

Wheels & Tyres



Are you confused by your car's tyres? Don't know your rolling radius from your radial? Then take a good long look through this page where I hope to be able to shift some of the mystery from it all for you. At the very least, you'll be able to sound like you know what you're talking about the next time you go to get some new tyres.

Decoding all that information on the sidewall

All numbers, letters, symbols, mysterious codes. Actually, most of that information is surplus to what you need to know. So here's the important stuff:

Key	Description
A	Manufacturers or brand name, and commercial name or identity.
B	Tyre size, construction and speed rating designations. <i>Tubeless</i> designates a tyre which requires no inner tube. See tyre sizes and speed ratings below. DIN-type marking also has the load index encoded in it. These go from a load index of 50 (190kg) up to an index of 169 (5800kg).
C	Denotes type of tyre construction.
D	M&S denotes a tyre designed for mud and snow. <i>Reinforced</i> marking only where applicable.
E	Pressure marking requirement.
F	ECE (not EEC) type approval mark and number.
G	North American Dept of Transport compliance symbols and identification numbers.
H	Country of manufacture.

Also on the sidewall, you might find the following info embossed in the rubber. The temperature rating - an indicator of how well the tire withstands heat buildup. "A" is the highest rating; "C" is the lowest.

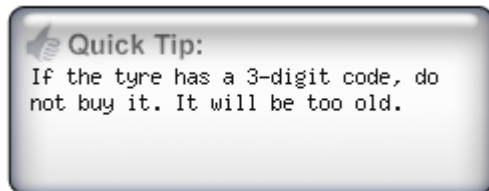
The traction rating - an indicator of how well the tire is capable of stopping on wet pavement. "A" is the highest rating; "C" is the lowest.

The tread-wear rating - a comparative rating for the useful life of the tire's tread. A tire with a tread-wear rating of 200, for example, could be expected to last twice as long as one with a rating of 100. Tread-wear grades typically range between 60 and 600 in 20-point increments. It is important to consider that this is a relative indicator, and the actual life of a tire's tread will be affected by quality of road surfaces, type of driving, correct tire inflation, proper wheel alignment and other variable factors. In other words, don't think that a tread-wear rating of 100 means a 30,000 mile tire.

Encoded in the US DOT information (G on the diagram above) is a two-letter code that identifies where the tyre was manufactured in detail. In other words, what factory and in some cases, what city it was manufactured in. It's the first two letters after the 'DOT' - in this case "FA" denoting Yokohama.

This two-letter identifier is worth knowing in case you see a tyre recall on the evening news where they tell you a certain factory is recalling tyres. Armed with the two-letter identifier list, you can figure out if you are affected. It's a nauseatingly long list, and I've not put it on this page. But if you [click here](#) it will popup a separate window with just those codes in it.

DOT Codes and the 6-year shelf life



As part of the DOT code (G above), there is a tyre manufacture date stamped on the sidewall. Take a look at yours - there will be a three- or four-digit code. This code denotes when the tyre was manufactured, and as a rule-of-thumb, you should never use tyres more than 6 years old. The rubber in tyres degrades over time, irrespective of whether the tyre is being used or not. When you get a tyre change, if you can, see if the tyre place will allow you to inspect the new tyres first. It's not uncommon for these shops to have stuff in stock which is more than 6 years old. The tyre might look brand new, but it will delaminate or have some other failure within weeks of being put on a vehicle.

Reading the code. The code is pretty simple. The three-digit code was used for tyres manufactured before 2000. So for example **1 7 8** means it was manufactured in the **17**th week of **8**th year of the decade. In this case it means 19**88**. For tyres manufactured in the 90's, the same code holds true but there is a little triangle after the DOT code. So for this example, a tyre manufactured in the 17th week of 19**98** would have the code 178△

After 2000, the code was switched to a 4-digit code. Same rules apply, so for example **3 0 0 3** means the tyre was manufactured in the **30**th week of 20**03**.

DOT Age Code Calculator

The calculation built in to this page is up-to-date based on today's date. If the DOT age code on your tyres is older than this code, change your tyres.

DOT AGE CODE: 03 01

Interesting note: in June 2005, Ford and GM admitted that tyres older than 6 years posed a hazard and from their 2006 model year onwards, started printing warnings to this effect in their drivers handbooks for all their vehicles.

The E-Mark

E (11) 01254

Item F in the diagram above is the E-mark. All tyres sold in Europe after July 1997 must carry an E-mark. The mark itself is either an upper or lower case "E" followed by a number in a circle or rectangle, followed by a further number.

An "E" (upper case) indicates that the tyre is certified to comply with the dimensional, performance and marking requirements of ECE regulation 30.

An "e" (lower case) indicates that the tyre is certified to comply with the dimensional, performance and marking requirements of Directive 92/33/EEC.

The number in the circle or rectangle denotes the country code of the government that granted the type approval. 11 is the UK. The last number outside the circle or rectangle is the number of the type approval certificate issued for that particular tyre size and type.

A Word on "guaranteed" tyres

It's not unusual to see 60,000 mile guarantees on tyres. It amazed me that anyone would be foolish enough to put a guarantee on a consumable product given that the life of the tyre is entirely dependent on the suspension geometry of the car it is being used on, the style of driving, the types of road, and the weather. Yet many manufacturers and dealers offer an unconditional* guarantee. There's the catch though. The '*' after the word "unconditional" takes you elsewhere on their information flyer, to the conditions attached to the unconditional guarantee. If you want to claim on that guarantee, typically you'll have to prove the tyres were inflated to the correct pressure all the time, prove they were rotated every 3000 miles, prove the suspension geometry of your car has always been 100%, prove you never drove over 80mph, prove you never left them parked in the baking hot sun or freezing cold ice, and prove you never drove on the freeways. Wording in the guarantee will be similar to:

"used in normal service on the vehicle on which they were originally fitted and in accordance with the maintenance recommendations and safety warnings contained in the attached owner's manual"

and

"The tyres have been rotated and inspected by a participating (tyre brand) tyre retailer every 7,500 miles, and the attached Mounting and Rotation Service Record has been fully completed and signed"

There will typically also be a long list of what isn't covered. For example:

Road hazard injury (e.g., a cut, snag, bruise, impact damage, or puncture), incorrect mounting of the tire, tire/wheel imbalance, or improper repair, misapplication, improper maintenance, racing, underinflation, overinflation or other abuse, uneven or rapid wear which is caused by mechanical irregularity in the vehicle such as wheel misalignment, accident, fire, chemical corrosion, tire alteration, or vandalism, ozone or exposure to weather.

Given that you really can't prove any of this, the guarantee is, therefore, worthless because it is left wide open to interpretation by the dealer and/or manufacturer. For a good example, check out the Michelin warranty or guarantee, [available on their website \(PDF file\)](#).

Don't be taken in by this - it's a sales ploy and nothing more. Nobody - not even the manufacturers - can guarantee that their tyre won't de-laminate or catch a puncture the moment you leave the tyre shop. Buy your tyres based on reviews, recommendations, previous experience and the recommendation of friends. Do not buy one simply because of the guarantee.

Tyre sizes and what they mean.

Okay, so you look at your car and discover that it is shod with a nice, but worn set of 185-65HR13's. Any tyre mechanic will tell you that he can replace them, and he will. You'll cough up and drive away safe in the knowledge that he's just put some more rubber on each corner of the car that has the same shamanic symbols on it as those he took off. So what does it all mean?

185	65	H	R	13
This is the width in mm of the tyre from sidewall to sidewall when it's unstressed and you're looking at it head on (or top-down). This is known as the <u>section width</u> .	This is the ratio of the height of the tyre sidewall, (<u>section height</u>), expressed as a percentage of the width. It is known as the <u>aspect ratio</u> . In this case, 65% of 185mm is 120.25mm - the section height.	This is the <u>speed rating</u> of the tyre.	This tells you that the tyre is a radial construction. Check out <u>tyre construction</u> if you want to know what that means.	This is the diameter in <i>inches</i> of the rim of the wheel that the tyre has been designed to fit on. Don't ask me why tyre sizes mix imperial and metric measurements. They just do.

More recently, there has been a move (especially in Europe) to adjust tyre designations to conform to DIN (Deutsche Industrie Normal). This means a slight change in the way the information is presented to the following:

185	65	R	13	91	V
Section width	<u>Aspect ratio</u>	Radial	Rim diameter	load rating	<u>speed rating</u> .

Classic / vintage / imperial crossply tyre sizes.

What ho. Fabulous morning for a ride in the Bentley. Problem is your 1955 Bentley is running on 7.6x15 tyres. What, you ask, is 7.6x15? Well it's for older vehicles with imperial measurements and crossply tyres. Both measurements are in inches - in this case a 7.6inch tyre designed to fit a 15inch wheel. There is one piece of information missing though - aspect ratio. Aspect ratios only began to be reduced at the end of the 1960s to improve cornering. Previously no aspect ratio was given on radial or crossply tyres. For crossply tyres, the initial number is both the tread width and the sidewall height. So in my example, 7.6x15 denotes a tyre 7.6 inches across with a sidewall height which is also 7.6 inches. After conversion to the newer notation, this is the equivalent to a 195/100 15. If you're plugging numbers into the tyre size calculator lower down this page, I've included an aspect ratio value of 100 for imperial calculations.

Note: I put 195/100 15 instead of 195/100R15 because technically the "R" means radial. If you're trying to get replacement crossply tyres, the "R" won't be in the specification. *However* if you're trying to replace your old crossply tyres with metric radial bias tyres, then the size *does* have the "R" in it. Bottom of Form

Classic / vintage radial tyre sizes.

Remember above that I said aspect ratios only started to come into play in the 1960s? Unlike the 100% aspect ratio for crossply tyres, for radial tyres, it's slightly different - here an aspect ratio of 80% is assumed. So for example, if you come across an older tyre with 185R16 stamped on it, this describes a tyre with a tread width of 185mm and a sidewall height which is assumed to be 80% of that; 148mm.

I've had varying figures from 80% up to 85% and everyone claims they're right. Well one reader took it to heart and did some in-depth research. It seems there is actually no fixed standard for aspect ratio when it is not expressly stated in the tyre size.

Different manufacturers use slightly different figures.

The English MOT (road-worthiness test) manual states: *Unless marked otherwise, "standard" car tyres have a nominal aspect ratio of 82%. Some tyres have an aspect ratio of 80%. These have "/80" included in their size marking e.g. 165/80 R13. Note: Tyres with aspect ratios of 80% and 82% are almost identical in size and can be safely mixed in any configuration on a vehicle.*

See http://www.motuk.co.uk/manual_410.htm for the online version.

If you're plugging vintage radial numbers into the tyre size calculator, I've included aspect ratios of 80 and 82 for these calculations.

Land Rovers and other off-road tyre sizes.



On older Land Rovers (on the LWB/110 vehicles and many "off-roaders"), you'll often find tyres with a size like 750x16. This is another weird notation which defies logic. In this case, the 750 refers to a decimalised notation of an inch measurement. 750 = 7.50 inches, referring to the "normal inflated width" of the tyre - i.e. the external maximum width of the inflated, unladen tyre. (This is helpfully also not necessarily the width of the tread itself). The 16 still means 16 inch rims. The next question if you came to this page looking for info on Land Rover tyres will be "What size tyre is that the equivalent of in modern notation?". Simple. It has no aspect ratio and the original tyres would likely be cross-ply, so from what you've learned a couple of paragraphs above, assume 100% aspect ratio. Convert 7.5 inches to be 190mm. That gives you a 190/100 R16 tyre. (You could use the calculator in the section on *Classic / vintage / imperial crossply tyre sizes* above to get the same result.)

Generally speaking, the Land Rover folks reckon a 265/65R16 is a good replacement for the "750", although the tread is slightly wider and might give some fouling problems on full lock. It's also 5% smaller in rolling radius so your speed will over-read by about 4mph at 70mph. If you can't fit those, then the other size that is recommended by Landrover anoraks is 235/86R16.

On Discoveries, Range Rovers, or the SWB Defenders/Series land rovers you'll find "205" tyres, denoting 205mm x 16 inches. The 205 type tyres can generally be replaced with 235/70R16 or 225/75R16. The 235 is a wider tyre and the general

consensus in Land Rover circles is that it holds the road better when being pushed. If you're really into this stuff, you ought to read Tom Sheppard's *Off Roader Driving* (ISBN 0953232425). It's a Land Rover publication first published in 1993 as "The Land Rover Experience". It's been steadily revised and you can now get the current edition from Amazon.

Speed ratings.

All tyres are rated with a speed letter. This indicates the maximum speed that the tyre can sustain for a ten minute endurance without coming to pieces and destroying itself, your car, the car next to you and anyone else within a suitable radius at the time.

Max Car Speed Capability			Max Car Speed Capability		
Speed Symbol	Km/h	MPH	Speed Symbol	Km/h	MPH
L	120	75	S	180	113
M	130	81	T	190	118
N	140	87	U	200	125
P	150	95	H	210	130
Q	160	100	V	240	150
R	170	105	W	270	168
			Z	240+	150+

'H' rated tyres are becoming the most commonplace and widely used tyres, replacing 'S' and 'T' ratings. Percentage-wise, the current split is something like this: S/T=67%, H=23%, V=8%. Certain performance cars come with 'V' or 'Z' rated tyres as standard. This is good because it matches the performance capability of the car, but bad because you need to re-mortgage your house to buy a new set of tyres.

Load indices.

The load index on a tyre is a numerical code associated with the maximum load the tyre can carry. These are generally valid for speed under 210km/h (130mph). Once you get above these speeds, the load-carrying capacity of tyres decreases and you're in highly technical territory the likes of which I'm not going into on this page. The table below gives you most of the Load Index (LI) values you're likely to come across. For the sake of simplicity, if you know your car weighs 2 tons - 2000kg - then assume an even weight on each wheel. 4 wheels at 2000kg = 500kg per wheel. This is a load rating of 84. The engineer in you should add 10% or more for safety's sake. For this example, I'd probably add 20% for a weight capacity of 600kg - a load rating of 90. Generally speaking, the average car tyre is going to have a much higher load rating than you'd ever need. It's better to have something that will fail at speeds and stress levels you physically can't achieve, than have something that will fail if you nudge over 60mph with a six pack in the trunk.

