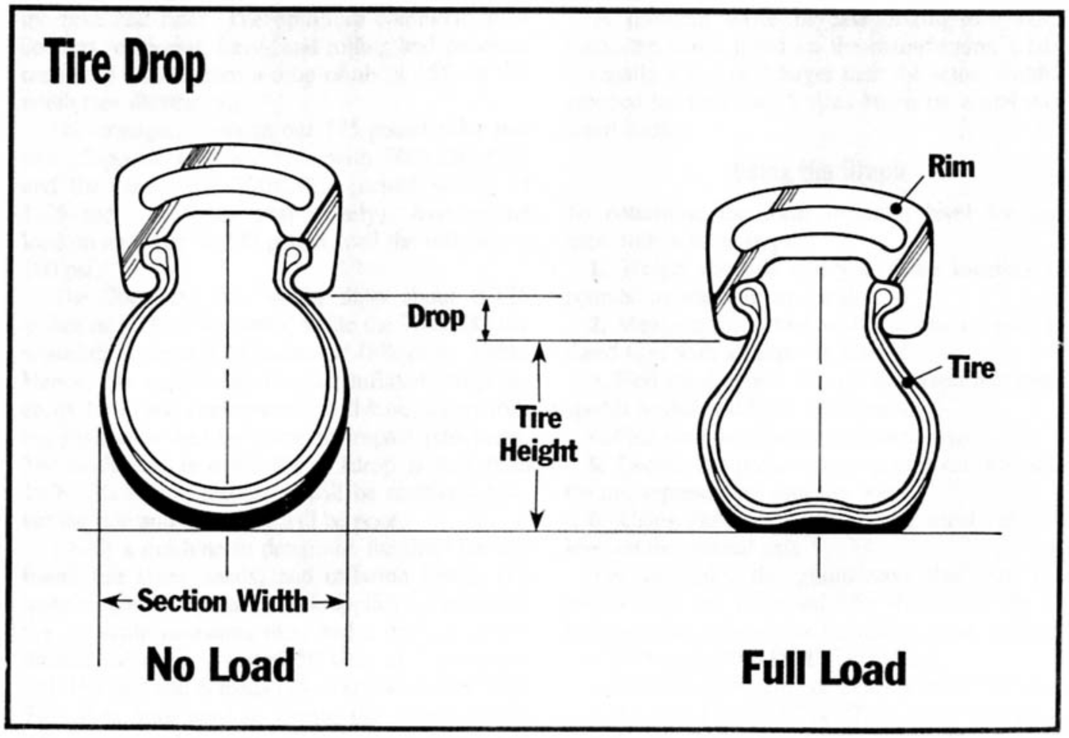
Under-inflated tires get more impact punctures because, upon riding into an unyielding object, the tire compresses so much that the inner tube gets pinched between the edge of the rim and the rock, pothole, railroad track or whatever you've hit. You can identify this puncture because it produces two 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 recomended 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.

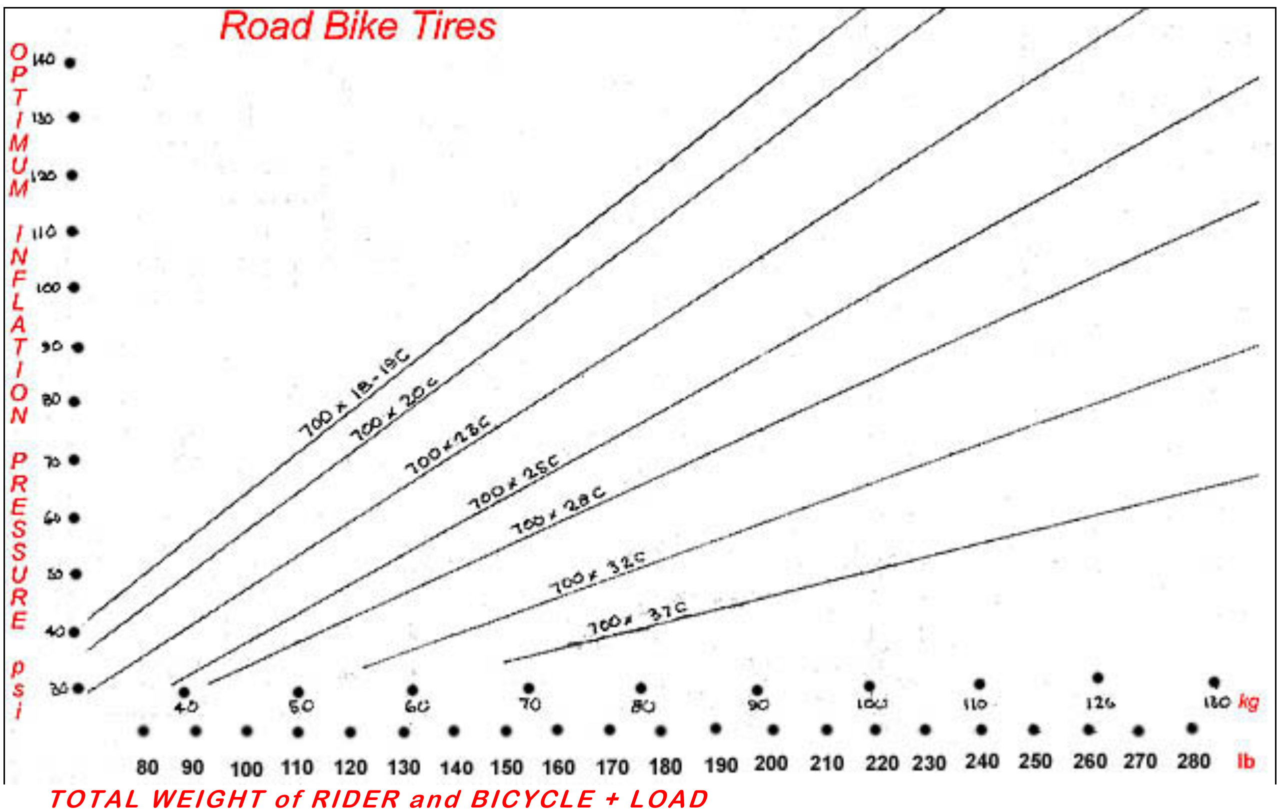
You also have to mount the tires correctly and make sure the beads are seated during inflation. To produce the optimum inflation graph, I inflated 50 different tires to 1.5 times their listed maximum pressures. The 135-psi rated tires were inflated to 200 psi. None of the tires blew off but I wore gloves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

