Bicycle Tires and Tubes

Parts of a Tire

Clincher Tires

Conventional tires used on 99% of all bicycles are "clincher" type, also known as "wire-on." They consist of an outer tire with a U-shaped cross section, and a separate inner tube. The edges of the tire hook over the edges of the rim, and air pressure holds everything in place.

Many people suppose that tires are made out of rubber, because that's what is visible. This is a major oversimplification -- rubber is the least important of the three components that make up a tire:

Bead

The "bead" is the edge of the tire. On most tires, the beads consist of hoops of strong steel cable. The beads hold the tire onto the rim, and are, in a sense, the "backbones" of a tire. While most beads are steel, some tires use Kevlar ® cord instead.

Fabric

Cloth fabric is woven between the two beads to form the body or "carcass" of the tire. This is the heart of the tire, the part that determines its shape. The vast majority of tires use nylon cord, though some use other polyamides. Up until the 1960s, cotton/canvas was commonly used. It was not as strong, and was prone to rot. Cotton and silk are still used for some tubulars.

The fabric threads don't interweave with crossing threads as with normal cloth, but are arranged in layers or "plies" of parallel threads. Each layer runs perpendicular to the next layer(s).

Some tires use thick thread, some use thin thread for the fabric. With thin thread, there are more threads per inch ("TPI") and this number is often considered an important indication of tire performance.

The higher the TPI number, the thinner and more flexible the tire fabric is. Thin-wall (high TPI) tires tend to be lighter and have lower rolling resistance, but they're more easily damaged by road hazards.

Bicycle tires have the threads of the fabric running diagonally, ("bias") from bead to bead. Modern car tires have the main threads running straight over from one bead to the other, known as "radial" construction. Radial tires will also have a "belt" of plies running all the way around the circumference of the tire, crossing the radial plies.

Radial tires have been tried for bicycles, but they tend to be too floppy from side to side. This floppiness feels quite unpleasant in actual riding--much like the feel of a grossly underinflated tire.

Some bicycle tires also have a Kevlar ® belt running under the tread area, in addition to the normal bias plies. This is intended as a puncture preventive.

Rubber

Once the fabric has been woven between the beads, and the tire has its basic shape, it is coated with rubber. The rubber is mainly there to protect the fabric from damage, and has no structural importance.

The rubber that comes into contact with the ground is called the "tread." This area usually has thicker rubber than the "sidewalls" of the tire, mainly for wear resistance. Most tires have some sort of 3-dimensional pattern molded into the tread, which may or may not enhance traction.

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Manufacturers mix different additives with the rubber to achieve desired traction/wear characteristics. Generally, a softer formulation will give better traction, but at the expense of more rapid wear. Rubber is normally a sort of tan color, but most tires are black. This is the result of adding carbon black to the mix. Carbon black considerably improves the durability and traction of the rubber in the tread area.

Some manufacturers substitute a silicon compound for the carbon black. These tires usually have a gray tread. Whether silicon or carbon black provides better traction is subject to dispute. Gray-tread tires are preferred for indoor use (for example, on wheelchairs), because they do not leave black marks on floors.

"Dual-compound" tires feature a center strip of fairly hard rubber for improved wear, with a softer, grippier formulation toward the sides of the tread. The intent is to provide better cornering traction without compromising the lifespan of the tread.

Many bicycle tires are "gumwalls" or "skinwalls." Gumwall tires have tan sidewalls, with no carbon black. This may make the sidewalls slightly more flexible, reducing rolling resistance. It is not clear to what extent this makes a difference.

Skinwalls have either no rubber on the sidewalls, or a very thin layer. This, too is an attempt to make the sidewall more flexible and reduce rolling resistance.

Tubular Tires

Tubular tires, also known as "sew-ups" or "sprints" differ from clinchers in that they don't have beads. Instead, the two edges of the tire are sewn together around the inner tube. Tubulars are used on special rims, and are held on to the rims by glue.

Tubulars used to be fairly common on high-performance bicycles, but these days they are an endangered species.