LI kg	LI kg	LI kg	LI kg	LI kg	LI kg
50 190	70 335	90 600	110 1060	130 1900	150 3350
51 195	71 345	91 615	111 1090	131 1950	151 3450
52 200	72 355	92 630	112 1120	132 2000	152 3550
53 206	73 365	93 650	113 1150	133 2060	153 3650
54 212	74 375	94 670	114 1180	134 2120	154 3750

55 218	75 387	95 690	115 1215	135 2180	155 3875
56 224	76 400	96 710	116 1250	136 2240	156 4000
57 230	77 412	97 730	117 1285	137 2300	157 4125
58 236	78 425	98 750	118 1320	138 2360	158 4250
59 243	79 437	99 775	119 1360	139 2430	159 4375
60 250	80 450	100 800	120 1400	140 2500	160 4500
61 257	81 462	101 825	121 1450	141 2575	161 4625
62 265	82 475	102 850	122 1500	142 2650	162 4750
63 272	83 487	103 875	123 1550	143 2725	163 4875
64 280	84 500	104 900	124 1600	144 2800	164 5000
65 290	85 515	105 925	125 1650	145 2900	165 5150
66 300	86 530	106 950	126 1700	146 3000	166 5300
67 307	87 545	107 975	127 1750	147 3075	167 5450
68 315	88 560	108 1000	128 1800	148 3150	168 5600
69 325	89 580	109 1030	129 1850	149 3250	169 5800

Tyre types for passenger cars.



There are several different types of tyre that you, the humble consumer, can buy for your car. What you choose depends on how you use your car, where you live, how you like the ride of your car and a variety of other factors. The different classifications are as follows, and some representative examples are shown in the image on the right.

Performance tyres or summer tyres

Performance tyres are designed for faster cars or for people who prefer to drive harder than the average consumer. They typically put performance and grip ahead of longevity by using a softer rubber compound. Tread block design is normally biased towards outright grip rather than the ability to pump water out of the way on a wet road. The extreme example of performance tyres are "slicks" used in motor racing, so-called because they have no tread at all.

All-round or all-season tyres

These tyres are what you'll typically find on every production car that comes out of a factory. They're designed to be a compromise between grip, performance, longevity, noise and wet-weather safety. For increased tyre life, they are made with a harder rubber compound, which sacrifices outright grip and cornering performance. For 90% of the world's drivers, this isn't an issue. The tread block design is normally a compromise between quiet running and water dispersion - the tyre should not be too noisy in normal use but should work fairly well in downpours and on wet roads. All-season tyres are neither excellent dry-weather, nor excellent wet-weather tyres, but are, at best, a compromise.

Wet-weather tyres

Rather than use an even harder rubber compound than all-season tyres, wet weather tyres actually use a softer compound than performance tyres. The rubber needs to heat up quicker in cold or wet conditions and needs to have as much mechanical grip as possible. They'll normally also have a lot more siping to try to disperse water from the contact patch. Aquachannel tyres are a subset of winter or wet-weather tyres and I have a little section on them further down the page.

Snow & mud or ice: special winter tyres

Winter tyres come at the other end of the spectrum to performance tyres, obviously. They're designed to work well in wintry conditions with snow and ice on the roads. Winter tyres typically have larger, and thus noisier tread block patterns. In extreme climates, true snow tyres have tiny metal studs fabricated into the tread for biting into the snow and ice. The downside of this is that they are incredibly noisy on dry roads and wear out both the tyre and the road surface extremely quickly if driven in the dry. Mud & snow tyres typically either have 'M&S' stamped on the tyre sidewall. Snow & Ice tyres have a snowflake symbol.

All-terrain tyres

All-terrain tyres are typically used on SUVs and light trucks. They are larger tyres with stiffer sidewalls and bigger tread block patterns. The larger tread block means the tyres are very noisy on normal roads but grip loose sand and dirt very well when you take the car or truck off-road. As well as the noise, the larger tread block pattern means less tyre surface in contact with the road. The rubber compound used in these tyres is normally middle-of-the-road - neither soft nor hard.

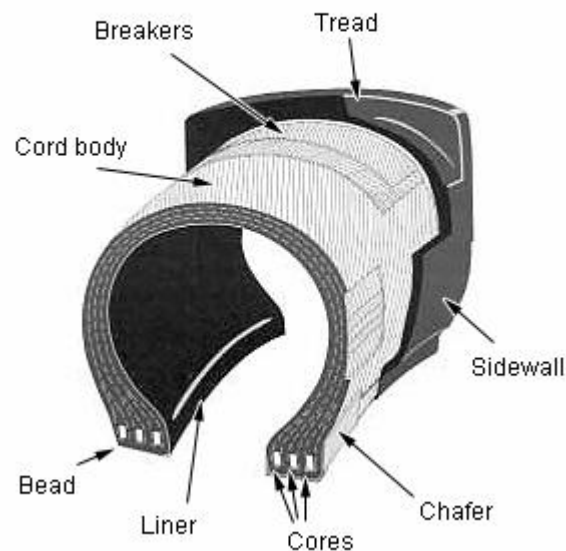
Mud tyres

At the extreme end of the all-terrain tyre classification are mud tyres. These have massive, super-chunky tread blocks and really shouldn't ever be driven anywhere other than loose mud and dirt. The tread sometimes doesn't even come in blocks any more but looks more like paddles built in to the tyre carcass.

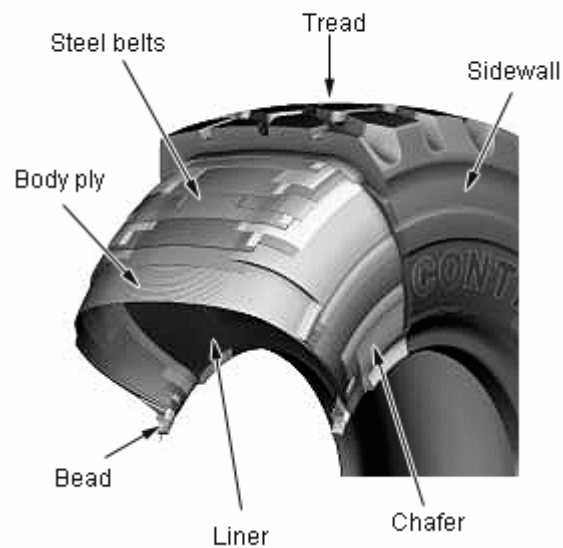
Tyre constructions.

Simply put, if you bought a car in the last 20 years or so, you should be riding on radial tyres. If you're not, then it's a small miracle you're still alive to be reading this. Radial tyres wear much better and have a far greater rigidity for when cars are cornering and the tyres are deforming.

Bias / cross-ply Construction.



Radial Construction.



Cross-ply components

The **tread** consists of specially compounded/vulcanised rubber which can have unique characteristics ranging from wear resistance, cut resistance, heat resistance, low rolling resistance, or any combination of these. The purpose of the tread is to transmit the forces between the rest of the tyre and the ground.

The **sidewall** is a protective rubber coating on the outer sides of the tyre. It is designed to resist cutting, scuffing, weather checking, and cracking.

The **chafer** protects the bead and body from chafing (wear from rubbing) where the tyre is in contact with the rim.

The **liner** is an integral part of all tubeless pneumatic tires. It covers the inside of the tire from bead to bead and prevents the air from escaping through the tire.

The **bead** of a cross-ply tyre consists of bundles of bronze coated high tensile strength steel wire strands which are insulated with rubber. A cross-ply tyre designed for off-road use typically has two or three bundles. A radial on-road tyre normally only has one. The bead is considered the foundation of the tire. It anchors the bead on the rim.

The **cord body** is also known as the tyre carcass. It consists of layers of nylon plies. The cord body confines the pressure, which supports the tyre load and absorbs shocks encountered during driving. Each cord in each ply is completely surrounded by resilient rubber. These cords run diagonally to the direction of motion and transmit the forces from the tread down to the bead.

The **breakers** are also known as belts. They provide protection for the cord body from cutting. They also increase tread stability which resists cutting. Breakers can be made of nylon, aralon, or steel wire.

Radial components

The **chafer** of a radial tire acts as a reinforcement. It increases the overall stiffness of the bead area, which in turn restricts deflection and deformation and increases the durability of the bead area. It also assists the bead in transforming the torque forces from the rim to the radial ply.

The **body ply** of a radial tire is made up of a single layer of steel cord wire. The wire runs from bead to bead laterally to the direction of motion (hence the term "radial plies"). The body ply is a primary component restricting the pressure which ultimately carries the load. The body ply also transmits the forces (torque, torsion, etc.) from the belts to the bead and eventually to the rim.

The **belts** are layers of steel cord wires located between the tread and the body ply. Off-road tyres can have up to five belts. Road tyres typically have one or two. The steel wire of the belts run diagonally to the direction of motion. The belts increase the rigidity of the tread which increases the cut resistance of the tire. They also transmit the torque forces to the radial ply and restrict tire growth which prevents cutting, cut growth and cracking.

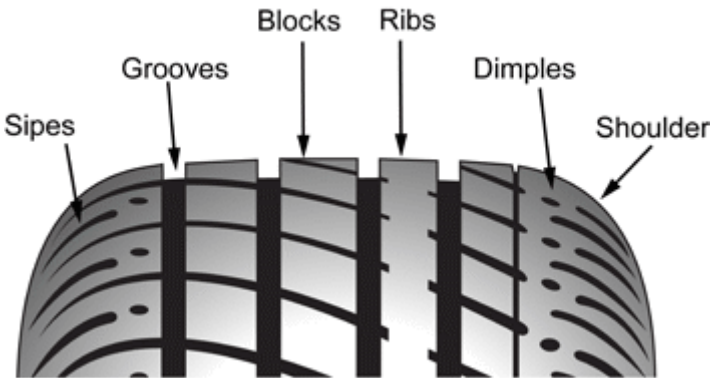
Comparison of Radial vs. Cross-ply performance

This little table gives you some idea of the advantages and disadvantages of the two types of tyre construction. You can see the primary reasons why radial tyres are almost used on almost all the world's passenger vehicles now, including their resistance to tearing and cutting in the tread, as well as the better overall performance and fuel economy.

	Cross-ply	Radial
Vehicle Steadiness	✓	✗
Cut Resistance - Tread	✗	✓
Cut Resistance - Sidewall	✓	✗
Repairability	✓	✗
Self Cleaning	✓	✗
Traction	✗	✓
Heat Resistance	✗	✓
Wear Resistance	✗	✓
Flotation	✗	✓
Fuel Economy	✗	✓

A subset of tyre construction: tyre tread.

You thought tread was the shape of the rubber blocks around the outside of your tyre didn't you? Well it is, but it's also so much more. The proper choice of tread design for a specific application can mean the difference between a comfortable, quiet ride, and a piss poor excuse for a tyre that leaves you feeling exhausted whenever you get out of your car. A proper tread design improves traction, improves handling and increases Durability. It also has a direct effect on ride comfort, noise level and fuel efficiency. Believe it or not, each part of the tread of your tyre has a different name, and a different function and effect on the overall tyre. Your tyres might not have all these features, but here's a rundown of what they look like, what they're called and why the tyre manufacturers spend millions each year fiddling with all this stuff.



Sipes are the small, slit-like grooves in the tread blocks that allow the blocks to flex. This added flexibility increases traction by creating an additional biting edge. Sipes are especially helpful on ice, light snow and loose dirt.

Grooves create voids for better water channeling on wet road surfaces (like the Aquachannel tyres below). Grooves are the most efficient way of channeling water from in front of the tyres to behind it. By designing grooves circumferentially, water has less distance to be channeled.

Blocks are the segments that make up the majority of a tyre's tread. Their primary function is to provide traction.

Ribs are the straight-lined row of blocks that create a circumferential contact "band."

Dimples are the indentations in the tread, normally towards the outer edge of the tyre. They improve cooling.

Shoulders provide continuous contact with the road while maneuvering. The shoulders wrap slightly over the inner and outer sidewall of a tyre.

The Void Ratio is the amount of open space in the tread. A low void ratio means a tyre has more rubber in contact with the road. A high void ratio increases the ability to drain water. Sports, dry-weather and high performance tyres have a low void ratio for grip and traction. Wet-weather and snow tyres have high void ratios.

Tread patterns

There are hundreds if not thousands of tyre tread patterns available. The actual pattern itself is a mix of functionality and aesthetics. Companies like [Yokohama](#) specialise in high performance tyres with good-looking tread patterns. Believe it or not, the look of the pattern is very important. People want to be safe with their new tyres, but there's a vanity element to them too. For example, in the following comparison, which would you prefer to have on your car?



The thought process you're going through whilst looking at those two tyres is an example of the sort of thing the tyre manufacturers are interested in. Sometimes they have focus groups and public show-and-tells for new designs to gauge public reaction. For example, given the choice, I'd prefer the tread pattern on the right. The challenge for the manufacturers is to make functionally safe tyres without making them look like a random assortment of rubber that's just been glued to a wheel in a random fashion. In amongst all this, there are three basic types of tread pattern that the manufacturers can choose to go with:

Symmetrical: consistent across the tyre's face. Both halves of the treadface are the same design.

Asymmetrical: the tread pattern changes across the face of the tyre. These designs normally incorporate larger tread blocks on the outer portion for increased stability during cornering. The smaller inner blocks and greater use of grooves help to disperse water and heat. Asymmetrical tyres *tend* to also be unidirectional tyres.

Unidirectional: designed to rotate in only one direction, these tyres enhance straight-line acceleration by reducing rolling resistance. They also provide shorter stopping distance. Unidirectional tyres must be dedicated to a specific side of the vehicle, so the information on the sidewall will always include a rotational direction arrow. Make sure the tyres rotate in this direction or you'll get into all sorts of trouble.



Tread depth and tread wear indicators



For the most part, motoring law in most countries determines that your tyres need a minimum tread depth to be legal. This varies from country to country but is normally around 1.6mm. To assist you in figuring out when you're getting close to that value, most tyres have tread wear indicators built into them. If you look around the tread carefully, at some point you'll see a bar of rubber which goes across the tread and isn't part of the regular pattern (see the picture here for an example). This is the wear indicator. It's really basic, but it's also pretty foolproof. The tread wear indicator is moulded into the rubber at a depth of about 2mm normally. As the rubber in your tyres wears away due to everyday use, the tread wears down. At some point, the tyre tread will become flush with the wear indicator (which is normally recessed into the tread). At this point you have about 2mm of tread left - in other words it is time to change tyres.