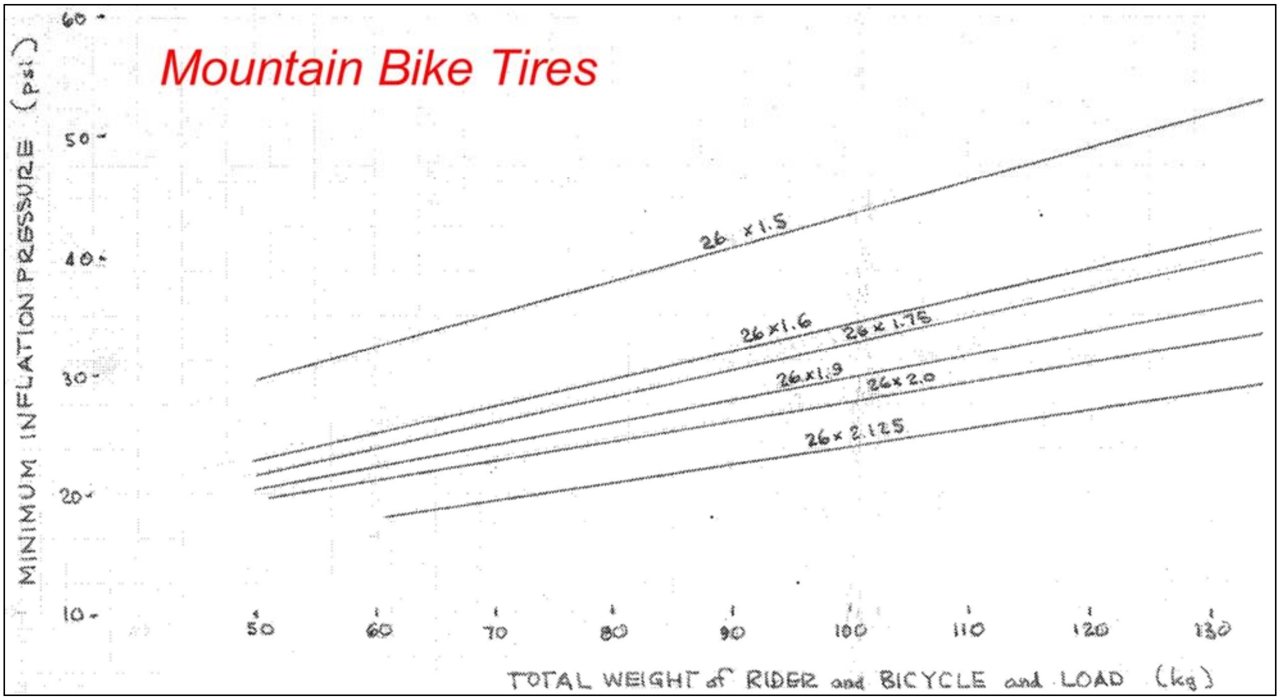
TIRE PRESSURE GAUGES

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."*

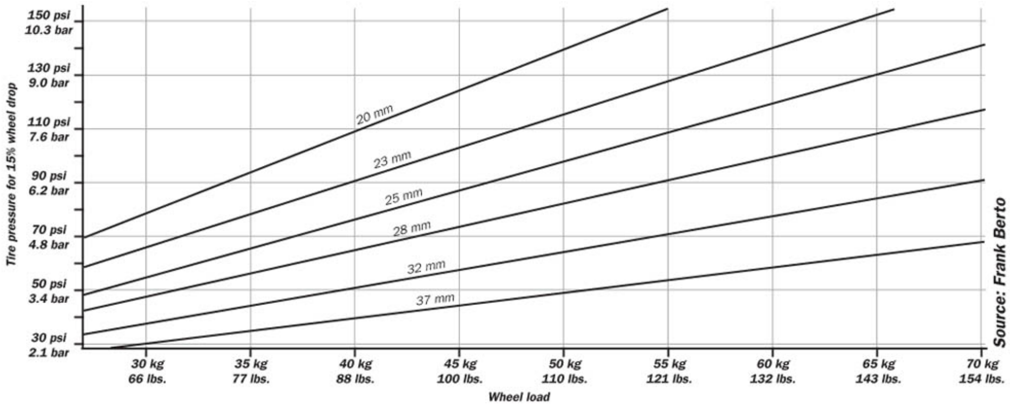
Tire Pressure Take-Home

Posted on March 9, 2016

What is the 'correct' tire pressure for your bike? The simple answer is: Whatever feels right to you. Confused? Here is how it works:

In the past, many riders inflated their tires to the **maximum** pressure rating. Now most cyclists now recognize that the **optimum** pressure often is much lower.

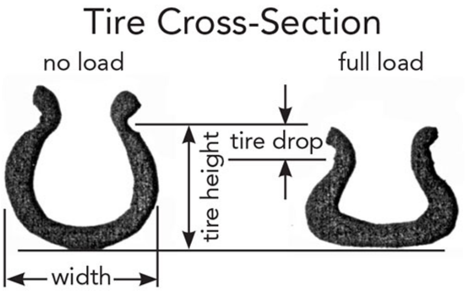
But what is the right tire pressure? At *Bicycle Quarterly*, we've done a lot of research into the rolling resistance of tires at various pressures, and on various road surfaces.



Tire inflation for 15% wheel drop in relation to wheel load and actual tire width.[4] Example: Rider and bike weight: 100 kg. Weight distribution: 45%/55%. Wheel loads: 45 kg/55 kg. Tire pressures for 20 mm tires: 125 psi/155 psi. Tire pressures for 37 mm tires: 45 psi/53 psi. For heavy riders/bikes, narrow tires require very high inflation pressures, and wide tires are a better choice.

Frank Berto's tire pressure chart (above), first published in *Bicycle Quarterly* many years ago, has received much attention. (Note that the weights are per wheel, not for the entire bike.)

Berto made the chart in the 1990s, when tires were much narrower. Hardly anybody today still rides on 20 mm tires, and even 23 mm are on their way out! At the other end, 37 mm no longer is huge, as many of us ride 42 mm tires on pavement, and even wider ones on gravel. How does it all translate into the modern world?



Much of it depends on the tires you run. Berto measured the tire drop (above; how much the tire deflects for a given load and pressure) for dozens of tires. He then averaged the values, and drew his chart for a tire drop of 15%.

The 15% as desirable tire drop was based on the recommendations of several tire manufacturers, but not on actual testing. So the chart shows how much you need to inflate an average 1990s tire to achieve a tire drop of 15% – nothing less and nothing more.

A few years ago, Berto sent me all his original data. Looking over his measurements, it's clear that supple tires – back then pretty much only the Michelin Hi-Lite – deflect much more than stiff ones, at the same pressure. This means that specific tires can vary quite a bit from the averages shown in the chart.