Tubular Pros:	Tubular Cons:
Tubulars are a bit lighter than comparable clinchers, due to the absence of the beads. The development of Kevlar® beads has considerably reduced this advantage. Tubular rims are lighter than clincher rims, since they don't need the flanges that hold the bead of the tire in place. Tubulars are less prone to pinch flats than clinchers, since the rims don't present the sharp edges of the clincher flanges. Many riders believe that tubulars provide a more comfortable ride and better traction than clinchers. If you get a flat on a tubular, you can install a spare tubular faster than you can change an inner tube in a clincher.	Tubulars are considerably more expensive than clinchers of comparable performance. Tubulars are very much harder to repair once punctured. Most people just throw them away. You need to carry a complete spare tubular in case you get a flat. This negates the weight advantage over clinchers, unless you have a team car following you with spare wheels. Improperly glued tubulars can roll off the rim. This almost always causes a serious crash.If you replace a tubular on the road, you cannot corner safely at high speeds until you go home and re-glue the tire. For safe high-speed cornering, the glue needs to dry for at least several hours. Tubulars have higher rolling resistance than the best clinchers. Tubulars are rarely as true and round as clinchers.

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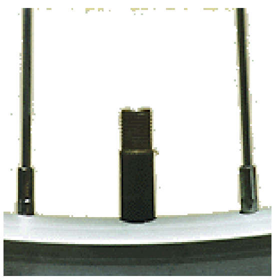
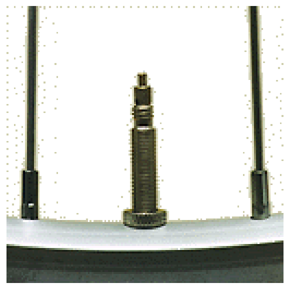
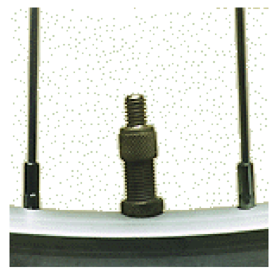
Inner Tubes

An inner tube is basically a doughnut-shaped balloon, with a valve for inflation. The only requirement for an inner tube is that it not leak. Being of rubber, it has no rigid structure. If an inner tube is inflated outside of a tire, it will expand to 2 or 3 times its nominal size, if it doesn't explode first. Without being surrounded by a tire, an inner tube can't withstand any significant air pressure.

Valve Types:		
		
Schrader valve	**Presta valve**	**Woods/Dunlop valve**

Butyl vs Latex

Before World War II, tires and tubes were made from natural latex rubber, harvested from tropical trees. When the supply of natural latex was insecure during the war, a substitute, "butyl" was invented. Butyl turned out to be a very successful substitute, better, in fact, than latex for this application. All modern tires and most inner tubes use butyl rubber.

Some riders prefer latex inner tubes, because they can be a bit lighter than butyl ones. Some riders believe that latex tubes have less rolling resistance than butyl.

Latex tubes are commonly a bit more porous than butyl ones, and need to have their pressure topped off more often.

How a Tire Supports its Load

It is commonly thought that the air pressure in a tire supports the rim. If you think about it, this cannot be true because the air pressure against the rim is equal, top and bottom. How, then, does a tire support its load?

First of all, the role of air pressure in the tire is to hold the fabric under tension -- in all abut one place, the contact patch with the road surface.

At the contact patch, the tread of the tire is flattened against the road. Air pressure can only push directly outward, and so here, it pushes directly downward. The downward force of the air must equal the weight load, and so the area of the contact patch equals the weight load, divided by the air pressure. For example, if the air pressure is 50 PSI, the contact patch will be two square inches.

The threads of the tire fabric can only transmit loads lengthwise and in tension. They bulge out to the sides. How then, is the load transferred from the contact patch to the rim?

The load is first transferred from the contact patch to the tire sidewalls by the shallower angle and lower tension of the threads either side of the contact patch -- they are pulling downward less and outward more. The load is similarly transferred from the sidewalls to the rim by the shallower angle and lower tension of the threads of the fabric where they meet the rim. As the threads pull downward less, they also pull outward more. The outward forces at the two sides are equal and opposite, and cancel out.

These effects produce the bulge seen at the bottom of a tire under load. Because the contact patch is flat aganst the road, the curvature of the sidewalls is increased -- the tire becomes effectively thinner, not counting the inactive width of the contact patch.

With a bias-ply tire, the load is carried lengthwise in both directions along the tire by the diagonal threads, so the bulge is longer and less deep than on a radial-ply tire. In the early days of radial-ply car tires, people often thought they were underinflated, because the bulge at the bottom was more pronounced.

A tire, then, supports its load by reduction of downward pull, very much the same way that spoking of the wheel supports its load. The tension-spoked wheel and the pneumatic tire are two examples of what are called preloaded tensile structures, brilliant, counterintuitive designs working together remarkably to support as much as 100 times their own weight.