Minimum legal tread depth does not mean "safe".

Actually it's wise to change your tyres before you get to the wear indicator, as by this point, the effectiveness of the tyre in the wet is pretty limited, and its grip in the dry won't be as sharp as it was when new. In 2006, Auto Express magazine in the UK did some pretty rigorous testing on "legal" tyres. They are campaigning to have the legal minimum in England increased from 1.6mm up to 3mm. Their reasons are backed up by testing : at 1.6mm, despite still being perfectly legal, the stopping distance is increased by 40% in the wet over tyres that have 3mm of tread left. They performed the test using the same car, under the same conditions with the same driver. The only thing that changed was the tyres. The *Fifth Gear* TV program performed a graphic demonstration of the problem by equipping two cars with different tyres. The lead car had 3mm of tread left, the trailing car had 1.6mm. The cars were driven at 50mph at a distance of 3 car lengths apart - not safe, but

representative of the real-world. When the lead driver performed an emergency stop, the trailing driver reacted nearly instantly, but despite years of training and an ABS-equipped car, he slammed into the lead vehicle still doing 35mph. This was the result:



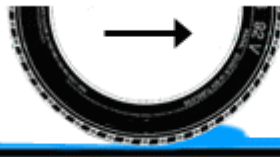
Despite knowledge like this, there are always going to be people who ignore their tyres and at the point where the tread is gone completely, they are within a couple of hundred miles of driving on the metal over-banding in the tyre carcass itself. There's really no excuse for not changing your tyres when the tread gets low. Sure, when you go to get them done, the price will seem steep - it always does with tyres. But it will seem like a wise investment next time you find yourself pirouetting across three lanes of wet motorway traffic towards the crash barrier. Which leads us nicely on to the subject of:

Aquaplaning / hydroplaning.

By this point you probably understand that one of the functions of your car's tyres is to pump water out of the tread on wet road surfaces. As the tyre spins, the tread blocks force water into the sipes and grooves and those channel water out and away from the contact patch where the tyre meets the road. As your tread wears down, the depth of the grooves and sipes gets less, which in turn reduces the tyre's ability to remove water. At some point, the tread will get down to a point where all but the lightest of showers will turn any road into a skating rink for you. This is called aquaplaning and how it happens is really simple: as you drive in the wet, your tyres form a natural but slight bow wave on the road surface. Some of the water escapes around the side of the tyre as spray whilst the rest goes under the tyre. The tyre tread pumps the water out to the sides and the contact patch remains in good contact with the road. As the amount of water becomes more or deeper (heavier rain, or travelling faster for example), you end up with the tyre riding on a cushion of water as the volume of water in the 'bow wave' overcomes the tyre's ability to disperse it. At this point, it doesn't matter what you do - braking, accelerating and steering have no effect because the tyre is actually making no contact with the road surface any more. In fact, the worst thing you can do is to brake, because stopping the rotation of the wheels removes any last chance the tyres have at removing the water. If you let off the accelerator instead, as wind resistance and other factors begin to slow you down, at some point you'll go back through the critical depth of water and the tyres will begin to grip again.



Under good conditions, with adequate tread, light water buildup and good road drainage, the tyre tread is able to disperse the water from the road surface so that the tyre's contact patch remains in good contact with the road.



As conditions worsen - less drainage, higher speed or more rain, the amount of water on the road surface increases. The tread is only able to disperse so much water, and begins to become inundated.



At this point, the tread is overwhelmed with water and is no longer effective. Water is incompressible so the tyre is lifted off the road and skates across the surface of the water.

Aquaplaning doesn't just happen because of dodgy tyre tread depth. You can get into just as much trouble with brand new tyres if you go careening through a deep puddle. The new tyres may have their full complement of tread depth with nice deep grooves and sipes, but the depth of the water in the puddle might be so much that the volume of water can't be removed quickly enough. Every tyre has a finite limit to the amount of water it can pump out of the way. Exceed that limit and you're aquaplaning.

Road surface design

It's worth spending a moment whilst we're on the subject of aquaplaning to talk about road surface design. I know your morning commute along pot-holed roads full of cracks might lead you to believe otherwise, but for the most part, roads, especially motorways, are designed to lessen the risk of aquaplaning in the first place. Most roads are built with a slope to one side or the other, or are crowned in the middle (ie. the road surface is higher in the middle than at the sides). The idea being that any water buildup is encouraged to run off the road surface to drainage ditches at the sides. Some newer designs of asphalt are more porous than the old stuff, and when laid on top of a subsurface drainage system, will allow a certain amount of water to run down through the road surface as well as off to the sides.

Slip sliding in a summer downpour.

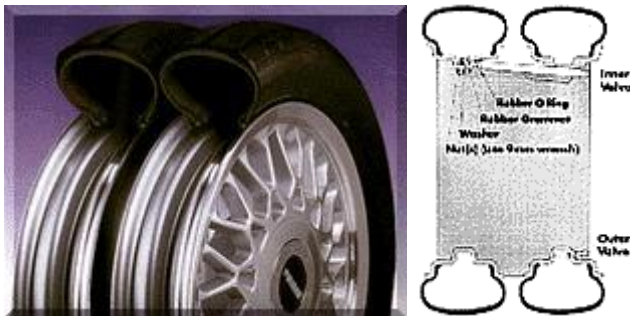
If you've driven for any length of time and ever been caught in a downpour on a hot summer day, you'll have seen how a super-glue sticky surface can turn into a teflon ice rink at the drop of a hat. This unusual phenomenon occurs because of the way most road surfaces are manufactured and put down. There's a lot of oil and tar involved in laying asphalt and over the course of its lifetime, a road surface will naturally leech out these products. During normal dry-weather driving or a light rain storm, they get dispersed gradually by the action of trucks, cars and motorbikes driving on the road. However, in a downpour, the road surface cools off extremely quickly. As it contracts slightly, the oils and tars are squeezed out at a quicker rate than normal and because oil is less dense than water, any residue floats to the top of the layer of rain water on the road. The result is oil-on-water which has zero grip. Next time you drive through a sudden summer downpour, look at the road surface once it has stopped raining - you'll see it covered in rainbow artifacts where the sunlight is reflecting off the wet, oily layer.

Aquachannel tyres.



In the last few years, there has been a gradually increasing trend for manufacturers to design and build so-called aquachannel tyres. Brand names you might recognise are *Goodyear Aquatread* and *Continental Aquacontact*. These differ noticeably from the normal type of tyre you would expect to see on a car in that they have a central groove running around the tread pattern. This, combined with the new tread patterns themselves lead the manufacturers to startling water-removal figures. According to Goodyear, their versions of these tyres can expel up to two gallons of water a second from under the tyre when travelling at motorway speeds. My personal experience of these tyres is that they work. Very well in fact - they grip like superglue in the wet. The downside is that they are generally made of a very soft compound rubber which leads to greatly reduced tyre life. You've got to weigh it up - if you spend most of the year driving around in the wet, then they're possibly worth the extra expense. If you drive around over 50% of the time in the dry, then you should think carefully about these tyres because it's a lot of money to spend for tyres which will need replacing every 10,000 miles in the dry.

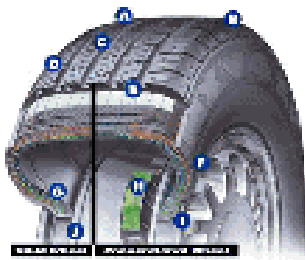
TwinTire™



This was an idea from the USA based on the twin tyres used in Western Australia on their police vehicles. It's long been the practice for closed-wheel racing cars, such as NASCAR vehicles, to use two inner tubes inside each tyre, allowing for different pressures inside the same tyre. They also allow for proper run-flat puncture capability. TwinTires tried putting the same principle into effect for those of us with road-going cars. Their system used specially designed wheel rims to go with their own unique type of tyres. Each wheel rim was actually molded as two half-width rims joined together. The TwinTires tyres then fitted those double rims. Effectively, you got two independent tyres per wheel, each with their own inner tube or tubeless pressure. The most

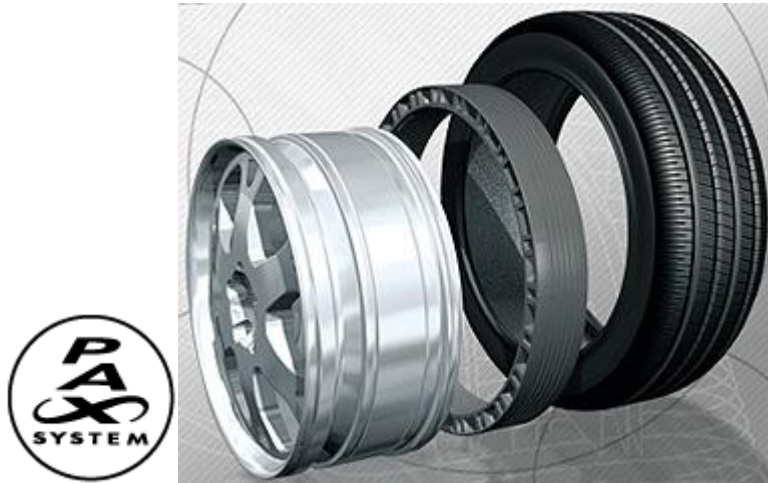
obvious advantage of this system was that it was an almost failsafe puncture proof tyre. As most punctures are caused by single objects entering the tyre at a single point, with this system, only one tyre would deflate, leaving the other untouched so that your vehicle was still controllable. TwinTires claimed a reduction in braking distance too, typically from 150ft down to 120ft when braking from a fixed 70mph. The other advantage was that the system was effectively an evolution of the Aquatread type single tyres that can be bought over the counter. In the dry, you had more or less the same contact area as a normal tyre. In the wet, most of the water was channeled into the gap between the two tyres leaving (supposedly) a much more efficient wet contact patch. History is cruel to those who buck the trend, and as it turned out this system was just a passing fad. Their products disappeared around 2001 and the website vanished shortly thereafter. [Dauntless Motor Corp](#) are the last remaining suppliers and they have all the remaining stock. For an independent opinion on TwinTyre systems from someone who used them avidly, have a read of [his e-mail to me which has a lot of information in it](#).

Run-Flat Tyres.



Yikes! Tyres for the accident-prone. As it's name implies, it's a tyre designed to run when flat. ie. when you've driven over a cunningly placed plank full of nails, you can blow out the tyre and still drive for miles without needing to repair or re-inflate it. I should just put one thing straight here - this doesn't mean you can drive on forever with a deflated tyre. It means you won't careen out of control across the motorway and nail some innocent wildlife when you blowout a tyre. It's more of a safety thing - it's designed to allow you to continue driving to a point where you can safely get the tyre changed (or fixed). The way it works is to have a reinforced sidewall on the tyre. When a normal tyre deflates, the sidewalls squash outwards and are sliced off by the wheel rims, wrecking the whole show. With run-flat tyres, the reinforced sidewall maintains some height in the tyre allowing you to drive on. Most run-flat tyres come with a TPMS to alert that you've got a puncture (see [TPMS](#) later in the page)

Both [Goodyear](#) (Run-flat Radials) and [Michelin](#) (Zero Pressure System) introduced run-flat tyres to their ranges in 2000. Goodyear named their technology "EMT", meaning Extended Mobility Tyre.



Not content with their Zero Pressure System, Michelin developed the [PAX system](#) too in late 2000 which is a variation on a theme. Rather than super-supportive sidewalls, the PAX system relies on a wheel-rim and tyre combination to provide a derivative run-flat capability. As well as the usual air-filled tyre, there is now a reinforced polymer support ring inside. This solid ring clips the air-filled tyre by its bead to the wheel rim which is the first bonus - it prevents the air-filled tyre from coming off the rim. The second bonus, of course, is that if you get a puncture, the air-filled tyre deflates, and the support ring takes the strain. Michelin say this system is good for over 100 miles at 80km/h (50mph). The downside is that I believe the PAX system is just that - a system. ie. you can't use PAX tyres on standard rims and you can't use standard tyres on PAX rims. This is because PAX tyres have asymmetric beads. In English this means that the inside bead and outside bead are a different diameter. Typically a 410 PAX tyre will have bead diameters of 400mm on the outside and 420mm on the inside.

Remember up the top of this page where I was talking about tyre sizes and mentioned that Michelin had come up with a new 'standard' ? Imagine you're used to seeing tyre sizes written like this : 205/60 R16. If you've read my page this far, you ought to know what that means. But for the PAX system, that same tyre size now becomes : 205-650 R410 A. Decoding this, the 205 is the same as it always was - tyre width in mm. The 650 now means 650mm in overall diameter, rather than a sidewall height of 65% of 205mm. The 410 is the metric equivalent of a 15inch wheel rim. Finally, the 'A' means "This is a PAX system wheel or tyre with an asymmetric bead".

What about the criminals?

"so now criminals can outfit their cars with these, and not be prone to the police stinger devices used to slow down getaway cars."
Here's Michelin's response.

MICHELIN®

"Michelin's aim is to propose products allowing people to drive in enhanced conditions of security. From this point of view, run-flat tyres and PAX System represent great progress in the history of the automotive industry. Indeed, these two developments allow drivers to go on driving even after a puncture, if, for instance, they do not feel safe to stop on the hard shoulder of a highway to repair their tyre, or they are in a hazardous area. Michelin is of course aware that such inventions, like any other innovations can be used in a distorted way : cheques for example are meant to facilitate transactions,

however the signature on a cheque can be falsified and money can go into the wrong hands ; run flat tyres are designed to provide better security to a driver, but could be used for other purposes by somebody having other intentions. Michelin is very sorry that it is unable to control any abuses made of its tyres by individuals intent on breaking the law."

Michelin Tweels.



In 2005, Michelin unveiled their "Tweel" concept - a word made up of the combination of Tyre and Wheel. After decades of riding around on air-filled tyres, Michelin would like to convince us that there is a better way. They're working on a totally air-less tyre. Airless = puncture proof. The Tweel is the creation of Michelin's American technology centre - no doubt working with the sound of the Ford Explorer / Bridgestone Firestone lawsuit still ringing in their ears.