To get the same tire drop with supple tires, you would need to run them at higher pressures. But is 15% tire drop really what you want with supple tires?

The answer is *"No."* The 15% tire drop is an arbitrary value. However, even if it's only by coincidence, the values in Berto's chart actually work quite well for Rene Herse tires. They'll result in more than 15% tire drop, but that is OK: Comfort and speed are optimized. And that is what really matters.

The biggest surprise of all our testing (above) was this: For supple tires, pressure makes little difference in performance. We tested three Vittoria tires (Rubino, CX clincher, CX tubular; all 25 mm wide) and found that the supple CX models roll as fast at 70 psi as they do at 130 psi. (For the rest of the world, that is 5 bar and 9 bar.)

The reason is simple: Higher pressure *decreases* the energy required to flex the tire. Less energy is lost due to internal deformation (hysteresis). But higher pressure *increases* the losses due to the vibrations of bike and rider. More energy goes to suspension losses. The two effects cancel each other. Whether you pump up your supple tires super-hard or ride them squishy-soft, they have the same resistance.

On the other hand, truly stiff tires feel sluggish at 15% tire drop. The stiff tire is much harder to flex, so it's useful to minimize that flex by increasing the pressure. For stiff tires, the suspension losses do not vary as much with pressure – they're always high – since the stiff casing transmits a lot of vibration at any pressure.

Recently, *Velo-News* confirmed our results: The performance of a hand-made tire with cotton casing did not change at different tire pressures. And a stiffer tire rolled slower at lower pressures than at higher ones. (It's nice to see that our results, after having been highly controversial for years, now are becoming generally accepted.)

It can be hard to believe this, because **higher pressure *feels* faster**. Here is why: When you go faster, your bike hits more road irregularities per second: The road buzz increases in frequency. Most cyclists know: *higher speed = higher frequency*.

Higher tire pressure cheats you into thinking that you are going faster, because it also increases the frequency of the vibrations: *higher pressure = higher frequency*.