Bias plies also help to transmit lateral and torque loads, by triangulating the connection between the contact patch and the rim -- much like the way the spokes of a semi-tangent spoked wheel transmit lateral and torque loads. With tubulars, the diagonal plies also work like a Chinese finger puzzle: the air pressure makes the tire fatter, and so makes it shorter and helps hold it to the rim.

If you would like to get into mathematical details, there is an excellent technical description in an old Britannica encyclopedia article online.

Traction

"Traction" refers to the tire's resistance to skidding/slipping. There are three areas where traction is at issue: braking, climbing, and cornering. Different tire designs, particularly in the tread, may enhance or degrade traction in each of these cases.

The traction of a tire is determined by three things: inflation pressure, rubber formulation, and tread pattern.

Traction is also influenced by the presence or absence of suspension, and by the rider's posture and technique

Tread Patterns

Tread for off-road use

Treads can help improve off-road traction in two ways:

The knobs of the tread can hook onto projections of hard, irregular surfaces, , reducing the tendency to slip.

On soft, squishy surfaces, the knobs poke into the surface, digging in for improved grip.

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In the late '80s, there was a revolution in tread design, started by the Specialized Ground Control. This tire, and many later MTB tires, had tall knobs at the side of the tread, with extra bracing to keep the knobs from being bent away from the centerline of the tire. These knobs greatly improved performance in sand and mud, because as a section of the tire rolls into contact with the ground, it flattens out. This flattening out causes the outer knobs to bend inward, so that they grab a loose surface like a pair of pliers.

Tread for on-road use

Bicycle tires for on-road use have no need of any sort of tread features; in fact, the best road tires are perfectly smooth, with no tread at all!

Unfortunately, most people assume that a smooth tire will be slippery, so this type of tire is difficult to sell to unsophisticated cyclists. Most tire makers cater to this by putting a very fine pattern on their tires, mainly for cosmetic and marketing reasons. If you examine a section of asphalt or concrete, you'll see that the texture of the road itself is much "knobbier" than the tread features of a good-quality road tire. Since the tire is flexible, even a slick tire deforms as it comes into contact with the pavement, acquiring the shape of the pavement texture, only while in contact with the road.

People ask, "But don't slick tires get slippery on wet roads, or worse yet, wet metal features such as expansion joints, paint stripes, or railroad tracks?" The answer is, yes, they do. So do tires with tread. All tires are slippery in these conditions. Tread features make no improvement in this.

Hydroplaning

Car and truck tires need tread, because these vehicles are prone to a very dangerous condition called "hydroplaning." This happens when driving fast in very wet conditions, which can lead to the tire riding up onto a cushion of liquid water. When this happens, there is a sudden and total lack of traction.

Cars can hydroplane because:	Bicycles canNOT hydroplane because:
A car tire has a square road contact, and the leading edge of the contact is a straight line. This makes it easier for a car tire to trap water as it rolls.	A bicycle tire has a curved road contact. Since a bicycle leans in corners, it needs a tire with a rounded contact area, which tends to push the water away to either side.
A car tire is quite wide, so water from the middle of the contact patch can have trouble escaping as the tire rolls over it, if there are not grooves to let it escape.	A bicycle tire is narrower, so not as much water is in contact with the leading edge at once.
Car tires run at much lower pressure than bicycle tires.	The high pressure of bicycle tires is more efficient at squeezing the water out from under.
Cars go much faster than bicycles, again leaving less time for water to escape.	At high speeds, hydroplaning is just possible for car tires, but is absolutely impossible for bicycle tires.

Even with automobiles, actual hydroplaning is very rare. It is a much more real problem for aircraft landing on wet runways. The aviation industry has studied this problem very carefully, and has come up with a general guideline as to when hydroplaning is a risk. The formula used in the aviation industry is:

Speed (in knots) = 9 X the square root of the tire pressure (in psi.)

Here's a table calculated from this formula:

Tire Pressure		Hydroplane Speed Miles per hour	Hydroplane Speed Kilometers per hour
P.S.I.	Bars		
120	8.3	113	183
100	6.9	104	167
80	5.5	93	149
60	4.1	80	129
40	2.8	66	105

Squirm

Knobby treads actually give worse traction on hard surfaces! This is because the knobs can bend under side loads, while a smooth tread cannot.

The bending of knobs can cause discontinuities in handling: the tire grips OK for mild cornering, but as cornering force exceeds some critical value, the knobs start to bend and the traction suddenly goes to Hell in a handbasket.