The Tweel is a combined single-piece tyre and wheel combination, hence the name, though it actually begins as an assembly of four pieces bonded together: the hub, a polyurethane spoke section, a "shear band" surrounding the spokes, and the tread band - the rubber layer that wraps around the circumference and touches the road. The Tweel's hub functions just like your everyday wheel right now - a rigid attachment point to the axle. The polyurethane spokes are flexible to help absorb road impacts. These act sort of like the sidewall in a current tyre. But turn a tweel side-on and you can see right through it. The shear band surrounding the spokes effectively takes the place of the air pressure, distributing the load. Finally, the tread is similar in appearance to a conventional tyre. *The image on the right is my own rendering based on the teeny tiny images I found from the Michelin press release. It gives you some idea what the new Tweel could look like.*

One of the basic shortcomings of a tyre filled with air is that the inflation pressure is distributed equally around the tire, both up and down (vertically) as well as side-to side (laterally). That property keeps the tire round, but it

also means that raising the pressure to improve cornering - increasing lateral stiffness - also adds up-down stiffness, making the ride harsher. With the Tweel's injection-molded spokes, those characteristics are no longer linked. Only the spokes toward the bottom of the tyre at any point in its rotation are determining the grip / ride quality. Those spokes rotating around the top of the tyre are free to flex to full extension without affecting the grip or ride quality.

The Tweel offers a number of benefits beyond the obvious attraction of being impervious to nails in the road. The tread will last two to three times as long as today's radial tires, Michelin says, and when it does wear thin it can be retreaded. For manufacturers, the Tweel offers an opportunity to reduce the number of parts, eliminating most of the 23 components of a typical new tire as well as the costly air-pressure monitors now required on all new vehicles in the United States. (See [TPMS](#) below).

Another benefit? No spare wheels. That leaves more room for boot/trunk space, and reduces the carried weight in the vehicle. Reporters who took the change to drive an Audi A4 sedan equipped with Tweels early in 2005 complained of harsh vibration and an overly noisy ride. Michelin are well aware of these shortfalls - mostly due to vibration in the spoke system. (They admit they're in extremely-alpha-test mode.) Another problem is that the wheels transmit a lot more force and vibration into the cabin than regular tyres. A plus point though is cornering ability. Because of the rigidity of the spokes and the lack of a flexing sidewall, cornering grip, response and feel is excellent.

There are other negatives: the flexibility, at this early stage, contributes to greater friction, though it is within 5% of that generated by a conventional radial tyre. And so far, the Tweel is no lighter than the tyre and wheel it replaces. Almost everything else about the Tweel is undetermined at this early stage of development, including serious matters like cost and frivolous questions like the possibilities of chrome-plating. Either way, it's a promising look into the future.

Tweels are being tested out on the iBot - Dean Kamen's (the Segway inventor) new prototype wheelchair, and by the military. The military are interested because the Tweel is incredibly resistant to damage, even caused by explosions. Michelin hope to bring this technology to everyday road car use, construction equipment, and potentially even aircraft tyres.



Coloured dots and stripes



When you're looking for new tyres, you'll often see some coloured dots on the tyre sidewall, and bands of colour in the tread. These are all here for a reason, but it's more for the tyre fitter than for your benefit.

The dots on the sidewall typically denote uniformity and weight. It's impossible to manufacture a tyre which is perfectly balanced and perfectly manufactured in the belts. As a result, all tyres have a point on the tread which is lighter than the rest of the tyre - a thin spot if you like. It's fractional - you'd never notice it unless you used tyre manufacturing equipment to find it, but it's there. When the tyre is manufactured, this point is found and a coloured dot is put on the sidewall of the tyre corresponding to the light spot. Typically this is a **yellow dot** (although some manufacturers use different colours just to confuse us) and is known as the weight mark. Typically the yellow dot should end up aligned to the valve stem on your wheel and tyre combo. This is because you can help minimize the amount of weight needed to balance the tyre and wheel combo by mounting the tire so that its light point is matched up with the wheel's heavy balance point. Every wheel has a valve stem which cannot be moved so that is considered to be the heavy balance point for the wheel.

As well as not being able to manufacture perfectly weighted tyres, it's also nearly impossible to make a tyre which is perfectly circular. By perfectly circular, I mean down to some nauseating number of decimal places. Again,

you'd be hard pushed to actually be able to tell that a tyre wasn't round without specialist equipment. Every tyre has a high and a low spot, the difference of which is called radial runout. Using sophisticated computer analysis, tyre manufacturers spin each tyre and look for the 'wobble' in the tyre at certain RPMs. It's all about harmonic frequency (you know - the frequency at which something vibrates, like the Tacoma Narrows bridge collapse). Where the first harmonic curve from the tyre wobble hits its high point, that's where the tyre's high spot is. Manufacturers typically mark this point with a **red dot** on the tyre sidewall, although again, some tyres have no marks, and others use different colours. This is called the uniformity mark. Correspondingly, most wheel rims are also not 100% circular, and will have a notch or a dimple stamped into the wheel rim somewhere indicating their low point. It makes sense then, that the high point of the tyre should be matched with the low point of the wheel rim to balance out the radial runout.

What if both dots are present?

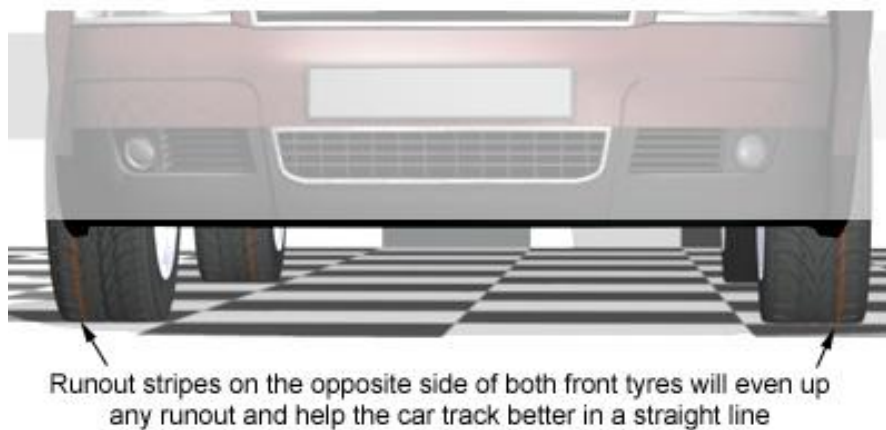
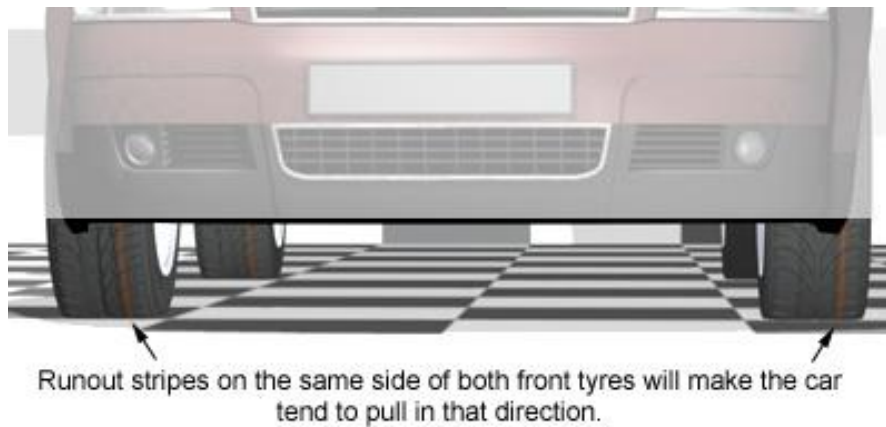
Generally speaking, if you get a tyre with both a red and a yellow dot on it, it should be mounted according to the red dot - ie. the uniformity mark should line up with the dimple on the wheel rim, and the yellow mark should be ignored.

What about the coloured stripes in the tread?

Often when you buy tyres, there will be a coloured band or stripe running around the tyre inside the tread. These can be any colour and can be placed laterally almost anywhere across the tread. Some are on the tread blocks whilst others are on the tyre carcass. The same tyre is often made with slightly tweaked specifications for different vehicles. To easily identify these same labelled tyres when they are warehoused or in storage, different markings and stripes are used. Sometimes stripes are added for huge bulk orders to various manufactures. Eg All the red outside stripes are for Toyota next week. This gives anyone in the warehouse a very quick visual check of the different types of tyres without needing to pull them all down and read the sidewall on each one.

As well as the colour, the actual position of the lines is something to take note of too. They're a measure of something called runout. Depending on how the belts are laid on the tyre during manufacturing, they can cause the tire to "run out" - to not track perfectly straight, but pull to the left or right. The closer to the centre of the tyre that these lines are, the less runout the tyre has and the straighter it will track when mounted on your car. So for example, if you were looking at your car from the front and you saw the coloured striped running around the right side of both your front tyres, the car would likely have a tendency to pull to that side. The best thing is to have the coloured stripes on opposite sides of the tyres for opposite sides of the car, so that the runout on each side will counteract the other and help maintain a good straight running. This is something that not many tyre fitting places know about or take any notice of. The obvious solution to having the stripes

both on one side is to flip one of the tyres around, but that will only work if they're not unidirectional tyres. If they are unidirectional (and thus must be mounted to rotate a specific way) then you should try to find another tyre from the same batch with the stripe on the opposite side.



Running in your new tyres

It may sound like an odd concept, but if you buy brand new tyres and slap them on your car, then try to drive the nuts off it, you're going to come a cropper. The reason, believe it or not, is that all tyres need a running-in (or scrubbing-in) period. When tyres are made, they're typically injection-moulded in a heat press. In order to get the tyres out of the mould, it is first lined with a non-stick coating. When the tyres pop out, some of that releasing agent sticks to the tyres themselves. What you get is a nice shiny new tyre, with 'shiny' being the operative word. The releasing agent can take as much as 500 miles to scrub off. Now for the everyday Joe, this isn't really so much of an issue, but for people who are fast drivers, or think they're fast drivers, this can lead to a distressing loss-of-grip mid-corner and a visit to something large and solid. It's doubly important for motorcyclists because they have half the number of tyres and a much smaller contact patch per tyre to boot.

Wheel Information.

Okay. If you want to change the wheels on your car, you need to take some things into consideration.

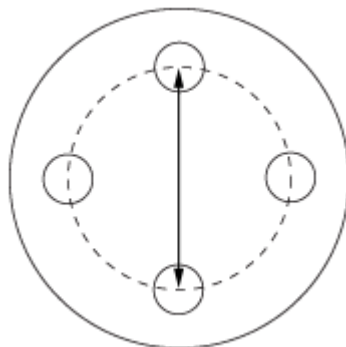
Number of bolts or studs

It goes without saying that you can't fit a 4-bolt wheel onto a 5-bolt wheel hub. Sounds obvious, but people have been known to fork out for an expensive set of wheels only to find they've got the wrong number of mounting holes.

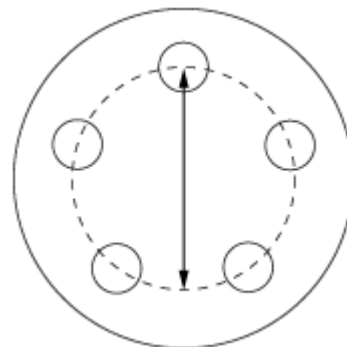
Pitch Circle Diameter

So you know how many holes there are. Now you need to know the PCD, or *Pitch Circle Diameter*. This is the diameter of the invisible circle formed by scribing a circle that passes through the centre point of each mounting hole. If you've got the right number of holes, but they're the wrong spacing, again the wheel just won't fit.

4 stud (bolt) PCD

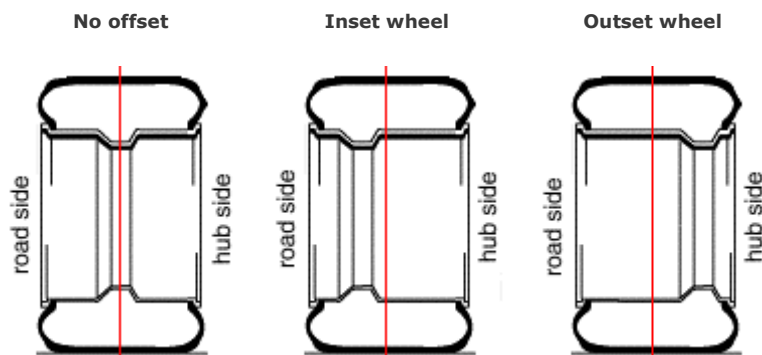


5 stud (bolt) PCD

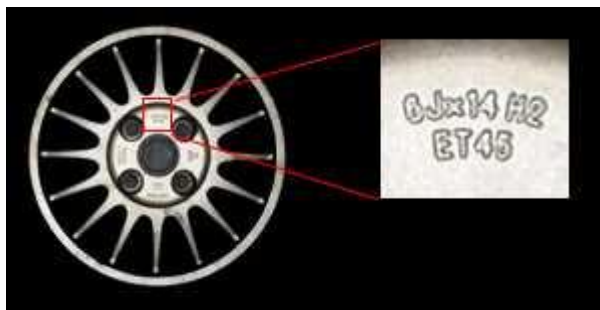


Inset or outset

This is very important. Ignore this and you can end up with all manner of nasty problems. This is the distance in mm between the centre line of the wheel rim, and the line through the fixing face. You can have inset, outset or neither. This determines how the suspension and self-centring steering behave. The most obvious problem that will occur if you get it wrong is that the steering will either become so heavy that you can't turn the car, or so light that you need to spend all your time keeping the bugger in a straight line. More mundane problems through ignoring this measurement can range from wheels that foul parts of the bodywork or suspension, to high-speed judder in the steering because the suspension setup can't handle that particular type of wheel. This figure will be stamped on the wheel somewhere as an *ET figure*.