It's natural to assume that this means: *higher pressure = higher frequency = higher speed*, but that is incorrect. Instead, you are looking at two different mechanisms that both increase the frequency of the road buzz.

Even after years of riding supple, wide tires, this 'placebo' effect sometimes plays tricks on me. A supple tire absorbs vibrations better, so it can feel slower – until you look at your speedometer.

What does it all mean? Here is the take-home summary:

- Stiff casings always will be slow. They are even slower at lower pressures.
- Supple casings are fast, and pressure doesn't matter.
- On smooth roads, tire pressure is a matter of personal preference (at least with supple tires). High and low pressures offer the same performance.
- On rough roads, lower pressures are faster. So if you want to optimize your speed on all roads, including rough ones, go with a relatively low, but safe, pressure.
- Your tire pressure needs to be high enough to avoid pinch flats. If you get pinch flats, increase your tire pressure, or better, choose wider tires. Pinch flats are rare with wide tires.
- On pavement, your pressure needs to be high enough that the tire does not collapse during hard cornering.
- The minimum safe pressure is higher for more supple casings. Stiff casings hold up the bike more, and thus require less air pressure.
- On gravel, you can run lower pressures than on pavement. On loose surfaces, the tires don't collapse as easily, because the cornering forces are much lower.
- Don't run your tires so low that the casing cords start to break. That happens only at very low pressures, but if you start seeing multiple lines across the casing where cords have broken, inflate the tires a bit more.
- Berto's chart still is a good starting point. Inflate your tires to the pressures it recommends, then experiment by adding or letting out some air.
- See what feels best to you. That is the optimum tire pressure for you. Don't worry about tire pressure any further! At least on paved roads, you won't go faster or slower if you change your tire pressure.

Even simpler, here is a summary in two sentences:

- Ride the tire pressure that feels good to you.
- When in doubt, let out some air.

It's really that simple!

Further reading:

- [Minimum tire pressure: How low can you go?]

- [What makes a tire supple?](#) (It’s not TPI alone.)
- *[Bicycle Quarterly](#)* magazine
- [Rene Herse tires](#)

Related

The Trouble with 'Road Tubeless'
In "Testing and Tech"

Myth 16: Higher Tire Pressure is Faster
In "Myths in Cycling"

Minimum Tire Pressure
In "Testing and Tech"

About Jan Heine

Spirited rides that zig-zag across mountain ranges. Bicycle Quarterly magazine and its sister company, Rene Herse Cycles, that turns our research into the high-performance components we need for our adventures.

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46 Responses to *Tire Pressure Take-Home*

Stephen Poole *says:*
March 9, 2016 at 10:02 pm

Brilliant, Jan! This is the most useful, helpful and succinct thing I’ve ever seen on this subject. Your public service medal should be on its way any day now.

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shastatour *says:*
March 9, 2016 at 10:38 pm

I would suggest a third sentence to the summary: Ride on supple tires.

Robert *says:*
March 9, 2016 at 10:49 pm

Supple tires are nice, but a puncture renders them unusable. With stiffer sidewalls I can at least limp home to fix any flat (but I am a short-rides-only-because-I-have-to cyclist).

> **[Jan Heine, Editor, Bicycle Quarterly](#)** *says:*
> March 10, 2016 at 6:47 am
>
> Even when I rode utility tires, I’ve never encountered a tire that could be ridden without air. Even under my light weight as a student, they compressed all the way when I had flats. (That is why it’s called a “flat” tire.) Are the new generation “puncture-resistant” tires really so stiff that you can ride them airless?
>
> We did test actual airless tires for rolling resistance. Even on a super-smooth track, they had 50% more resistance than the worst air-filled tire. Where I was pedaling at moderate effort on the best tires to maintain the speed we

had selected for our testing, I had to work all-out on the airless tires. And the cornering, even in the wide corners of the inner apron of the track we used (not on the banking) was awful!

Airless tires haven't caught on because they ride so horribly. I would think that a tire that can be ridden without air would be close in feel…

On the other hand, if you ride half a mile to a train station every morning, like many Europeans do, a flat means you missing your train and being an hour late to work. In that scenario, riding the most puncture-resistant tire makes sense.

Geoff Hazel *says:*
March 9, 2016 at 10:56 pm

Sounds like a strategy when using supple tires is: Inflate to chart pressure. Ride. Don't look at pressure or re-inflate until tires either (1) don't feel right or (2) cords start showing or (3) you get pinch flats. If any of those happen, add 5-10 lbs of air and note that as the pressure you should maintain going forward.

Eddie *says:*
March 9, 2016 at 10:59 pm

I have to ask, what about in something as specific as CX races, where most riders tend to have pressures of just 20-30 psi and are always flirting with pinching, burping, or rolling tires? Is there any takeaway from your research for such a situation or is this a similar case of trial and error ("how low can you go")?

Jan Heine, Editor, Bicycle Quarterly *says:*
March 10, 2016 at 12:27 am

Cyclocross is a very special application. With the extra-supple FMB tubulars I run, I use the same approach – drop the pressure as much as I can until the tires start collapsing under hard cornering. That point depends on how much traction the course offers. If it's very muddy, the pressure is lower. If there are significant paved sections, it has to be higher.