Combination Treads

Many tire makers market "combination-tread" tires, that are purported to work well on both pavement and dirt. Generally, they don't.

The usual design is to have a smooth ridge down the center of the tread, with knobs on the sides. The theory is that the ridge will provide a smooth ride on pavement, with the tire inflated fairly hard, and the knobs will come into play off-road, with the tire running at lower pressure (or sinking into a soft surface.) Another aspect of this design is that the knobs are intended to come into play as you lean into a turn.

In practice, combination-tread tires don't work all that well. They do OK in dirt, but they're pretty lousy on pavement. They're much heavier than street tires, and if you corner aggressively, the transition from the center strip to the knobs can cause sudden washout. They aren't quite as slow and buzzy as true dirt tires, but they're much worse in this respect than smoothies.

If you mostly ride on pavement, but also do a fair amount of dirt, a combination tire on the front may be a good choice for you, with a road tire on the back. See the section on mixing/matching tires.

Sizes

Traditionally, each major bicycle-producing country had its own system for measuring and designating tire and rim sizes. As the industry became more international, these national sizing systems have become a source of considerable confusion, especially since some tires with different numbers were actually interchangeable, while others with the same numbers were **not** interchangeable!

There is a relatively new, international system of tire sizing which eliminates these confusions. This is explained in considerable detail on this site in the article on **Tire Sizing.**

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Rolling Resistance

"Rolling resistance" is the mechanical friction generated as the tire rolls. As a segment of the tire tread rolls into contact with the road, it deforms from its normal curved shape into a flat shape against the road, then back to the curve as the tire rolls onward. The deformation of the rubber in this process is what causes the friction. A bias-ply tire has some additional friction because of the "Chinese finger puzzle" effect of the bias plies. The edges of the contact pact scrub against the road as a segment of the tread becomes shorter and wider where it flattens out, then longer and narrower as it becomes round again.
There are two ways to reduce this friction, each subject to trade-offs:

1. The thinner and softer the rubber/fabric of the tire is, the more flexible they become.

The trade-off with this is that the thinner the tire gets, the more fragile it is, and the sooner it will wear out.

2. The higher the air pressure, the less the tire will deflect.

The trade-off with this is that if you pump the tire up too hard, you lose the benefits of pneumatic tires: the ride becomes excessively harsh, and traction will be reduced. In addition, extremely high pressures require a stronger (heavier) fabric and stronger (heavier) rim flanges.

When riding on a smooth surface, rolling resistance does decrease theoretically with any increase in pressure, but with modern, high-quality tires the rolling resistance at correct inflation pressure is already so low that the infinitesimal reductions gained are more than outweighed by the trade-offs.

In practice, riding surfaces aren't perfectly smooth, and overinflation actually increases rolling resistance, due to vibration.

Width and Pressure

Tire width and pressure are inextricably linked. It is a serious mistake to consider one independently of the other. Generally, wider tires call for lower pressures, narrower tires call for higher pressures.

Consider, for example, a tire one inch across, at a pressure of 100 PSI (pounds per square inch). Air is pushing down against the bottom half of the tyre cross-section with a force of 100 pounds per inch of length. Each sidewall of the tire bears half that load, and so each inch of length of tire sidewall will be under a tension of 50 pounds. Now let's consider a tire twice as wide, two inches across, at the same 100 PSI. Each inch of sidewall will be under a tension of 100 pounds. So, a wider a tire would ride harder, and need stronger fabric, if inflated to the same pressure,

The part of the tire that is actually touching the ground at any moment is called the "contact patch." Generally, the area of the contact patch will be directly proportional to the weight load on the tire, and inversely proportional to the inflation pressure. For instance, if the rear tire of a bike is supporting a load of 100 lbs, and the tire is inflated to 100 PSI (pounds per square inch) the contact area of the tire will be roughly one square inch. If the pressure is reduced to 50 PSI, the tire will squish out until the contact patch has become 2 square inches (or until the rim bottoms out against the tire.)

A common debate among cyclists centers on the issue of whether a wider tire has more or less rolling resistance *at the same pressure*. The constant pressure is proposed because it appears more scientific to eliminate this as a variable, but this is not realistic in practice. The short answer to this question is that, yes, a wider tire of similar construction will have lower rolling resistance than a narrower one at the same pressure. This fact is, however, of no practical value. If you are comparing two tires of similar construction, with the same load, and the same pressure, **either the wider tire is overinflated, or the narrower tire is underinflated!**

Bicycle Tires and Tubes

A tire is **supposed** to deflect a bit under load. This deflection is the whole purpose of pneumatic tires. When you sit on your bike, your tires should visibly bulge out at least a bit under your weight. If they don't, they're overinflated.