A real example

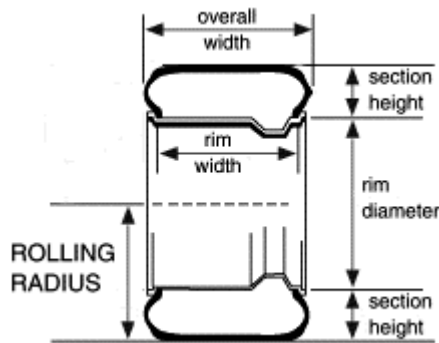


They say a picture is equivalent to a thousand words, so study this one carefully. It's one of the wheels off one of my old cars. Enlarged so you can read it is the wheel information described above. You'll notice it reads "6J x 14 H2 ET45". The "6J x 14" part of that is the size of the wheel rim - in this case it has a depth of 6 inches and a diameter of 14 inches (see the section directly below here on wheel sizes for a more in-depth explanation). The "J" symbolises the shape of the tyre bead profile. (see [rim contours](#) below)

The "H2" means that this wheel rim is a double hump design (see [hump profiles](#), below). The "ET45" figure below that though symbolises that these wheels have a positive offset of 45mm. In other words, they have an *inset* of 45mm. In my case, the info is all stamped on the outside face of the wheel which made it nice and easy to photograph and explain for you. On most aftermarket wheels, they don't want to

pollute the lines and style of the outside of the wheel with stamped-on information - it's more likely to be found inside the rim, or on one of the inner mounting surfaces.

Matching your tyres to your wheels.



Wheel sizes

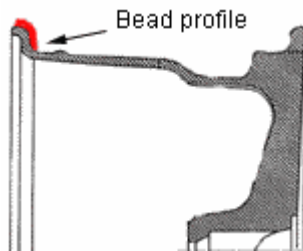
Wheel sizes are expressed as WWWxDDD sizes. For example 7x14. A 7x14 wheel has a *rim width* of 7 inches, and a *rim diameter* of 14 inches. The width is usually below the width of the tyre for a good match. So a 185mm tyre would usually be matched to a wheel which is 6 inches wide. (185mm is more like 7 inches, but that's across the entire tyre width, not the bead area where the tyre fits the rim.)

Rolling Radius

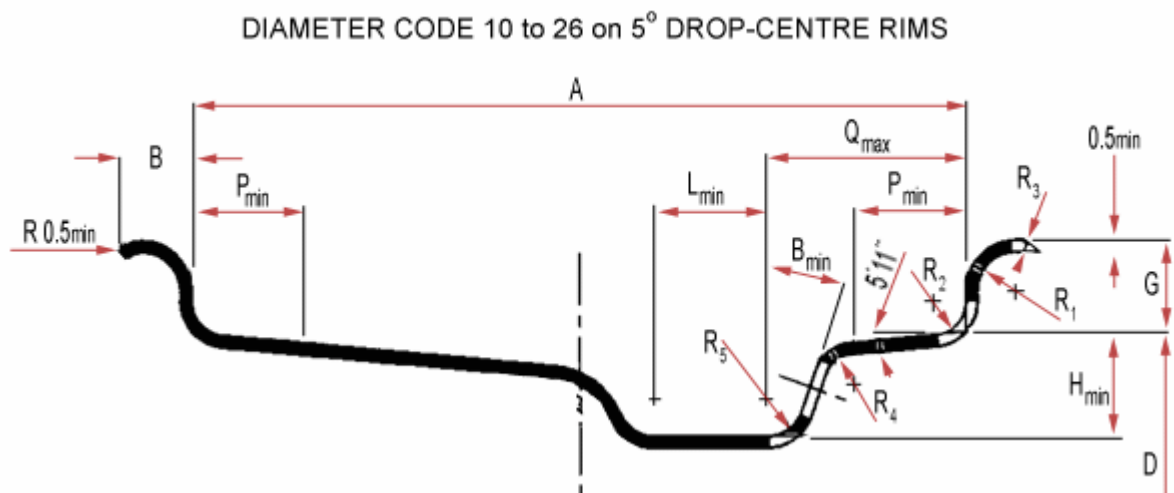
The important thing that you need to keep in consideration is **rolling radius**. This is so devastatingly important that I'll mention it in bold again: **rolling radius!** This is the distance in mm from the centre of the wheel to the edge of the tread when it's unladen. If this changes because you've mismatched your new wheels and tyres, then your speedo will lose accuracy and the fuel consumption might go up. The latter reason is because the manufacturer built the engine/gearbox combo for a specific rolling radius. Mess with this and the whole thing could start to fall down around you.

It's worth pointing out that the actual radius the manufacturers use for speedo calculation is the 'dynamic' or the 'laden' radius of the wheel at the recommended inflation pressure and 'normal' loading. Obviously though, this value is entirely dependent on the unladen rolling radius.

J, JJ, K, JK, B, P and D: Tyre bead profiles / rim contour designations.



The letter that typically sits between the rim width and diameter figures stamped on the wheel, and indicates the physical shape of the wheel where the tyre bead meets it. In the cross-section on the left you can see the area highlighted in red. Like so many topics, the answer as to which letter represents which profile is a long and complicated one. Common wisdom has it that the letter represents the shape. ie. "J" means the bead profile is the shape of the letter "J". Not so, although "J" is the most common profile identifier. 4x4 vehicles often have "JJ" wheels. Jaguar vehicles (especially older ones) have "K" profile wheels. Some of the very old VW Beetles had "P" and "B" profile wheels. Anyway the reason it is an "awkward topic to find definitive data on" is very apparent if you've ever looked at Standards Manual of the European Tyre and Rim Technical Organisation. It is *extremely* hard to follow! There are pages and pages (64 in total) on wheel contours and bead profiles alone, including dimensions for every type of wheel you can think of (and many you can't) with at least a dozen tabled dimensions for each. Casually looking through the manual is enough to send you to sleep. Looking at it with some concentration is enough to make your brain run out of your ears. To try to boil it all down for you, it seems that they divide up the rim into different sections and have various codes to describe the geometry of each area. For example, the "J" code makes up the "Rim Contour" and specifies rim contour dimensions in a single category of rims called "Code 10 to 26 on 5° Drop-Centre Rims". To give you some idea of just how complex / anal this process is, I've recreated one such diagram with Photoshop below to try to put you off the scent.



From the tables present in this manual, the difference in dimensions between "J" and "B" rims is mainly due to the shape of the rim flange. This is the part in the above diagram defined by the R radius and B and P_{min} parameters.

Hence my somewhat simpler description : tyre bead profiles. **Note** that in my example, the difference between "J" and "B" rims is small but not negligible. This area of rim-to-tire interface is very critical. Very small changes in a tyre's bead profile make large differences in mounting pressures and rim slip.

"A" and "D" contour designations come under the category of "Cycles, Motorcycles, and Scooters" but also show up in the "Industrial Vehicles and Lift Trucks" category. Naturally, the contours have completely different geometry for the same designation in two different categories. The "S", "T", "V" and "W" contour designation codes fall into the "Commercial Vehicles, Flat Base Rims" category. The "E", "F", "G" and "H" codes fall into the "Commercial Vehicles, Semi-Drop Centre Rims" category. Are you beginning to see just how complex this all is?

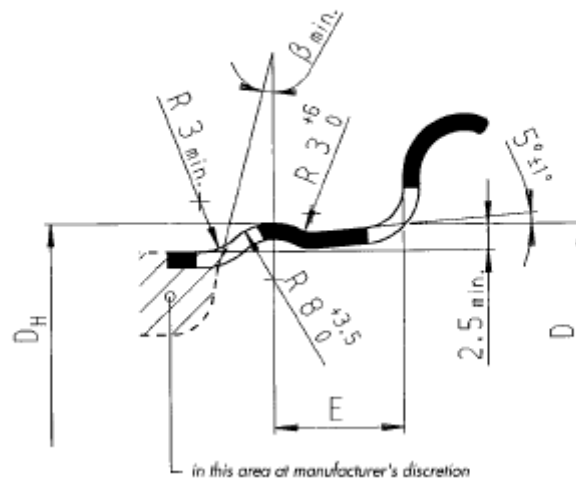
I think the best thing for you, dear reader, is a general rule-of-thumb, and it is this : if your wheels are stamped 5J15 and you buy 5K15 tyres, rest assured they absolutely won't fit.

H, H2, FH, CH, EH and EH2 : Hump profiles.

More alphabet soup. So you might have just about understood the bit about bead profiles, but there's another design feature of wheel rims. The 'hump' is actually a bump put on the bead seat (for the bead) to prevent the tire from sliding off the rim while the vehicle is moving. As with rim contours, there are several different designations of hump design and configuration, depending on the number and shape of the humps. For the inquisitive reader, here's a table of the hump designations, and a diagram similar to the one above which displays in nauseating detail just what a hump really is. The eagle-eyed amongst you will notice that this diagram is an enlarged view of the area around P_{min} in the other ETRO diagram above, because that's typically where the hump is.

Designation	Bead Seat Contour		Marking
	Outside	Inside	
Hump	Hump	Normal	H
Double Hump	Hump	Hump	H2
Flat Hump	Flat Hump	Normal	FH
Double Flat Hump	Flat Hump	Flat Hump	FH2
Combination Hump	Flat Hump	Hump	CH
Extended Hump	Extended Hump	Extended Hump	EH2
Extended Hump 2+	Extended Hump 2+	Extended Hump 2+	EH2 +

HUMP 'H' BASIC CONTOURS



If you're obsessive-compulsive and absolutely must know everything there is to know about bead profiles, humps and rim flanges, you can check out the [ETRTO \(European Tyre and Rim Technical Organisation\)](#) website from where you can purchase their manuals and documents. Go nuts. Meanwhile, the rest of us will move on to the next topic.

Why would I want to change my rims and tyres anyway?

A good question. Styling and performance are the only two reasons. Most cars come with horrible narrow little tyres and 13 inch rims. More recently the manufacturers have come to their senses and started putting decent combinations on factory cars so that's not so much of a problem any more. The first reason is performance. *Speed in corners* more specifically. If you have larger rims, you get smaller sidewalls on the tyres. And if you have smaller sidewalls, the tyre deforms less under the immense sideways forces involved in cornering.

So how does it all figure out?

Point to note: 1 inch = 25.4mm. You need to know that because tyre/wheel manufacturers insist on mixing mm and inches in their ratings. Also note that a certain amount of artistic licence is required when calculating these values. The tyre's rolling radius will change the instant you put load on it, and calculating values to fractions of a millimetre just isn't worth it - tyre tread wear will more than see off that sort of accuracy.

Lets take an average example: a car with factory fitted 6x14 wheels and **185/65 R14's** on them.

- Radius of wheel = **7** inches (half the diameter) = **177.8mm**
- Section height = 65% of 185mm = 120.25mm
- So the rolling radius for this car to maintain is
 $177.8 + 120.25 = \mathbf{298.05mm}$

lets assume I want 15 inch rims which are slightly wider to give me that nice *fat* look. I'm after a set of 7x15's

First we need to determine the ideal width of tyre for my new wider wheels. 7 inches = 177.8mm. The closest standard tyre width to that is actually 205mm so that's what we'll use. (remember the tyre width is larger than the width of the bead fitting.)

- Radius of wheel = 7.5 inches (half of 15) = 190.5mm
- We know that the overall rolling radius must be as close to 298.05mm as possible
- So the section height must be $298.05mm - 190.5mm = \mathbf{107.55mm}$
- Figure out what percentage of 205mm is 107.55mm. In this case it's 52.5%
- So combine the figures - the new tyre must be **205/50 R15**
- giving a new rolling radius of **293mm** - more than close enough.

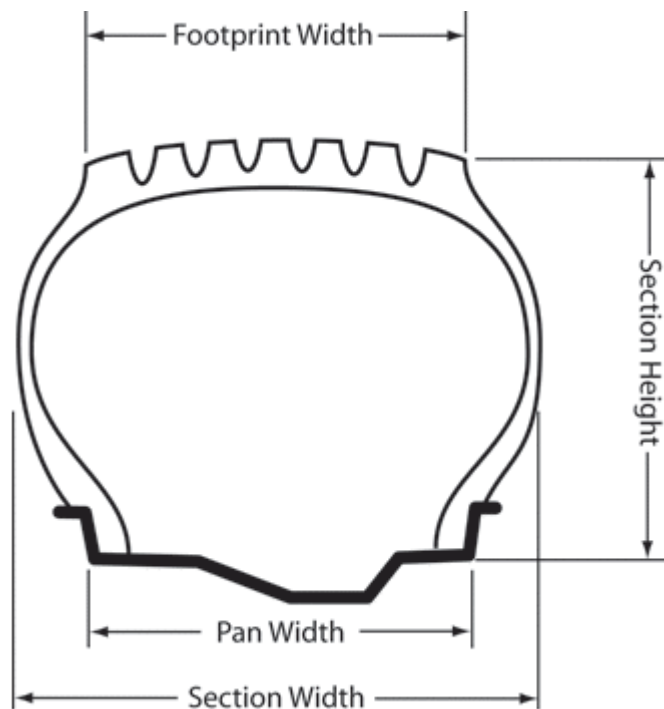
A Speedometer error means an odometer error too.

It stands to reason that if you change the rolling radius of your wheels and tyres, and the speedometer no longer reads correctly, that your odometer will also gradually become inaccurate. Assume for example that you bought a car brand new and changed the wheels and tyres on day one from 195.65R14 to 205/50R15 - not an uncommon change. By the calculator above, that makes your speedometer over read by 1.7%. Consequently, the registered odometer reading will also be out by the same value. So for example, when you get to 10,000km of driving (in the real world), your odometer will actually read 10,170km. OK so that's not a huge difference but it is one of the reasons why most car dealers have a disclaimer on their secondhand vehicles telling you that they won't guarantee the displayed mileage. ("Clocking" the odometer is the other reason). Odometer errors due to mis-matched tyres and wheels will happen on regular odometers as well as the newer digital ones.

Motorcycle speedometers.

Veering off-topic for a moment, it's worth pointing out that without exception, all motorbike speedometers are designed to inflate the ego of the rider by at least 5%. In some cases, they are as much as 10% optimistic. ie. the speedometer on a motorbike will *always* over-read. 100mph? Not likely - you're actually doing closer to 90mph.

Aspect Ratio and Rim / Pan Width.



Aspect ratio is, as you know if you read the bit above, the ratio of the tyre's section height to its section width. The aspect ratio is sometimes referred to as the tyre 'series'. So a 50-series tyre means one with an aspect ratio of 50%. The maths is pretty simple and the resulting figure is stamped on all tyres as part of the sizing information:

$$\text{Aspect ratio} = \frac{\text{Section height}}{\text{Section width}}$$

The actual dimensions of a tyre are dependent on the rim on which it is mounted. The dimension that changes the most is the tyre's section width; a change of about 0.2" for every 0.5" change in rim width.