I haven't raced 'cross on clinchers, but I am sure somebody else will weigh in on this.

Bryan Willman *says:*
March 10, 2016 at 10:03 am

I have raced cross (poorly) on both clinchers and tubulars – not on tubeless. With clinchers and my very heavy weight, it takes a relatively high amount of air just to keep the tire on the rim (at one point nearly 50psi fro a 33mm tire.) Tubulars allow even someone as heavy as me to run rather lower pressures, low enough that sometimes it seems faster to add air – if there is a particular kind of hard pack, or pavement. For most PNW 'cross courses, it seems I did best when the pressure was "just enough" to keep the tire from "slewing" sideways – it didn't seem likely to roll off, but was no longer retaining a "tire shape". Where that is would depend on rider weight and the tire as well as the terrain. I am quite heavy (call it 230# race weight) and went to dugast cotton tublar cross tires a few years ago and have stuck with them – because they are very compliant, and being tubulars tolerate low pressures under my weight. I don't/wouldn't hassle with tubulars outside of 'cross racing.

Luis Bernhardt *says:*
March 9, 2016 at 11:31 pm

Coming from a track racing background, where we're used to inflating 21mm tubulars to 180 psi, I am finally convinced. I've been running the same 21mm tubulars in Burnaby at 110-120 psi and there's no difference in speed or effort to hold a given

speed, but the tires last longer because the casings are not stressed. (And the tread just lasts forever on a wooden track!)
The latest bike I had built actually has room for a 32mm tire in back, and I'm slowly stockpiling and aging supple 25s and 28s as I gradually wear thru my stock of 23mm tires (it was a 3-year supply – I find that rubber aged for one or two years does appear to resist punctures better than fresh rubber; perhaps that myth will be the next object of your inquiries!).
However, heeding some of the pioneers of the "less pressure" school of thought (Uncle Al comes to mind), I tried lowering the pressure in my 23mm tires from 120 psi to 110 psi. And promptly started getting pinch flats (btw, I weigh 175-180 lbs). I'm running Vredestein Fortezza Tri-Comps, and I'm not sure if they'd be considered a "supple" tire, as one of the big reasons I use them is because the sidewalls are not prone to failure, as on Conti GP's and similar "skinwall" ciinchers. Tri-Comp sidewalls are definitely not as supple as Contis, but they last much longer, usually 10,000 km on the front and 5,000 on the rear before worn to the cord.
So my question is this: why is it that "pinch flats are rare with wide tires?" It would seem to me that as long as the tube can get caught between the rim and a rock, you'll pinch flat.
And while we're on the subject of tire pressures, I would like to question the convention of airing the front tire less than the rear. The accepted practice is derived from the bike's static weight distribution with rider. I air my tires for "worst case," 120 lbs front AND rear. This is because under braking, or when climbing out of the saddle, the front tire will have more weight on it than the rear. Worst case.

huges84 *says:*
March 10, 2016 at 4:00 am

Pressure equals force divided by area. Which means force equals pressure times area. You hit a bump with the same force regardless of tire width. Let's assume you run two different width tires at the same pressure. With a skinny tire a large impact force is applied to a small area, so the opposing force from the tire pressure is small. With a wide tire the impact force is applied to a large area, so the tire pressure provides a larger opposing force. But in real life we don't run the same pressure on both tires. The wider tire will be at a lower pressure. So maybe the lower pressure will have more of an impact than the larger area. Then why do we say wider tires

Well, wider tires are also taller than skinnier tires. So there is effectively more travel to the suspension of the tire. And as the tire gets compressed, the internal pressure is rising and more of the tire contracts the bump. Also the force needed to deflect the sidewall increases with further compression. So the force the tire applies to oppose the bump increases with increased deflection off the tire. So it takes a lot more force to overcome the travel of the tire suspension on a wider tire. Pinch flats can only happen when you bottom out the tire against the rim.

Keep in mind the area I am talking about is the contract area with the bump. The bumps that tend to cause pinch flats are usually wider than the tire. Since wider tires have wider and shorter contact areas compared to skinny tires, the contract area of the tire and bump will always be bigger for a wider tire.

John Duval *says:*
March 11, 2016 at 8:53 pm

Using the section of a torus method, both in a mathematical (Excel spreadsheet) model and CAD model, turned up some interesting findings:

1. the contact patch is only shorter and wider when the two sizes are inflated to the same pressure, and then only barely. Fact is, the wheel radius is so large compared to the with, that the length of the contact patch changes only very slightly.
2. even at the same pressure, the taller tire has more "suspension travel" (which is the question that kicked off this study). When supporting a given load on a flat surface, a tire twice as wide must compress twice the distance to create the same size contact patch. So in theory, a wide tire will ride softer even at the same pressure.
3. The wide tire deforms more, not less, than a skinny tire at either the same or proportional pressure. So lower rolling resistance does not come, even partially, from lower hysteresis.

The pressure curve determined by Burto is indeed linear, and the difference between it and the torus section method is within 5psi across the chart. The section of a torus method is obviously still an approximation, and tire deformation is much more nuanced, but the numbers line up well enough to refine a number of hypothesis.