Underinflation	Correct Inflation	Overinflation
An underinflated tire will have more rolling resistance. An underinflated tire will be prone to pinch flats. An underinflated tire will tend to wallow and may even come off the rim during cornering. This is a particular problem with wide tires on narrow rims.	A correctly inflated tire will have negligible rolling resistance. A correctly inflated tire will not get pinch flats in normal use. A correctly inflated tire will absorb minor surface irregularities, improving rider comfort. A correctly inflated tire will absorb surface irregularities without bouncing and losing traction.	An overinflated tire will have slightly less rolling resistance if the surface is very smooth.. An overinflated tire is more prone to damage from sharp rocks and similar road hazards. An overinflated tire will give a harsh ride on anything but the smoothest pavement. An overinflated tire can bounce on surface roughnesses. This can cause dangerous interruptions in traction, particularly if it happens during cornering.

Pressure Recommendations

Most tires have a "maximum" pressure, or a recommended pressure range marked on the side of the tire. These pressure ratings are established by the tire manufacturers after consultation with the legal and marketing departments.

The lawyers want the number kept conservatively low, in case the tire gets mounted on a defective or otherwise loose fitting rim. They commonly shoot for half of the real blow-off pressure.

The marketing department wants the number high, because many tire purchasers make the (unreliable) assumption that the higher the pressure rating, the better the quality of the tire.

Newbies often take these arbitrary ratings as if they had some scientific basis. While you'll rarely get in trouble with this rote approach, you will usually not be getting the best possible performance.

Savvy cyclists experiment with different pressures, and often even vary the pressure for different surface conditions.

Optimal pressure for any given tire will depend on the load it is being asked to support. Thus, a heavier rider needs a higher pressure than a lighter rider, for identical tires.

Since most bicycles have substantially more weight on the rear wheel than on the front, the rear tire should almost always be inflated to a higher pressure than the front, typically by about 10%.

Rough surfaces generally call for a reduction in pressure to improve ride comfort and traction, but there is a risk of pinch flats if you go too far. Even at the lower appropriate pressure, wider tires, because they also are deeper, are more immune to pinch flats.

Rider skill also enters into this: more experienced cyclists learn to "get light" for a fraction of a second while going over rough patches; newbies tend to sit harder on the saddle, increasing the risk of pinch flats.

The table below is based on my experience and a certain amount of guesswork, and should only be used as a **very rough guide to a starting point**. Interpolate/extrapolate for your own weight/tire sizes.

Tire widths are in millimeters, pressure recommendations in pounds per square inch. (Divide by 15 if your gauge reads in bars/atmospheres.)

	Tire width in mm						
Wheel load	**50 mm**	**37 mm**	**32 mm**	**28 mm**	**25 mm**	**23 mm**	**20 mm**
100 lbs/50 kg	**45**	**60**	**75**	**100**	**110**	**120**	**130**
70 lbs/35 kg	**35**	**50**	**65**	**80**	**90**	**100**	**110**

Note that these recommendations are based on the actual tire width. Many tires are marked wider than they actually are.

Dishonesty in Sizing

Competitive pressures have often led to inaccuracy in width measurement. Here's how it works: Suppose you are in the market for a high-performance 700 x 25 tire; you might reasonably investigate catalogues and advertisements to try to find the lightest 700-25 available. If the Pepsi Tire Company and the Coke Tire Company had tires of equal quality and technology, but the Pepsi 700-25 was actually a 700-24 marked as a 25, the Pepsi tire would be lighter than the accurately-marked Coke 700-25. This would put Pepsi at a competitive advantage. In self-defense, Coke would retaliate by marketing an even lighter 700-23 labeled as a 700-25.

This scenario prevailed throughout the '70's and '80's. The situation got so out-of-hand that cooler heads have prevailed, and there is a strong (but not universal) trend toward accurate width measurements.

Mixing/Matching Tires

Most bikes come with identical tires front and rear. This is all right for general use, but if you want to optimize your bike, you should consider using different tires front and rear. The front and rear tires have different loadings and different requirements.

Narrower Front, Wider Rear

If lightness is the primary goal, tire width/weight is limited by the risk of pinch cut flats, a.k.a. "snake bites." Since there is more weight carried on the rear tire, you can get away with a slightly narrower tire in front than you can in back.