The ratio between the section width and the rim width is pretty important. If the rim width is too narrow, you pinch the tyre in and cause it to balloon more in cross-section. If the rim width is too wide, you run the risk of the tyre ripping away at high speed.

For 50-series tyres and above, the rim width is 70% of the tyre's section width, rounded off to the nearest 0.5.

For example, a P255/50R16 tyre, has a design section width of 10.04" (255mm = 10.04inches). 70% of 10.04" is 7.028", which rounded to the nearest half inch, is 7". Ideally then, a 255/50R16 tyres should be mounted on a 7x16 rim.

For 45-series tyres and below, the rim width is 85% of the tyre's section width, rounded off to the nearest 0.5.

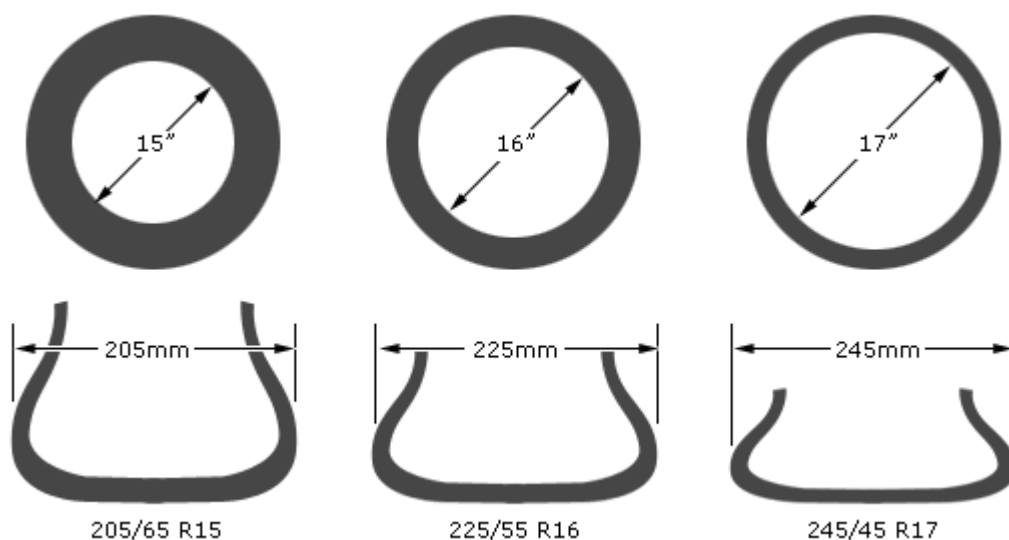
For example, a P255/45R17 tyre, still has a design section width of 10.04" (255mm = 10.04inches). But 85% of 10.04" is 8.534", which rounded to the nearest half inch, is 8.5". Ideally then, a 255/45R17 tyre should be mounted on an 8½x17 rim.

Too wide or too narrow - does it make a difference?

Given all the information above, you ought to know one last thing. A rim that is too narrow in relation to the tyre width will allow the tyre to distort excessively sideways under fast cornering. On the other hand, unduly wide rims on an ordinary car tend to give rather a harsh ride because the sidewalls have not got enough curvature to make them flex over bumps and potholes. That's why there is a range of rim sizes for each tyre size in my Rimwidthulator above. Put a 185/65R14 tyre on a rim narrower than 5inches or wider than 6.5inches and suffer the consequences.

The *Plus One* concept

The *plus one* concept describes the proper sizing up of a wheel and tyre combo without all that spiel I've gone through above. Basically, each time you add 1 inch to the wheel diameter, add 20mm to the tyre width and subtract 10% from the aspect ratio. This compensates nicely for the increases in rim width that generally accompany increases in diameter too. By using a larger diameter wheel with a lower profile tyre it's possible to properly maintain the overall rolling radius, keeping odometer and speedometer changes negligible. By using a tyre with a shorter sidewall, you gain quickness in steering response and better lateral stability. The visual appeal is obvious, most wheels look better than the sidewall of the tyre, so the more wheel and less sidewall there is, the better it looks.



Tyre size table up to 17" wheels

Here, for those of you who can't or won't calculate your tyre size, is a table of equivalent tyres. These all give rolling radii within a few mm of each other and would mostly be acceptable, depending on the wheel rim size you're after.

80 SERIES	75 SERIES	70 SERIES	65 SERIES	60 SERIES	55 SERIES	50 SERIES
135/80 R 13	-	145/70 R 13	-	175/60 R 13	-	-
-	-	155/70 R 13	165/65 R 13	-	-	-
-	-	-	175/65 R 13	-	-	-
145/80 R 13	-	155/70 R 13	175/65 R 13	185/60 R 13	185/55 R 14	-
-	-	165/70 R 13	165/65 R 14	175/60 R 14	-	-
-	-	175/70 R 13	-	-	-	-
155/80 R 13	165/75 R 13	175/70 R 13	165/65 R 14	175/60 R 14	195/55 R 14	195/50 R 15
-	-	185/70 R 13	175/65 R 14	185/60 R 14	185/55 R 15	-
-	-	165/70 R 14	-	195/60 R 14	-	-
165/80 R 13	-	185/70 R 13	175/65 R 14	195/60 R 14	205/55 R 14	205/50 R 15
-	-	165/70 R 13	185/65 R 14	205/60 R 14	185/55 R 15	195/50 R 16
-	-	175/70 R 14	-	-	195/55 R 15	-
-	-	-	-	-	205/55 R 15	-
175/80 R 13	175/75 R 14	175/70 R 14	185/65 R 14	205/60 R 14	195/55 R 15	215/50 R 16
-	-	185/70 R 14	195/65 R 14	215/60 R 14	205/55 R 15	195/50 R 16
-	-	-	185/65 R 15	195/60 R 15	-	205/50 R 16
185/80 R 13	185/75 R 14	185/70 R 14	195/65 R 14	215/60 R 14	205/55 R 16	205/50 R 16
-	-	195/70 R 14	185/65 R 15	225/60 R 14	-	225/50 R 16
-	-	-	195/65 R 15	195/60 R 15	-	205/50 R 17
-	-	-	-	205/60 R 15	-	-
-	-	-	-	215/60 R 15	-	-

So that's it then?

Yes - that's it. A little time with a calculator, a pen and some paper will enable you to confidently stride into your local tyre/wheel supplier and state exactly what you want.

Oversizing tyres

If you want the *fat* look but don't want to go bonkers with new wheels, you can oversize the tyres on the rims usually by about 20mm (to be safe). So if your standard tyres are 185/60 R14s, you can oversize them to about 205mm. But make sure you recalculate the percentage value to keep the sidewall height the same.

Fat or thin? The question of contact patches and grip.

If there's one question guaranteed to promote argument and counter argument, it's this : do wide tyres give me better grip?

Fat tyres look good. In fact they look stonkingly good. In the dry they are mercilessly full of grip. In the wet, you might want to make sure your insurance is paid up, especially if you're in a rear-wheel-drive car. Contrary to what you might think (and to what I used to think), bigger contact patch does not *necessarily* mean increased grip. Better yet, fatter tyres do not mean bigger contact patch. Confused? Check it out:

Pressure=weight/area.

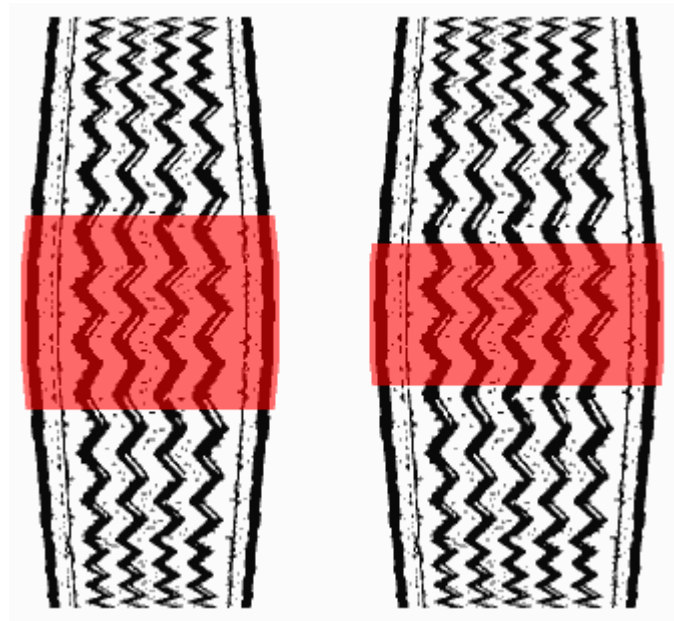
That's about as simple a physics equation as you can get. For the general case of most car tyres travelling on a road, it works pretty well. Let me explain. Let's say you've got some regular tyres, as supplied with your car. They're inflated to 30psi and your car weighs 1500Kg. Roughly speaking, each tyre is taking about a quarter of your car's weight - in this case 375Kg. In metric, 30psi is about 2.11Kg/cm².

By that formula, the area of your contact patch is going to be roughly $375 / 2.11 = 177.7\text{cm}^2$ (weight divided by pressure)

Let's say your standard tyres are 185/65R14 - a good middle-ground, factory-fit tyre. That means the tread width is 18.5cm side to side. So your contact patch with all these variables is going to be about $177.7\text{cm}^2 / 18.5$, which is 9.8cm. Your contact patch is a rectangle 18.5cm across the width of the tyre by 9.8cm front-to-back where it sits 'flat' on the road.

Still with me? Great. You've taken your car to the tyre dealer and with the help of my tyre calculator, figured out that you can get some swanky 225/50R15 tyres. You polish up the 15inch rims, get the tyres fitted and drive off. Let's look at the equation again. The weight of your car bearing down on the wheels hasn't changed. The PSI in the tyres is going to be about the same. If those two variables haven't changed, then your contact patch is still going to be the same : 177.7cm^2

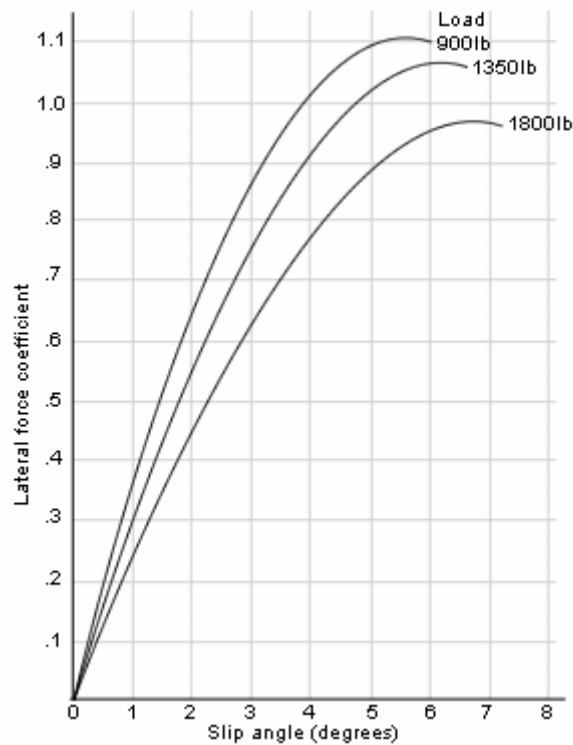
However you now have wider tyres - the tread width is now 22.5cm instead of 18.5cm. The same contact patch but with wider tyres means a narrower contact area front-to-back. In this example, it becomes $177.7\text{cm}^2 / 22.5$, which is 7.8cm.



Imagine driving on to a glass road and looking up underneath your tyres. This is the example contact patch (in red) for the situation I explained above. The narrower tyre has a longer, thinner contact patch. The fatter tyre has a shorter, wider contact patch, but the area is the same on both.

And there is your 'eureka' moment. Overall, the *area* of your contact patch has remained more or less the same. But by putting wider tyres on, the *shape* of the contact patch has changed. Actually, the contact patch is really a squashed oval rather than a rectangle, but for the sake of simplicity on this site, I've illustrated it as a rectangle - it makes the concept a little easier to understand. So has the penny dropped? I'll assume it has. So now you understand that it makes no difference to the contact patch, this leads us on nicely to the sticky topic of grip.

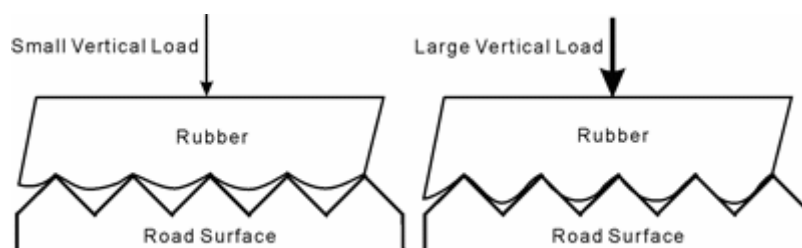
The *area* of the contact patch does not affect the actual grip of the tyre. The things that *do* affect grip are the coefficient of friction and the load on the tyre - **tyre load sensitivity**. Get out your geek-wear because this is going to get even more nauseatingly complicated now.



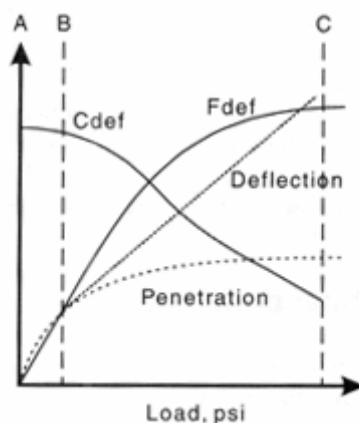
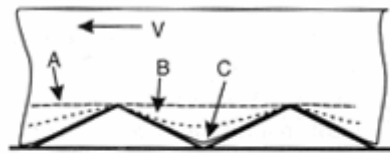
The graph up above here shows an example plot of normalised lateral force versus slip angle. Slip angle is best described as the difference between the angle of the tyres you've set by steering, and the direction in which the tyres actually want to travel. Looking at it, you can see that for any given slip angle, a higher coefficient of friction is obtained with less vertical load on the tyre.

$$\text{Lateral Force Coefficient} = \frac{\text{Lateral Force}}{\text{Load On Tyre}}$$

As the load on the tyre is increased, the peak obtainable lateral force is increased but at a decreasing rate. ie. more load doesn't mean infinitely more lateral force - at some point it's going to tail off. Rubber friction is broken into two primary components - adhesion and deformation or mechanical keying. Rubber has a natural adhesive property and high elasticity which allows it readily deform and fill the microscopic irregularities on the surface of any road. This has the effect of bonding to various surfaces, which aids in dry weather grip but is diminished in wet road conditions. Look at this next drawing - this depicts the deformation process as the load varies.