Jan Heine, Editor, Bicycle Quarterly *says:*
March 12, 2016 at 12:36 pm

Those are interesting findings, but before we accept them, we must validate the model used to derive them. It would be interesting to actually measure the contact patch of various tires at different pressures. I can think of a few ways in which this could be done.

Jan Heine, Editor, Bicycle Quarterly *says:*
March 10, 2016 at 6:07 am

> *why is it that "pinch flats are rare with wide tires?"*

When you look at the tire drop curves in Berto's chart, you see that wider tires have a much shallower slope. What this means is that you can add significant weight with less deformation than with narrow tires. Or in other words, a bump also will deform the tire much less.

Jason Miles *says:*
March 11, 2016 at 3:00 pm

Do you have analytical model for Berto's chart? I'm guessing that would either be related to calculating the surface area of a partial torus or the surface area of a ellipse. The math geek in me cannot accept that this chart is truly linear.

Also which tire do you think would loose air faster a large tire at low pressures or a small tire at high pressures? The smaller tire has to contain higher pressures, but it also has a smaller surface area to bleed from. I'm guessing either way the wide tires would be better because of the lower slope mentioned and the fact that they have higher volume so you will have to bleed more area to affect the pressure the same amount. I ask because I often get pinch flats when I am too lazy to pump up my tires and am riding at a too low of pressure.

Jan Heine, Editor, Bicycle Quarterly *says:*
March 11, 2016 at 4:11 pm

Berto's chart is purely empirical. He measured the actual tire drop with a lot of tires and averaged the results. Then he plotted them on the chart.

Jason Miles *says:*
March 11, 2016 at 3:19 pm

"What this means is that you can add significant weight with less deformation than with narrow tires." I am not sure if this is correct. I think the chart shows us that with wider tires you can add significant weight without having to change your tire pressure as much.

In my experience your other post is correct. Lower pressure higher volume tires bounce at lower frequency but higher amplitude. When riding a fatbike on large bumps you can really feel this amplitude because the undamped suspension from the tires is enough to seemingly try and buck you from the bike.

In general I consider this the lower sloped pressure change line for larger tires to be a negative trait because it makes your pressure adjustments more sensitive.

Jan Heine, Editor, Bicycle Quarterly *says:*
March 11, 2016 at 6:22 pm

> *I think the chart shows us that with wider tires you can add significant weight without having to change your tire pressure as much.*

The two are directly related. With wider tires, you don't have to change your tire pressure much as you add weight, because the tire deformation doesn't change as much.

> *In general I consider this the lower sloped pressure change line for larger tires to be a negative trait because it makes your pressure adjustments more sensitive.*

That would be true if you wanted to get exactly 15% tire drop. But as the article explains, the 15% value is just a good starting point, not important by itself. With wide tires, tire pressure actually matters less, because you aren't going to get pinch flats. Whether you have 15% or 20% tire drop (or even more) doesn't affect the performance of wide tires.

In a real-world example, I can ride my 42 mm tires at 55 psi or at 40 psi, or anywhere in between. They feel great and roll fast at all those pressures.

[Jason Miles](#) *says:*
March 11, 2016 at 6:54 pm

I gave an analytical derivation a try, unfortunately either my assumptions are incorrect or I screwed up the derivation because when I plug in real numbers I don't get the correct result. If anyone else would like to give it a try, here is my attempt:

https://goo.gl/F2I2Vf

Tran *says:*
March 10, 2016 at 12:29 am

I think the article meant to say that we should ride the tire pressure that feels good while observing the recommended minimum pressure, if indicated ? For the Elk Pass, that minimum is 4.5 Bars, which is more that I would like to run it at.

Jan Heine, Editor, Bicycle Quarterly *says:*
March 10, 2016 at 6:05 am

On most tires, you can ignore the minimum tire pressure. It was put on the tires for liability protection, not for technical reasons.

Don't worry about going lower than 4.5 bars on the Elk Pass. For most of our tires, we don't indicate a minimum tire pressure for that reason.

Ed Bernasky *says:*
March 10, 2016 at 2:05 am

Wonderful Blog post!!

Aside from cost constraints, I can't see a reason not to run high performance, widish, supple tires because they are not only more comfortable but the time savings on a 1200 Km range from 2 hours for average tires to 4 hours savings when moving from slower tires. I don't get many flats and the ten minutes to leisurely fix one is a small price to pay from my perspective. The additional time when running "slow" tires could be the difference between Hors Delai or successfully finishing on whatever time scale is desired.

On a fast Brevet last year I was struggling to hold the pace or at least until we hit a 6-8 mile stretch of the nastiest chip seal and pot holed road imaginable and suddenly my required powered dropped significantly while my former "Tormentor in Chief" struggled on his 23 mm tires probably pumped to 115 psi. I was running the 32 mm Compass EL tires at 65 psi front and 80 psi rear. What I like about the Compass tires compared to the very few other performance oriented wide tires is their relative durability. I'm currently experimenting with some tubeless options from other Mfgs (Schwalbe and Specialized) but the durability is probably going to be unacceptable. Most of my rides are on Compass tires but I also use a few others.