Wider Front, Narrower Rear

A wider front tire makes sense in many applications, however, when handling and ride comfort are considered. A wider tire will generally provide better cornering traction than a narrower one, assuming appropriate inflation pressure.

A wider tire also provides superior shock absorbency. I personally prefer a slightly wider tire in front, since I suffer from some wrist discomfort on occasion.

Off-Road Issues

Bikes that are used some of the time on loose surfaces often benefit from a wider front tire, with a fairly aggressive tread, coupled with a somewhat narrower, smoother rear tire.

The wide, knobby front tire will provide the all-important front wheel traction. Front-wheel skidding almost always leads to a crash. For riding on soft surfaces, such as sand or mud, a wide front tire is essential. If the front tire sinks in and gets bogged down, you're stuck. If the front tire rolls through a soft patch OK, you can generally power the rear through to follow it.

The narrower, smoother rear tire will have lower rolling resistance. Since most of the weight is carried by the rear tire, rolling resistance is more important on the rear than the front. If the rear tire slips, in most cases the worst that will happen is that you'll have to get off and walk.

This is a great idea that developed out of BMX racing.

Some mountain-bike tires come in matched sets, with different tread front/rear. The front tires tend to have the knobs set up more or less parallel to the direction of travel, for improved lateral grip and better steering control. The rears tend to have transverse knobs for driving/braking traction.

Kevlar ®

Kevlar ® is used for two different, almost opposite reasons in bicycle tires. This results in considerable confusion as people try to buy "Kevlar ®" tires without understanding the difference.

Belts

> Some bicycle tires also have a Kevlar ® belt running under the tread area, in addition to the normal bias plies. This is intended as a puncture preventive. Such belts slightly increase weight and rolling resistance, but they probably have some value against certain road hazards, particularly broken glass.

Beads

> While most beads are steel, some tires use Kevlar ® cord instead. Using Kevlar ® for this purpose typically saves about 50 grams (2 ounces) per tire. Since Kevlar ® is much more flexible than steel, tires with Kevlar ® beads can be folded up compactly, which is convenient for touring or other applications where it may be advisable to carry a spare tire.

Tire Wear-When should you replace your tires?

Many cyclists waste money replacing perfectly functional tires simply because they're old, or may have discolored sidewalls. If you just want new tires because the old ones look grotty, it's your money, but if you are mainly concerned with safety/function, there are only two reasons for replacing old tires:

1. When the tread is worn so thin that you start getting a lot of flats from small pieces of glass and the like, or the fabric shows through the rubber.
2. When the tire's fabric has been damaged, so that the tire has a lumpy, irregular appearance somewhere, or the tube bulges through the tire.

Cracks in the tread are harmless. Small punctures in the tire such as are typically caused by nails, tacks, thorns or glass slivers are also harmless to the tire, since the tire doesn't need to be air-tight.

Gumwall tires sometimes get unsightly blistering on the sidewalls from ozone damage. (This is frequently caused by storing the bike near a furnace--the powerful electric motors in typical furnaces can put a fair amount of ozone into the air.) This blistering is ugly, but doesn't actually compromise the safety/reliability of the tire in the least.

Label placement

Most good bicycle mechanics pay attention to the orientation of labels. The most usual custom for tires is to locate the label right at the valve, facing to the right. Some justify this on the grounds that having a standard tire mounting orientation can make it easier to find a thorn or glass sliver in a tire, once the hole has been located in the (removed) tube. While there's an element of truth to this, placing the label consistently is really more about pride of workmanship and attention to detail.

Tread Directionality

Some tires have an asymmetrical tread, for instance "V" shaped tread blocks that could be oriented with the point of the "V" facing forward > or backward <. The question then arises, which way should they face?

Road Applications

With tires for road use, it really doesn't matter, since tire tread patterns serve no function on hard surfaces.

Tires with "V" patterns are common for motorcycles, and are generally installed so that the point of the "V" hits the road first. This is to help "squirt" the water out ahead of and to the side of the tire contact patch, as a protection against hydroplaning . Since hydroplaning is impossible on a bicycle, there's no need to observe this custom.

Off-road Applications

For off-road use in soft surfaces, there may be some merit in paying attention to the tread orientation, though this is far from certain.

Ideally, you would like the front tire to offer maximum traction in the braking direction, while the rear tire would normally be oriented to produce maximum traction for drive forces. Thus, if a particular tread pattern is perceived to have better traction in one direction than the other, it should be facing one way if used on the front wheel, and the opposite way if used on the rear wheel.