As the load is increased the amount of tire deformation also increases. Increasing the load also increases the contact between the tire and road improving adhesion. As the load increases, the rubber penetrates farther into the irregularities, which increases grip but at a diminishing rate. This next little graph shows the change in deformation friction (F_{def}) and the deformation coefficient of friction (C_{def}) with change in load.



As far as cars are concerned, any reduction in load usually results in an increase in the coefficient of friction. So for a given load increasing the contact patch area reduces the load per unit area, and effectively increases the coefficient of friction.

If this change in coefficient of friction were not true then load transfer would not be an issue. During acceleration grip is reduced partly from the change in suspension geometry and partly from the transfer of load from one set of tires to another. Since the coefficient of friction is changing (non-linearly lower for higher loads), the net grip during acceleration is reduced. In other words maximum grip occurs when all four tires are loaded equally.

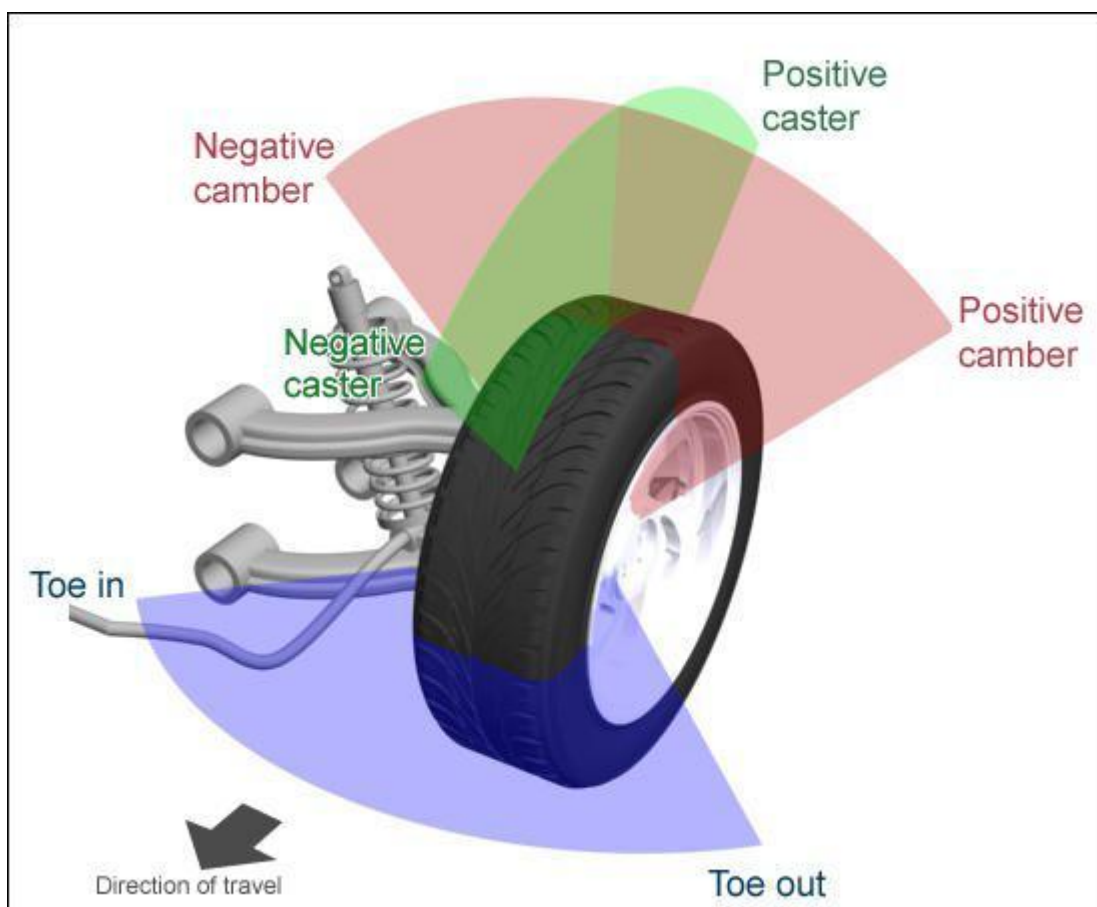
That last paragraph also explains why dynamic setup on your car is pretty important. In reality the contact patch is effectively spinning around your tyre at some horrendous speed. When you brake or corner, load-transfer happens and all the tyres start to behave differently to each other. This is why weight transfer makes such a difference to the handling dynamics of the car. Braking for instance; weight moves forward, so load on the front tyres increases. The reverse happens to the rear at the same time, creating a car which can oversteer at the drop of a hat. The Mercedes A-class had this problem when it came out. The load-transfer was all wrong, and a rapid left-right-left on the steering wheel would upset the load so much that the vehicle lost grip in the rear, went sideways, re-acquired grip and rolled over. (That's since been changed.) The Audi TT had a problem too because the load on its rear wheels wasn't enough to prevent understeer which is why all the new models have that daft little spoiler on the back.

If you decide to fatten up the tyres on your car, **another consideration** should be clearance with bits of your car. There's no point in getting super-fat tyres if they're going to rub against the inside of your wheel arches. Also, on cars with McPherson strut front suspension, there's a very real possibility that the tyre will foul the steering linkage on the suspension. **Check it first!**

Caster, camber, alignment etc:

Alignment

This is the general term used to gloss over the next three points:



Caster

This is the forward (negative) or backwards (positive) tilt of the spindle steering axis. It is what causes your steering to 'self-centre'. Correct caster is almost always positive. Look at a bicycle - the front forks have a quite obvious rearward tilt to the handlebars, and so are giving positive caster. The whole point of it is to give the car (or bike) a noticeable centre point of the steering - a point where it's obvious the car will be going in straight line.

Camber

Camber is the tilt of the top of a wheel inwards or outwards (negative or positive). Proper camber (along with toe and caster) make sure that the tyre tread surface is as flat as possible on the road surface. If your camber is out, you'll get tyre wear. Too much negative camber (wheels tilt inwards) causes tread and tyre wear on the inside edge of the tyre. Consequently, too much positive camber causes wear on the outside edge.

Negative camber is what counteracts the tendency of the inside wheel during a turn to lean out from the centre of the vehicle. 0 or Negative camber is almost always desired. Positive camber would create handling problems. The technical reason for this is because when the tyres on the inside of the turn have negative camber, they will tend to go toward 0 camber, using the contact patch more efficiently during the turn. If the tyres had positive camber, during a turn, the inside wheels would tend to even more positive camber, compromising the efficiency of the contact patch because the tyre would effectively only be riding on its outer edge.

Toe in & out

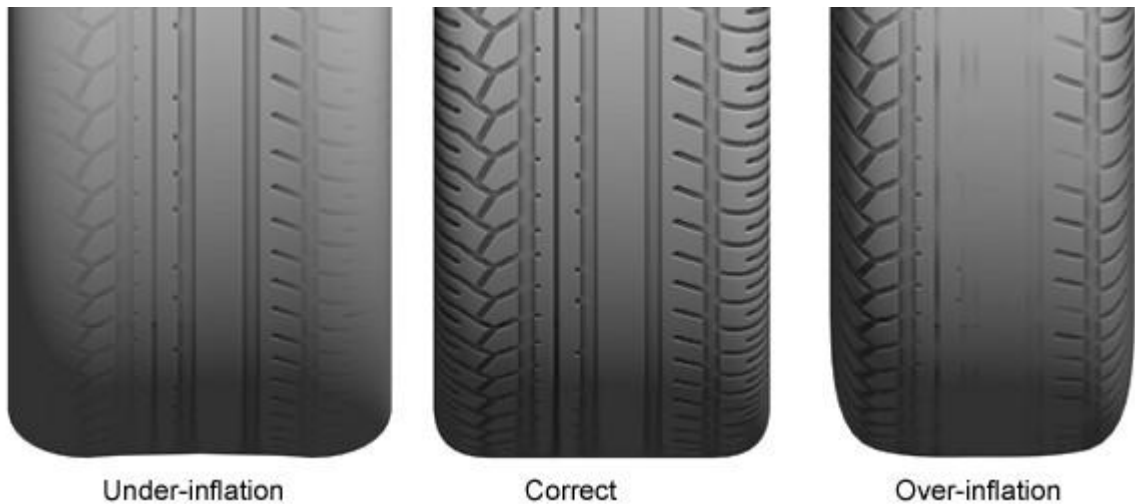
'Toe' is the term given to the left-right alignment of the front wheels relative to each other. Toe-in is where the front edge of the wheels are closer together than the rear, and toe-out is the opposite. Toe-in counteracts the tendency for the wheels to toe-out under power, like hard acceleration or at motorway speeds (where toe-in disappears). Toe-out counteracts the tendency for the front wheels to toe-in when turning at motorway speeds. It's all a bit bizarre and contradictory, but it does make a difference. A typical symptom of too much toe-in will be excessive wear and feathering on the outer edges of the tyre tread section. Similarly, too much toe-out will cause the same feathering wear patterns on the inner edges of the tread pattern. A reader of my site emailed me this which is a nice description of toe-in and toe-out.

As a front-wheel-drive car pulls itself forwards, the wheels will tend to pivot around the king-pins, and thus towards the center of the car. To ensure they end up straight ahead, they should sit with a slight toe-out when at rest. A rear-wheel-drive car pushes itself forward, and the front wheels are rotated by friction... thus they will tend to want to trail the king-pins, and therefor will want to splay apart. To ensure that they run parallel when rolling, they should be given some toe-in when at rest.

The perfect 4WD car will have neutral pressure on the front wheels, so have neither toe-in or toe-out... however very few companies make the perfect 4WD, so some will have a small amount to toe-in/out, depending on the dominant axle.

Diagnosing problems from tyre wear.

Firstly, let me state *my* views on rotating your tyres. This is the practice of swapping the front and back tyres to even out the wear. I used to believe that this wasn't a good idea. Think about it: the tyres begin to wear in a pattern, however good or bad, that matches their position on the car. If you now change them all around, you end up with tyres worn for the rear being placed on the front and vice versa. Having had this done a few times both on front-wheel drive and all-wheel-drive vehicles though, I now reckon it actually is A Good Thing. It results in even *overall* tyre wear. By this, I mean wear in the tread depth. This is a valid point, but if you can't be bothered to buy a new pair of tyres when the old pair wear too much, then you shouldn't be on the road, let alone kidding yourself that putting worn front tyres on the back and partly worn back tyres on the front will cure your problem. Your tyre wear pattern can tell you a lot about any problems you might be having with the wheel/tyre/suspension geometry setup. The first two signs to look for are over- and under-inflation. These are relatively easy to spot:



Here's a generic fault-finding table for most types of tyre wear:

Problem	Cause
Shoulder Wear <i>Both Shoulders wearing faster than the centre of the tread</i>	Under-inflation Repeated high-speed cornering Improper matching of rims and tyres Tyres haven't been rotated recently
Centre Wear <i>The centre of the tread is wearing faster than the shoulders</i>	Over-inflation Improper matching of rims and tyres Tyres haven't been rotated recently
One-sided wear <i>One side of the tyre wearing unusually fast</i>	Improper wheel alignment (especially camber)

	Tyres haven't been rotated recently
Spot wear <i>A part (or a few parts) of the circumference of the tread are wearing faster than other parts.</i>	Faulty suspension, rotating parts or brake parts Dynamic imbalance of tyre/rim assembly Excessive runout of tyre and rim assembly Sudden braking and rapid starting Under inflation
Diagonal wear <i>A part (or a few parts) of the tread are wearing diagonally faster than other parts.</i>	Faulty suspension, rotating parts or brake parts Improper wheel alignment Dynamic imbalance of tyre/rim assembly Tyres haven't been rotated recently Under inflation
Feather-edged wear <i>The blocks or ribs of the tread are wearing in a feather-edge pattern</i>	Improper wheel alignment (faulty toe-in) Bent axle beam

Checking your tyres.

It's amazing that so many people pay such scant attention to their tyres. If you're travelling at 70mph on the motorway, four little 20-square-centimetre pads of rubber are all that sits between you and a potential accident. If you don't take care of your tyres, those contact patches will not be doing their job properly. If you're happy with riding around on worn tyres, that's fine, but don't expect them to be of any help if you get into a sticky situation. The key of course, is to check your tyres regularly. If you're a motorcyclist, do it every night before you lock the bike up. For a car, maybe once a week. You're looking for signs of adverse tyre wear (see the section above). You're looking for splits in the tyre sidewall, or chunks of missing rubber gouged out from when you failed to negotiate that kerb last week. More obvious things to look for are nails sticking out of the tread. Although if you do find something like this, don't pull it out. As long as it's in there, it's sealing the hole. When you pull it out, *then* you'll get the puncture. That doesn't mean I'm recommending you drive around with a nail in your tyre, but it does mean you can at least get the car to a tyre place to get it pulled out and have the resulting hole plugged. The more you look after your tyres, the more they'll look after you.

Lies, damn lies, and tyre pressure gauges.

Whilst on the subject of checking your tyres, you really ought to check the pressures once every couple of weeks too. Doing this does rather rely on you having, or having access to a working, accurate tyre pressure gauge. If you've got one of those free pencil-type gauges that car dealerships give away free, then I'll pop your bubble right now and tell you it's worth nothing. Same goes for the ones you find on a garage forecourt. Sure they'll fill the

tyre with air, but they can be up to 20% out either way. Don't trust them. Only recently - since about 2003 - have I been able to trust digital gauges. Before that they were just junk - I had one which told me that the air in my garage was at 18psi with nothing attached to the valve. That's improved now and current-generation digital gauges are a lot more reliable. One thing to remember with digital gauges is to give them enough time to sample the pressure. If you pop it on and off, the reading will be low. Hold it on the valve cap for a few seconds and watch the display (if you can). Generally speaking you should only trust a decent, branded pressure gauge that you can buy for a small outlay - \$30 maybe - and keep it in your glove box. The best types are the ones housed in a brass casing with a radial display on the front and a pressure relief valve. I keep one in the car all the time and it's interesting to see how badly out the other cheaper or free ones are. My local garage forecourt has an in-line pressure gauge which over-reads by about 1.5psi. This means that if you rely on their gauge, your tyres are all 1.5psi short of their recommended inflation pressure. That's pretty bad. My local garage in England used to have one that under-read by nearly 6 psi, meaning everyone's tyres were rock-hard because they were 6psi over-inflated. I've yet to find one that matches my little calibrated gauge. One reader pointed something else out to me. Realistically even a cheap pressure gauge is OK provided it is consistent. This is easy to check by taking three to five readings of the same tyre and confirming they are all the same, then confirming it reads (consistently) more for higher pressure and less for lower pressure. One last note : if you're a motorcyclist, don't carry your pressure gauge in your pocket - if you come off, it will tear great chunks of flesh out of you as you careen down the road....