Steven Krusemark *says:*
March 10, 2016 at 4:03 am

We rode our tandem around the world on specialized 27×1-3/8 tires until our supply (and money) started running low then we ran many 1-¼ tires that we picked up along the way. (It was amazing how many free tires we received from shops in the U.S. because their customers just wanted new tires) We ran the tires at ~100psi (or as high as we could go using our Zefal). We now riding the Grand Bois Hetre 650x42B tires at about 65psi. The tires ride like being on clouds and we find we go as fast than on the stiffer tires. These tires would have been nice on the rough roads of India or the sandy roads going over the Snowy Mountains in Australia! Although worldwide availability of 650B tires are limited, 27 inch tires were also not available in many places when we traveled in the 80's. We entered India with six tires folded up, strapped to various places on the bike. Besides being more comfy, these tires fold easier and are much easier to inflate after a flat on the road with the hand pump after 60 miles of riding in 120 degree heat dodging elephants and TATA Lories!

Harald *says:*
March 10, 2016 at 4:47 am

Higher pressure decreases the energy required to flex the tire. Less energy is lost due to internal deformation (hysteresis). But higher pressure increases the losses due to the vibrations of bike and rider. More energy goes to suspension losses. The two effects cancel each other. Whether you pump up your supple tires super-hard or ride them squishy-soft, they have the same resistance.
Recently, Velo-News confirmed our results: The performance of a hand-made tire with cotton casing did not change at different tire pressures.
Isn't this contradictory? The Velo News test was on a drum and therefore didn't measure suspension losses. Nonetheless, rolling resistance remained approximately the same at all pressures for the supple tire. Hence, in a real-world setting, riding at lower pressures should *decrease* overall resistance. So I don't think that the Velo News drum test and your real-world testing actually have the same result.

> **Jan Heine, Editor, Bicycle Quarterly** *says:*
> March 10, 2016 at 6:32 am
>
> I was wondering about that, too. In the past, the same tests showed that higher pressures rolled faster. I assume that they use a shock absorber to keep the tire from bouncing on the patterned treads they now use on their rollers. That shock absorber also will use energy as it absorbs the shocks. So if you calibrate it correctly, you could conceivably measure suspension losses. You'd still need to validate your calibration with real-road testing…
>
> Real road testing has the advantage that your model is perfect. (You are testing under the actual conditions that you encounter when riding.) The key, however, is to reduce the noise in the data. You need to set up your test very, very carefully, test only when there is no wind and constant temperature, and then do a rigorous statistical analysis to show that you are measuring real differences between tires and pressures, and not just noise in the data.

Gunther *says:*
March 10, 2016 at 6:14 am

Certainly, higher pressure increases vibrations in the rider. But one may still discuss how this is distributed over amplitude and frequency. Maybe you are mainly hit harder (amplitude) rather than more often (frequency).

> **Jan Heine, Editor, Bicycle Quarterly** *says:*
> March 10, 2016 at 6:22 am

The frequency also changes… Pick up one end of the bike and let it drop. The bouncing you get depends on the tire pressure. Low pressure, it bounces with low frequency (but higher amplitude, since the energy you put in is the same). At higher pressure, it bounces much faster, but not so high.

We used to do this to check our tire pressure when we were poor students and didn't have floor pumps with gauges.

Bill Wood *says:*
March 10, 2016 at 11:46 am

Nice tip!!

Larry *says:*
March 10, 2016 at 6:19 am

Since much of this discussion is predicated on how supple ones tires are …. Is there a definitive definition of a Supple tire ?

Jan Heine, Editor, Bicycle Quarterly *says:*
March 10, 2016 at 6:25 am

Defining a supple tire isn't easy, because like so many qualities, simple measurements don't tell the story. I wrote about that in this post.

All I can add is that *"When you ride a set of supple tires, you'll know."*

Pano G. *says:*
March 10, 2016 at 9:18 am

Another take-home point that may need to be highlighted is that the type and thickness of the tread compound used affects the "suppleness" of the particular tire and could be detrimental to rolling resistance by counteracting against the desirable effects of the supple sidewalls.

Jan Heine, Editor, Bicycle Quarterly *says:*
March 10, 2016 at 9:21 am

Absolutely. Designing a great tire must take everything in consideration. If the tread is too thick, or there is too much rubber on the sidewalls, or you put puncture-resistant belts under the tread – all deteriorate both comfort and performance. Fortunately, modern rubber compounds are so good that you can get great grip and great longevity without needing excessively thick tread.

Wider tires last longer anyhow, since the wear is spread over a larger surface area. That means that modern supple tires may be expensive when you buy them, but they don't cost much per mile.

Arthur *says:*
March 10, 2016 at 10:27 am

Are there any pictures that show what broken casing cords look like?

Jan Heine, Editor, Bicycle Quarterly *says:*
March 10, 2016 at 2:46 pm

Sorry, don't have any. It's never happened to me – I just don't let the pressure get quite that low.