Tyre pressure and MPG.

Well for one it proves that tyre pressure is absolutely linked to your car's economy. I can get an extra 50 miles between fill-ups now. It also proves that it's worth researching things if you think something is a little odd. It does also add weight to the above motto about not trusting forecourt pressure gauges. Imagine if you're underfilling your tyres because of a dodgy pressure gauge - not only is it dangerous, but it's costing you at the pump too.

TPMS - Tyre (Tire) Pressure Monitor Systems.

For those of you who live in America and are in to cars, you'll no doubt remember the Ford Explorer / Firestone Bridgestone lawsuits of the early 21st century. A particular variety of Firestone tyre, sold as standard on Ford Explorers, had a nasty knack of delaminating at speed causing high-speed blowouts, which, because the Explorer was an S.U.V, resulted in high-speed rollover accidents. After the smoke cleared, it turned out that the tyres were particularly susceptible to running at low-pressure. Where most tyres could handle this, the Firestones could not, heated up, delaminated and blammo - instant lawsuit.

The NHTSA ruling.

The American National Highways and Transport Safety Association made some sweeping regulatory changes in 2002 because of the Ford Explorer case. Section 13 of the Transportation Recall Enhancement, Accountability and Documentation (TREAD) Act, required the Secretary of Transportation to mandate a warning system in all new vehicles to alert operators when their tires are under inflated. After extensive study, NHTSA determined that a direct tire pressure monitoring system should be installed in all new vehicles. In a "return letter" issued after meetings with the auto industry, the Office of Management and Budget (OMB) demurred, claiming its cost-benefit calculations provided a basis for delaying a requirement for direct systems. The final rule, issued May 2002, would have allowed auto makers to install ineffective TPMS and would have left too many drivers and passengers unaware of dangerously underinflated tires. The full text of the various rulings and judgments, along with a lot more NHTSA information on the subject can be found [at this NHSA link](#).

Indirect TPMS

Indirect TPMS works without actually changing anything in the wheel or tyre. It relies on a component of the ABS system on some cars - the wheel speed sensors. Indirect TPMS reads the wheel speeds from all 4 ABS sensors and compares them. If one wheel is rotating at a different rate to the other three, it means the tyre pressure is different and the onboard computer can warn you that one tyre is low. Indirect systems don't work if you're losing pressure in all four tyres at the same rate because there is no differential between the rotations. Typically losing pressure in all tyres at once is a result of either incredibly bad luck or driving over a police spike strip.

Current / First / Second generation Direct TPMS.

The current generation of direct tyre pressure monitoring systems all work on the same basic principle, but have two distinctly different designs. The idea is that a small sensor/transmitter unit is placed in each wheel, in the airspace inside the tyre. The unit monitors tyre pressure and air temperature, and sends information back to some sort of central console for the driver to see. This is a prime example of trickle-down technology from motor racing. Formula 1 teams have been using this technology for years and now it's coming to consumer vehicles.

At its most basic, the system has 4 lights in the cabin and a buzzer or some other sound. When one of the tyre pressure monitors registers over-temperature or under-inflation, the driver is alerted by a sound and a light indicating which tyre has the problem.



Strap-on sensors.

The first type of sensor is a strap-on type. It's about the size of your thumb and it clamped to the inside of the wheel rim with a steel radial belt. [SmarTire](#) manufacture an aftermarket kit that can be fitted to most vehicles. Typically these sensors weigh in at about 42g (about 1½ ounces) and the load is centred on the wheel rim. Normal wheel-balancing procedures can compensate for these devices. The downside is that you have the potential for the steel strap to fail and start flailing about inside your tyre, and if you do get a flat, the location of the sensor means it will be crushed and destroyed within the first wheel rotation of your tyre going flat. Then again, these devices are there to warn you of weird operating conditions. They cannot predict a blowout.



Valve-stem sensors.

The second type of sensor is a small block which forms part of the inside of the tyre valve stem. It's a little smaller than the strap-on type and doesn't have the associated steel band to go with it. [Autodax](#) are one of the manufacturers of this type of system. This is the type that you can now get on some GM and Subaru vehicles. These sensors are lighter and weigh about 28g (an ounce). Because they are smaller and are part of the valve stem itself, they are mounted to one side of the wheel rim. Again, regular wheel-balancing can account for this weight. The disadvantage of this system is that *because* of its proximity to the side of the wheel, a ham-fisted tyre-changer can easily destroy the sensor with the machine that is used to take tyres off the rims. Also, when re-fitting the tyres, the tyre bead itself, if not correctly located, can crush the sensor.

Dust-cap sensors.



The third type of sensor is perhaps the easiest to use as an add-on item. [PressurePro](#) sell a system where the sensors are actually built in to the dust caps that you screw on to your tyre valves. In their system, the in-car monitor (\$199 at the time of writing) plugs into the 12v accessory socket so it requires no in-vehicle wiring. The PressurePro sensors send readings to the in-car unit every 7 seconds via wireless RF. The system alerts you if the pressure in any tyre drops 12.5% below its baseline pressure - the pressure the tyre was at when the sensor cap was first screwed on. 12.5% is actually quite a lot. For a passenger car tyre running at 34psi, 12.5% represents a drop of 4.25; psi. Whilst that's definitely into the danger zone - the reason for TPMS in the first place - a drop of 1psi is enough to begin to affect tyre temperature and gas mileage. Note: the PressurePro system doesn't monitor tyre temperature.

I've been in contact with one of the engineering types at PressurePro and will be reviewing their system for these pages in August 2006. One concern I had about this system was the construction of their dustcaps themselves. Built wrong, they could cause the one thing they're designed to prevent - tyre deflation. How? In order for the dustcap-monitor to work, it has to hold the valve stem open once it is screwed on (see also *The Low Tech Approach* below). If the unit should crack or break under duress whilst it is holding the valve stem open, it could lead to tyre deflation. After speaking to a PressurePro rep, he informed me that there are three failsafes built into the dustcap to prevent this from happening, even if the cap itself begins to distort. The caps are tested up to 300°F (148°C) and down to -40°F (-40°C) for distortion and brittle fracture. Each cap costs \$50 retail at the time of writing, so judge for yourself if they're likely to be built better than the low tech approach which cost \$19 for four. See the [product review page](#) for my test of the PressurePro system.



Driver displays.

As I mentioned above, the driver displays range from the über simple buzzer and light, to items which would look at home on the bridge of the starship Enterprise. In the SmarTire picture above, you can see their sensor has 4 lights on it to the right of the box - an example of the basic system. The Autodax image shows a more complex system which shows actual pressures and temperatures as well. SmarTire have a second generation display available now which shows a graphic representation of the vehicle along with the problem tyre. Their new system can be set to trigger at specific temperatures and inflation pressures. For example it can go off when the tyre gets too hot, when the pressure goes below a set threshold, or the pressure gets a specified amount below the "starting" pressure (eg if it loses 1psi of pressure). This is SmarTire's second-generation display showing some of their operating modes:



The limits of what TPMS can do.

All TPMS systems have limits. These are usually around ± 1.5 PSI/.1 BAR in pressure accuracy, and $\pm 5.4^{\circ}\text{F}/3^{\circ}\text{C}$ temperature accuracy. They *cannot* warn you of an impending blowout. Tyre blowouts are caused by instantaneous failure of the tyre. *However* they can tell you about the symptoms that lead to blowouts, and that is the primary reason for having TPMS. Tyre failures are usually preceded by long periods of running at lower-than-acceptable pressures - TPMS would warn you about that. When the tyre pressure is low,

the sidewall flexes a lot more, generating more heat - TPMS can tell you about that too.

Typically, tyre pressure is transmitted as soon as your vehicle starts moving. Pressure data is then transmitted every 4-6 minutes randomly, although the sensors read tire pressure every 7 seconds. If the new pressure reading differs from the last transmitted pressure by more than 3 PSI/.21 BAR, then the data is transmitted immediately to alert you of a problem. Tyre temperature is also normally transmitted as soon as the vehicle starts moving. As with pressure data, temperature data is then transmitted every 4-6 minutes randomly. Again the sensors will read the temperature more frequently, however the system will only alert you if the temperature exceeds 80°C/176°F.

One thing to note is that if you rotate the tyres on your vehicle, you **MUST** re-program the receiver unit inside otherwise it will think the sensor is on a different wheel.

The hidden down-side of current TPMS.

TPMS sensors need power to work. All the current sensors use batteries. Whilst these are rated for about 5 years use, or 250,000 miles, the batteries *are not replaceable* in any system. The manufacturers don't want a battery cover to come loose and start zipping around inside your tyre. For one it is dangerous to the inside of the tyre and for another, if the battery compartment opened, the battery would come out and you'd lose all sensor data for that wheel. As a result, the batteries are built-in to the sealed unit during manufacture. If you get a dead sensor, you need to buy a whole new one. Also, you know what batteries are like in extreme cold and extreme hot - bear that in mind if you regularly park in snow and ice.... Currently, there are no laws mandating manufacture dates to be put on these third-party systems. So if you buy one from a store, it could be brand new, or it could have been sitting on the shelf for a year. You've been warned.

Next-generation TPMS.

Several companies are working on the battery problem for the sensor modules. As I mentioned above, the basic pitfall of all existing systems is that at some point, the battery will wear out, and you'll need a new sensor. There are a few competing, emerging technologies right now trying to tackle the problem of perfecting transmitter-sensors that don't require a battery.. The [Pera Piezotag](#) system relies on the inherent properties of piezoelectric materials - that is a material which generates current when pressure is applied to it. The inside of a tyre is constantly at pressure so it seems reasonable that a correctly-manufactured piezoelectric wafer could generate enough current to operate the sensor just from the pressure inside the tyre. The [ALPS Batteryless TPMS](#) system (licenced from [IQ Mobil](#), a small German R&D company) is similar to an RFID chip in that it gets its power from the radio signal which interrogates it. Current systems, (including the Pera proposal) are classified as "active" transmitter / receiver systems. The sensors transmit signals of their own accord and the in-car receiver picks them up. The ALPS system is a "passive" RFID transceiver system. The sensors remain dormant and un-powered until the in-car transceiver sends a high-power short-range radio signal out which basically carries a "tell me your status" command. The RF power in the radio signal is enough to cause the

RFID unit in the sensor to power up, take a reading, transmit it and power down. Clever eh? The downside of this system is that it's likely to be pricey compared to others coming to the market. There are 9 pcbs in their system; one in each wheel, one in each wheel arch and one in the console. [Transense Technologies](#) in England are licensing their technology to SmarTire, Michelin and Honeywell. Unlike the Alps system, Transense's system has only one PCB and employs passive surface acoustic wave sensors (piezo-based again) at the inner end of each tyre valve. Their sensors monitor both pressure and temperature. It's worth noting that Transense hold the patent for resonant SAW technology which expires in 2019. Pera were exposed to this technology in the early 90's and have since come out with their own Piezotag system (see above). Coincidence?

Michelin has an inductive (125kHz) system for trucks developed for them by TI, Goodyear and Siemens have a similar technology system for passenger cars. QinetiQ (formerly DERA / RAE Farnborough) also have an offering.

The low-tech approach.

If all this electronic wizardry seems too much for you, you can always go to the low-tech approach. Valve-cap pressure sensors. These are available over-the-counter at just about any car parts store and are about as simple a device as you can get. You inflate your tyre, and replace the dust cap on the valve with one of these. If it shows green, you're OK. If it shows yellow, your tyres have lost some pressure. If it shows red, your tyres are dangerously underinflated. This system does of course require you to walk around the car and check each time you want to drive off.

There are some drawbacks to this system which you should be aware of. For the pressure sensor to read the tyre pressure, it has to depress the valve stem when its screwed on. This means that the tyre valve is no longer the thing keeping the air in your tyre - it's now the seal between this pressure cap and the screw threads. If it's not snug, it will leak slowly and let air out of your tyre. Secondly, there's the question of balance. If you use these screw-on caps, you should get your wheels re-balanced afterwards because it's adding weight to the rim. Third there's the question of durability - it's better for one of these things to come off completely if you hit a pothole because then the valve stem will re-seal. If you crack the pressure cap, you'll let all the air out of the tyre very quickly. And finally, the question of accuracy. Typically these things are very coarse in their readings. A "yellow" signal might not appear until you're 4psi down, and it might not show red until you're as much as 8psi down. Even 1psi can be a problem so 4psi or 8psi is dangerously underinflated.



The ultra-low-tech approach, and why all this money is being spent in the first place.

Drivers are lazy. That is the very simple reason that all these companies are burning off millions in R&D budgets, sales and marketing. If we all checked our tyre pressures once a week using one of the tyre pressure gauges mentioned above, we'd know if there was a problem brewing. That is the ultra-low-tech approach. The problem is that 90% of drivers don't ever bother to check their tyres. They either rely on their servicing mechanic or garage to do it for them, or they rely on blind dumb luck. For as long as uneducated people drive around blissfully unaware of the latent danger in their tyres, governments and safety regulators will mandate TPMS. The real question is this : given how unaware some drivers are of their surroundings and their instruments (think of the number of people you see driving with their indicators on on the motorway, or with their fog lights on in bright sunshine) do we really believe that an extra warning light in the vehicle is going to make any difference? Probably not. The key is that if the system was installed, and it worked, and the driver ignored it, then the car, wheel and tyre manufacturers can no longer be held accountable for blowouts and rollovers.

Some TPMS links.

[Google Search.](#)

[Subaru / GM valve-stem info \(PDF file\).](#)

[TyreAlert. A US manufacturer of TPMS products.](#)

[TyreAlert-UK. A UK manufacturer of TPMS products.](#)

[Action Imports of Australia, dealing with TPMS products.](#)