PabloB *says:*
March 10, 2016 at 10:44 am

As the road is very rough in my area, so I prefer to ride at very slow pressures too, but my rear tire has often collapsed during cornering. Thou I have limited wheels to compare this effect seems to more prone when same tires are mounted in (most road) narrow rims than in wider (like the Rhino Lite for example).

Any Thoughts

Jan Heine, Editor, Bicycle Quarterly *says:*
March 10, 2016 at 2:47 pm

Timely question, since we just published an article in the Spring 2016 *Bicycle Quarterly* on this. Wider rims help stabilize stiff tires, but with supple tires, rim width doesn't make as much difference.

alliwant *says:*
March 10, 2016 at 2:45 pm

Something about this statement seems a little off: "Higher pressure decreases the energy required to flex the tire. Less energy is lost due to internal deformation (hysteresis)." Isn't is more accurate to say that higher pressure *increases* the energy required to flex the tire, which would result in less internal deformation (and by extension, moreenergy transmitted by vibration)?

Jan Heine, Editor, Bicycle Quarterly *says:*
March 10, 2016 at 2:49 pm

Sorry it is easy to misunderstand. I see where you are coming from… Here is what I meant:

For a given weight of the rider, the tire flexes less at higher pressures. So less energy is lost to tire flexing.

Michael *says:*
March 11, 2016 at 12:11 pm

Speaking of tire deflections…
I ride through a gated community and the track that the gate glides on is a metal strip with a tongue about two inches high and one deep that runs the whole length of the track.. So its like someone riding over a spike strip without the spikes. Just a blunt ridge.
Is repeated riding over these types of ridges bad for the tire, since it is such a directed point of force into the tire as the tire rides over the tongue?

Haven't gotten any pinch flats or anything. Wondering if it stresses the casing or something. No way around the ridges except hopping off and walking the bike across.

I ride 650b cypres and loups at 45 psi.

Jan Heine, Editor, Bicycle Quarterly *says:*
March 11, 2016 at 4:10 pm

Any hard hit on a sharp edge is bad for your tire. However, if you know it's coming, you simply unweigh the bike (or even jump a bit), and the impact will be negligible.

thebvo *says:*
March 11, 2016 at 3:11 pm

I remember switching to 48mm wide utility tires and they felt so much better than the cheap 28's I had been riding previously. But then I rode supple tires and even at the skinny ish size of 32 it was totally noticeable. It's not my metaphor but supple tires truly make roads feel freshly paved. And now we can have wide AND supple (fast) tires!!!
Thanks for pushing the envelope in this direction and making it fun and easy to understand for fools like me.

Jan Heine, Editor, Bicycle Quarterly *says:*
March 11, 2016 at 4:15 pm

We have found that casing suppleness is more important than width. So a supple 25 mm tire feels much better than a stiff 38 mm tire… Of course, as you say, a supple, wide tire is much. better than both.

Bill Wood *says:*
March 13, 2016 at 12:55 pm

Hi Jan, I have some hard to interpret results here. Inspired by the Berto chart, I measured tire drop for two sets of tires, front and rear. I measured unweighted and weighted (70 lbs front, 130 lbs rear) rollout at 3 different tire pressures. I measured along a tape measure for 5 rotations, then divided the difference between weighted and unweighted circumference by the measured tire width. Each measurement was repeated several times and the average taken. Measurements were consistent. These graphs show the %tire drop vs PSI:

Roubaix Pro 30/32 (measured @33mm): https://docs.google.com/spreadsheets/d/1ptSMWTu4KUs8ywOknlK5mwyny-Qa2PO2aq50D9qastc/pubchart?oid=286831095&format=interactive

Continental GP4000S II 28 (measured @31mm):
https://docs.google.com/spreadsheets/d/1ptSMWTu4KUs8ywOknlK5mwyny-Qa2PO2aq50D9qastc/pubchart?oid=258933175&format=interactive

As you can see, the Contis, while narrower and more supple, require substantially less tire pressure to provide a 15% drop (65psi vs 90psi on the rear wheel and 33psi vs 35psi on the front), which is opposite what I expected based on your post.

Thoughts?

PS. Soon I will measure Bon Jon Pass 35 extra lights.

Jan Heine, Editor, Bicycle Quarterly *says:*
March 13, 2016 at 2:49 pm

Do we know that the Contis are more supple? In my experience, Contis usually ride quite harshly… I'll be interested to see more results.

Bill Wood *says:*
March 13, 2016 at 4:01 pm

The Contis certainly feel more supple, and are more collapsed when mounted without air on the rim, kind of like Compass tires, whereas the Roubaix Pros sit tall. Also the Conti 28s have great reviews for rolling resistance. I will be trying them at lower pressure (50 front 75 rear), see how they feel.

Bill Wood *says:*
March 13, 2016 at 3:56 pm

Oops I meant to say "divided the difference between weighted and unweighted RADIUS by the measured tire width"

Another Frank *says:*
March 14, 2016 at 4:13 pm

One reader asked for a picture of broken casing cords. Perhaps like this? Continental GP4000S II in my experience have fragile sidewalls: https://dl.dropboxusercontent.com/u/9474052/GP4000S%20II%2028mm.JPG
